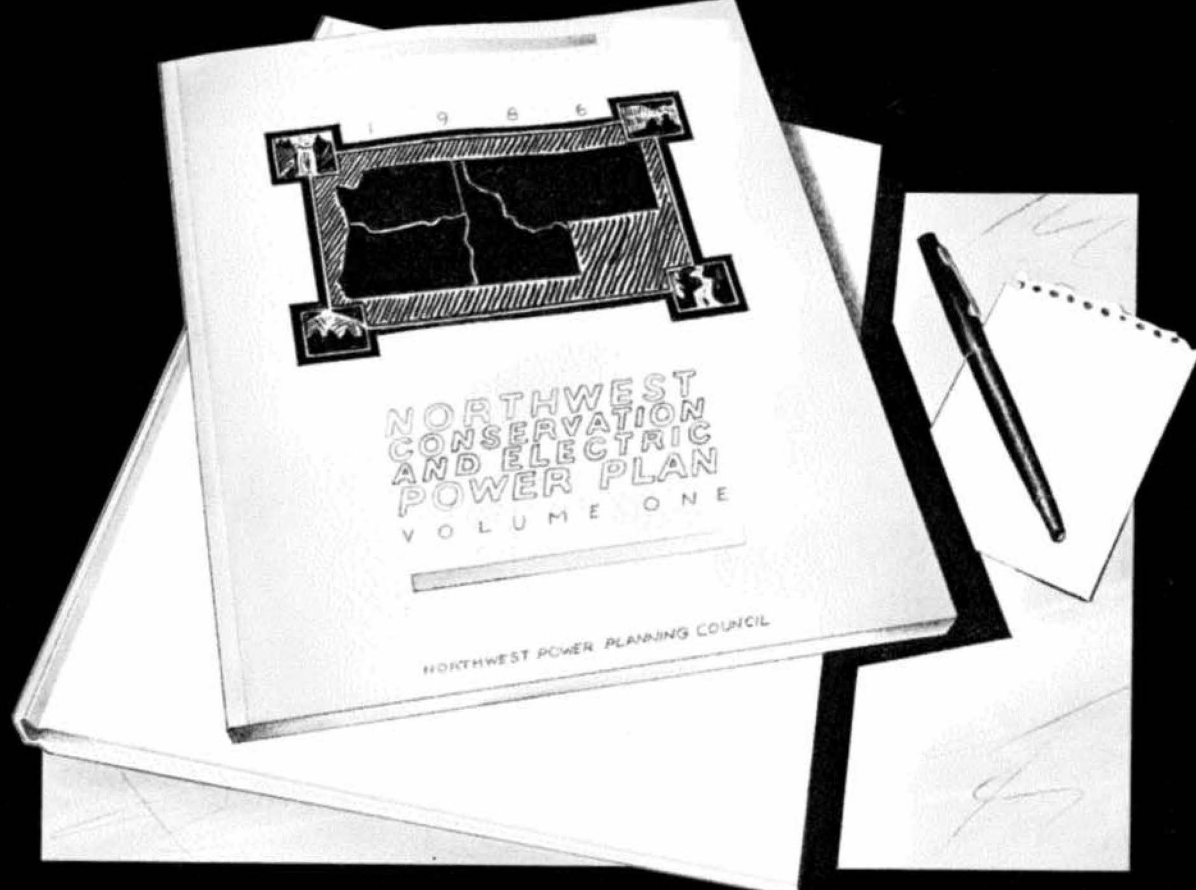
1989 SUPPLEMENT TO THE 1986 NORTHWEST CONSERVATION AND ELECTRIC POWER PLAN

VOLUME TWO

89-1A



ROY:[PS,ISAAC.SUPPF]STRAT_RØ.DA

priority order in Supp

——————— Resource Strategy Data for the Joint Decision Model ———————

Comments to first line of asterisks.

DRAFT: Illustrative Data

Recognized party types are: 'IOU', 'GPUB', & 'BPA'.
Party IDs and Resource IDs must match their counterparts in the ownership and resource data files exactly (including case).

'*' in column 1 comments out resources in priority list.

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*******************************************************************************
ID of Planning Party to keep Seperate in Dispatch                    |
Dispatch Position wrt Parties of Same Type (Before,After,Random)     |A
*******************************************************************************
Party Name                        |BPA
Party ID                          |BPA
Party Type                        |BPA
Resource Option Level             |.90
Resource Build Level              |.50
Uniform Planning Adj.             | 0
Endogenous Reqts on BPA           |
Independence Premium (m/kwh)      |
Fraction of Deficits on BPA       |
RESOURCE PRIORITIES:
Res ID    Priority
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MCSSF      0.
MCSMF      0.
MCSC       0.
WTRHT      0.
REFR       0.
FRZR       0.
NEWMH      0.
REPLAC     .1
HYDEFF     1.
SYSEFF     2.
SMLH1      3.
IRR        4.
INDSTR     5.
EXCOMM     6.
SMLH2      7.
SCCT       8.
SFWX       9.
MFWX      10.
COGEN     11.
*LICOAL    12.
SMLH3     13.
LCOAL     14.
OTHER     15.
*WNP3       5.3
*WNP1       5.4
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FORCED GEN RES ARRIVALS:

Res ID	# Units	Inven	I/S	Count Opt E
WNP1	1	1989		F
WNP3	1	1989		F

Gibson

1989 Supplement to the 1986 Northwest Conservation and Electric Power Plan

Volume II

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Note: All figures used in both volumes of this supplement are in 1988 dollars unless otherwise specified. Since the Northwest's hydropower system is primarily energy constrained, the term "megawatts" refers to average annual megawatts unless otherwise specified. All references to "energy," "capacity" and "power" refer to electrical energy resources only.

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Chapter 1

Economic Forecasts for the Pacific Northwest

Introduction

Under the Pacific Northwest Electric Power Planning and Conservation Act of 1980, Congress charged the Northwest Power Planning Council (Council) with forecasting electric power requirements as the basis for a plan for meeting regional electricity needs. The Bonneville Power Administration (Bonneville) has prepared regional electricity demand forecasts since 1981 to use as a basis for its planning. These draft forecasts represent the first time coordinated forecasts between the Council and Bonneville will be used as a common basis for resource planning and analysis. This report describes revised economic and demographic assumptions to be used in developing forecasts of electricity use for the supplement to the Council's 1986 Power Plan.

Economic and demographic assumptions are the dominant factors influencing the forecasts of demand for electricity. A good rule of thumb is that demand for electricity will parallel economic activity in the absence of other changes. This relationship is modified by shifts in relative energy prices, including the price of electricity and other fuels; by changes in the composition of economic activity; and by the gradual depreciation and replacement of buildings and energy-using equipment in the region.

Recognizing that the future is highly uncertain, the Council and Bonneville have adopted planning strategies that incorporate flexibility and risk management. Economic and demographic assumptions are both extremely important determinants of future electricity needs and, at the same time, highly uncertain. The objective of the range of planning assumptions discussed in this report is to help define the extent of uncertainty. Planning must address a range of future electricity needs that reflects, among other factors, this underlying economic uncertainty.

In order to recognize uncertainty explicitly, the Council and Bonneville have prepared forecasts that bracket the highest and lowest plausible economic scenarios for the next 20 years. The purpose of this approach is to develop a flexible resource strategy that provides an adequate supply of electricity at the lowest possible cost. The risks are twofold: the risk of not having an adequate supply of electricity, and the risk of being saddled with expensive investments in unnecessary resources.

The Council and Bonneville have developed a range of forecasts for each state in the Northwest. The forecasts are built from analysis of individual sectors of the economy. The forecasts are influenced by results produced by Bonneville's Regional Economic Model, as well as studies and expertise provided by groups and individuals throughout the Northwest. Detailed review by the Council's Economic Forecasting Advisory Committee and other interested parties is reflected in the forecasts presented in this paper.

Since future economic conditions are highly uncertain, the forecasts encompass a wide range of possibilities for future economic growth. The high forecast assures that the Council's plan will accommodate record regional economic growth should it occur. In the high forecast, total regional employment grows 65 percent faster than a high national forecast of employment. The high forecast represents a case in which the region grows faster relative to the nation than in any historical 20-year period. The low forecast assumes that the Pacific Northwest grows at a rate 40 percent lower than a low-growth national forecast. The low case implies a relative performance below historical experience in the region over a 20-year period. Table 1-1 shows a comparison of the forecast range to a range of national forecasts prepared by Wharton Econometric Forecasting Associates. Detailed tables showing employment, population and household forecasts by state are in Appendix 1-D.

One way to characterize the forecast range has been to compare the levels of growth for each scenario relative to forecasts of national economic growth. As discussed earlier, the high and low cases represent levels of growth that are, relative to a national forecast, higher and lower, respectively, than that which has occurred in the region historically. Does this mean that the range is too wide? There are examples of relative growth outside the range presented here in historical experience. States that have experienced growth relative to the nation for 20-year periods faster than shown in the high case include Alaska, Arizona, California, Florida, North Dakota, New Mexico, Nevada, Texas, and Utah. States that have experienced growth relative to the nation slower than shown in the low case include Illinois, Indiana, Massachusetts, Maine, Michigan, New Hampshire, New York, Ohio, Pennsylvania, Rhode Island, Vermont and West Virginia. New Hampshire is interesting because it experienced extremely low growth compared to the nation in some periods of history but may soon enter the company of states that have experienced relatively high levels of growth for 20-year periods as well.

A more likely range of outcomes is bound by the medium-high and medium-low forecasts. This smaller, more probable, range shows growth higher than the nation for most of the range. This is consistent with historical patterns, since the Pacific Northwest has grown faster than the nation over the long-term. The medium range of forecasts assumes this will continue to some extent.

Table 1-1
Comparison of Forecasts
1987 - 2010
Average Annual Rate of Growth (%)

REGION	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Total Employment	2.8	2.1	1.6	1.1	0.4
Manufacturing	1.3	0.5	0.0	-0.5	-1.3
Non-manufacturing	3.1	2.4	1.8	1.3	0.6
Total Population	2.0	1.5	1.2	0.9	0.4
Households	2.7	2.0	1.6	1.3	0.4

WHARTON NATIONAL OUTLOOK	1987 - 2007		
	HIGH	MEDIUM	LOW
Total Employment	1.7	1.2	0.7
Manufacturing	0.1	-0.3	-0.9
Non-manufacturing	2.0	1.5	0.9
Total Population	1.1	0.8	0.6
Households	NA	1.4	NA

The total employment forecasts in this report are similar in many respects to the forecasts for the Council's 1986 Power Plan. The forecasts encompass a range of employment growth between 1987 and 2010 comparable to the range in the 1986 plan between 1985 and 2005. In spite of the general similarity of the forecast range to that in the 1986 Power Plan, there are several important changes in the details of the economic and demographic forecasts and in the fuel price assumptions. Table 1-2 shows a comparison of the draft 1988 forecasts with Council forecasts in the 1986 Power Plan. Significant changes include:

- Lower manufacturing employment forecasts, especially in the medium-low and low cases.
- Lower fuel price assumptions.
- Increased relative importance of the non-manufacturing sector.
- Higher forecasts for the lumber industry.

Table 1-2
Comparison of Council Forecasts
1985 - 2005[a]
Average Annual Rate of Growth (%)

1986 PLAN	MEDIUM-HIGH	MEDIUM-HIGH	LOW	LOW
Total Employment	3.2	2.4	1.5	0.5
Manufacturing	1.6	1.1	0.5	-0.4
Non-manufacturing	3.4	2.7	1.7	0.7
Population	2.0	1.5	0.9	0.2
Households	2.8	2.0	1.3	0.3
1989 SUPPLEMENT				
Total Employment	3.0	2.2	1.2	0.6
Manufacturing	1.6	0.8	-0.4	-1.1
Non-manufacturing	3.3	2.5	1.5	0.8
Population	2.0	1.5	0.9	0.5
Households	2.8	2.0	1.4	0.6

Comparison of Bonneville Medium Forecasts
1986 - 2006[a]
Average Annual Rate of Growth (%)

	1986 FINAL	1989 SUPPLEMENT
Total Employment[b]	1.6	1.7
Manufacturing	0.1	0.2
Non-manufacturing	1.9	1.9

a Growth rates differ from those shown in previous tables because they cover different time periods.

b Excludes agricultural employment.

The forecasts for oil and natural gas prices are generally lower than those in the 1986 Power Plan, reflecting recent history and an improved understanding of the world oil market. The ability of oil producers to achieve ever higher prices for their oil is severely limited by market responses, both on the demand side and on the supply side.

Forecasts of employment growth in a number of manufacturing industries are lower in these forecasts than in the 1986 Power Plan forecasts. This is especially true for the electronics industry, which has experienced slower growth in the 1980s. These lower growth rates are offset by higher forecasts of productivity growth in many manufacturing industries.

In the lumber and wood products industry, higher productivity growth and a lower wage structure have made the Northwest lumber industry relatively more competitive. In addition, new studies by the Forest Service indicate an improved supply outlook compared to other regions in the nation.

The non-manufacturing industries accounted for 83.9 percent of total employment in the region in 1987. Non-manufacturing industries are projected to increase employment faster than manufacturing industries in all scenarios.

Changes to Bonneville's medium case forecast are shown in Table 1-2 as well. In general, the forecast is slightly higher than Bonneville's 1986 forecast. The major change is in the non-manufacturing sectors. This reflects a shift from manufacturing to non-manufacturing jobs in the underlying national forecast between February 1986 and July 1987. While Wharton's July 1987 forecast showed an increase in consumer demand projections, there was an even more dramatic change in the composition of consumer demand in the two forecasts. Consumer spending shifted from durable goods to services. Factors affecting changes in consumer demand included federal tax reform, higher forecasts of interest rates and higher forecasts of prices for durable goods. Although the forecasts for manufacturing employment were only slightly changed, there were significant changes in the outlook for specific industries. The forecasts for machinery and petroleum were significantly lower, while the forecasts for food processing, pulp and paper products, lumber and wood products and primary metals were significantly higher.

Forecasts for Utility Service Areas

The economic and demographic assumptions are divided into public and investor-owned utility service areas to provide inputs into the demand forecasting system, which forecasts electricity consumption by utility type. Industrial production at the detailed industry level, employment in the commercial sector, and housing units are divided into public and investor-owned utility areas for each state. The splits between public and investor-owned utility areas are provided by Bonneville. According to these estimates, approximately 40 percent of regional manufacturing production, commercial employment and households are located in public utility service areas. In the case of major manufacturing industries, the shares of production allocated to public or investor-owned utilities were developed by detailed industry analysis of plant location or county employment patterns. Housing stock shares were allocated on the basis of customer counts in the residential sector at the utility and state level. The commercial sector shares incorporated new data provided by Seattle City Light, which showed a decrease in the public utility share of King County's employment in Washington state. This historical shift was assumed to continue for King County. For the rest of Washington state and for the other states and counties, the shares of commercial sector employment were based on residential customer counts by utility and state. They were assumed to remain constant over the forecast period.

Forecast Overview

Overview of the Regional Economy

The Pacific Northwest is blessed with rich natural resources of minerals, agricultural lands, fisheries and forests. The abundance of natural resources has provided the region's inhabitants with jobs and income, as well as a desirable environment for recreation and a high quality of life.

The development of the vast Columbia/Snake River system for navigation, electricity production, irrigation and recreation has contributed to economic growth in the region. Low electricity rates, relative to those found elsewhere in the nation, have attracted electricity-intensive industries, such as the aluminum industry, to the Pacific Northwest.

More recently, industries such as electronics have grown in the region, attracted primarily by the quality of the labor force and quality of life. The development of port facilities and growing trade with Alaska and the Pacific Rim countries have provided a source of new jobs for the region. Growth in the non-manufacturing sectors, in general, has occurred at a rapid rate. These developments have lent diversity to a region dependent on resource-based industries.

During the 1960s and 1970s, total employment grew faster in the region than in the nation. Table 1-3 compares growth patterns between the region and the nation for the last two decades. Since 1979, the region has experienced slower growth than the nation. From 1979 to 1987, it is estimated that total employment increased at an annual rate of 1.6 percent nationally, while total employment in the region increased at an annual rate of 1.0 percent. Only in 1986 and 1987 did the region begin to perform better than the nation during the 1980s.

Table 1-3
Comparison of U.S. and Pacific Northwest Employment Trends
Average Annual Rate of Growth (%)

	1960 - 1979		1979 - 1987	
	PNW	U.S.	PNW	U.S.
Total Employment	3.0	2.2	1.0	1.6
Manufacturing Employment	2.2	1.2	-0.5	-1.2
SIC[a] 20 - Food and Kindred Products	1.3	-0.2	-0.7	-0.7
SIC 24 - Lumber and Wood Products	1.0	0.8	-3.0	-0.5
SIC 26 - Pulp and Paper Products	0.3	0.9	0.4	-0.5
SIC 28 - Chemicals and Allied Products[b]	-0.1	1.6	2.8	-1.0
SIC 33 - Primary Metals	2.9	0.3	-5.0	-6.2
SIC 35 - Non-electric Machinery	6.3	2.8	-0.2	-2.4
SIC 36,38 - Electrical Equipment and Instruments	9.0	2.2	2.3	-0.1
SIC 37 - Transportation Equipment	2.3	1.1	1.2	-0.7
Other Manufacturing	3.4	1.0	0.1	-1.0
Non-manufacturing Employment	3.2	2.5	1.3	2.3
Mining	1.2	1.6	-4.4	-3.2
Construction	4.2	2.2	-3.2	1.5
Transportation, Communication and Utilities	1.8	1.5	0.3	0.8
Wholesale and Retail Trade	4.2	3.1	1.5	2.2
Finance, Insurance and Real Estate	5.4	3.4	1.1	3.6
Services	5.7	4.5	3.8	4.4
Government	3.7	3.5	0.8	0.8

[a] Standard Industrial Classification (SIC) code is the classification of industries used in federal statistics. See Table 1-B-1 in Appendix 1-B for list.

[b] Change in classification of a facility in the region to chemicals has artificially raised the rate of growth from 1979-1987. Excluding this facility in the 1987 data would yield a growth rate of 1.8 percent.

The region's stronger performance in 1986 and 1987 was fueled by high operating levels in some key industries, such as forest products, aerospace and aluminum. After enduring a severe depression in the early 1980s, the region's wood products industry set new production records in 1986 and 1987. During this period, however, productivity gains were so high that employment remains more than 20 percent lower than in 1979.

The lumber and wood products category includes logging activities, some of which are related to pulp and paper production. In addition, many companies both wood and paper products. Including pulp and paper products, the forest products industry accounted for 27 percent of manufacturing employment in 1987.

The second largest regional manufacturing industry is transportation equipment, which is composed primarily of aerospace. It accounted for 20 percent of manufacturing employment in 1987. After employment declined more than 20 percent in the early 1980s, the industry has recovered, increasing employment more than 40 percent since 1983.

Primary metals is the largest industrial consumer of electricity in the region, accounting for nearly half of all industrial electricity consumption. Most of the electricity consumption is concentrated in the primary aluminum industry, which operates 10 plants in the Northwest. This industry has experienced dramatic swings in prices of aluminum, increasing electricity prices, and increasing competition from lower-cost producing areas. Recently, aluminum smelters have increased their operating rates in response to higher worldwide aluminum prices and more attractive electricity rates.

Pulp and paper is the second largest industrial consumer of electricity, followed by chemicals and lumber and wood products. In 1981, the top four industrial consumers of electricity accounted for almost 90 percent of the electricity used by industrial customers in the region.

Major Trends

There are a number of basic trends common to the range of forecasts. While the extent of change resulting from these trends varies somewhat in each forecast, it nevertheless forms a context for the future. Many of the trends relate to demographic patterns in the existing population.

One of the primary demographic changes that will occur is the aging of the population. From 1987 to 2010, the national population between 45 and 59 years of age is projected to increase more than 80 percent, while the population between 25 and 34, is projected to decline by more than 10 percent. The population over the age of 60 is projected to increase by 37 percent during this period. Figure 1-1 shows the percentage change in population by age group for the nation from 1987 to 2010. Although the age composition of the population in the region will vary among scenarios because of migration, the general patterns of demographic change will persist.

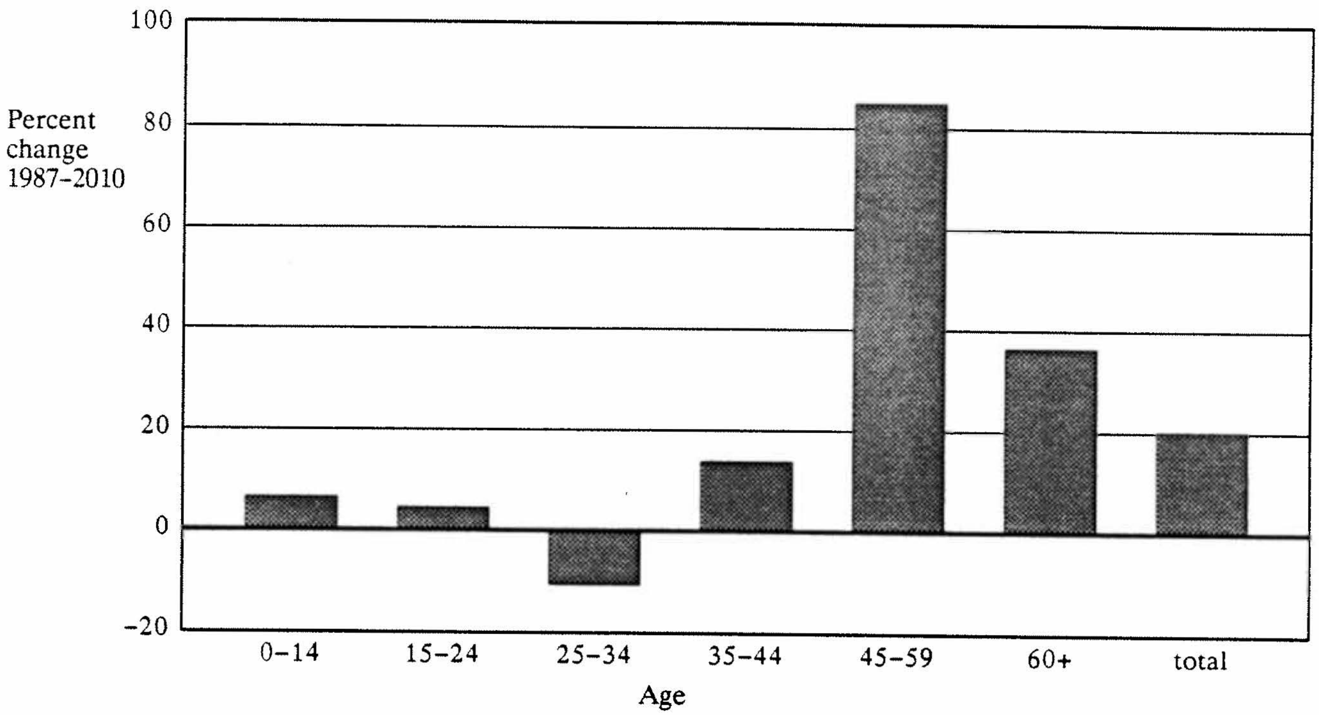

Figure 1-1
Percent Population Change by Age Group
U.S. 1987-2010

This aging of the population is expected to affect consumption patterns, the labor force and labor productivity. Consumption patterns are expected to emphasize personal services, clothing, travel, and health services, as the older population increases in size. Over the next twenty years, the number of young people entering the labor force will increase at a slower rate than historically. From 1987 to 2010, the population aged 15-24 is projected to increase at an average annual rate of only 0.2 percent, while from 1970 to 1980, the population in this age group increased at an average annual rate of 1.8 percent. This is the primary reason that the labor force is projected to increase at a slower rate over the next twenty years than historically. The tightening labor supply will put upward pressure on wages. Producers will seek to substitute capital for labor, which tends to increase productivity, or output per employee. In addition, the rapid pace of technological changes and continuing pressure of international competition will stimulate capital investment as well.

A second major trend is the increase in the proportion of women in the labor force. From 1960 to 1987, the female labor force participation rate increased from 37 percent to 57 percent. This trend is expected to continue to varying extents in all forecasts. This is reflected in the increase in the proportion of the population that is employed. The employment-population ratios are shown in Table 1-4.

Growth in the importance of non-manufacturing industries is projected in each of the forecasts. Traditionally, studies of regional economic growth have focused on the manufacturing industries. Recently, the non-manufacturing industries have attracted more attention because of their size and rapid growth. In 1987, non-manufacturing industries accounted for 83.9 percent of total employment in the region. Non-manufacturing employment increased at a rate nearly 70 percent higher than manufacturing employment from 1960 to 1979.

The outlook is strong for industries, such as communications and machinery, that will play a key role in growing technological changes and productivity-enhancing investments. The foreign trade sector is expected to continue to increase in importance. The Pacific Northwest is well positioned to participate in trade to the Pacific Rim countries, and that possibility is assumed to be an important component of the higher growth forecasts.

Slower growth of the region's large resource-based industries characterizes all of the forecast range. Lumber, paper, and food products are not expected to be important sources of economic growth for the region even in the high forecasts. As shown in Table 1-4, these industries account for a smaller proportion of manufacturing employment in all scenarios.

Table 1-4
Comparison of 1987 and 2010

		2010				
	1987	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Persons per Household	2.58	2.20	2.32	2.32	2.32	2.59
Employment/Population Ratio	0.43	0.51	0.49	0.47	0.45	0.42
Percent of Total Employment	100.0	100.0	100.0	100.0	100.0	100.0
Manufacturing	16.1	11.3	11.3	11.3	11.2	11.1
Non-manufacturing	83.9	88.7	88.7	88.7	88.8	88.9
Percent of Manufacturing	100.0	100.0	100.0	100.0	100.0	100.0
Lumber and Wood Products	21.8	14.4	15.4	16.1	16.7	17.7
Transportation Equipment	20.1	19.9	19.7	18.9	17.9	17.0
Food and Kindred Products	12.3	9.9	10.8	11.1	11.6	12.4
Electronics (SIC 35,36,38)	15.4	24.6	22.8	22.1	21.3	20.5
Pulp and Paper Products	4.8	3.4	3.7	4.0	4.6	5.1
Other	25.6	27.8	27.6	27.8	27.9	27.3
Percent of Non-manufacturing	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture	9.4	4.9	5.3	5.8	6.1	6.9
Mining	0.3	0.3	0.3	0.3	0.2	0.2
Construction	4.6	4.5	4.7	4.4	4.2	4.6
Transportation, Communication and Public Utilities	5.9	4.6	4.4	4.6	4.8	4.8
Wholesale and Retail Trade	27.3	29.8	30.2	30.5	30.3	29.8
Finance, Insurance and Real Estate	6.6	7.1	7.0	7.0	6.9	6.7
Services	23.6	29.0	27.9	27.7	28.1	26.9
Government	22.3	19.8	20.0	19.8	19.4	20.1

Description of the Scenarios

The economic assumptions rely on basic policy assumptions, many of which operate at the national level. Each of the five regional economic forecasts was made within the context of a corresponding view of the national economy. Forecasts developed by Wharton[1] were the primary sources of national economic variables used in developing regional projections.

The national forecast is used directly in developing the medium case. It provides the inputs to Bonneville's Regional Economic Model. In the ranges, certain results of the national forecasts are included directly in the regional forecasts. These include inflation rates, interest rates, industry-specific productivity growth, and basic demographic patterns. Other assumptions create a greater variation in the regional forecasts than in the national forecasts, however. These include wider fuel price ranges, regional shares of national employment growth by industry, and specific assumptions about the viability of the regional aluminum industry.

In developing the scenarios, it is important to recognize the wide range of possible outcomes for the regional economy. A short-term view of the future was rejected in favor of developing scenarios that would encompass a wide range of uncertainty about the region's economy in the long run. The high case presents quite a different view of the regional economy in the year 2010 than the low case. For example, there are 75 percent more jobs in the region in the high case than in the low case by the year 2010.

In addition to an underlying high-growth scenario on the national level, the regional outlook for the high-growth case implies that the region's economy fares better, relative to the nation, than it has in the past. The large resource-based industries, such as forest products, aluminum, agriculture and basic chemicals, maintain a vital presence in the region's economy, but are not expected to contribute to new jobs. In the high case, employment in lumber and wood products is projected to decline 12 percent from 1987 to 2010. Other resource-based industries show no increase in jobs. On the other hand, industries such as electronics, trade and services expand rapidly, more than doubling their employment in 20 years. As shown in Table 1-1, total employment is projected to increase 2.8 percent per year, which is similar to the rate of growth sustained by the region in 1960-1980. Population is projected to grow 2.0 percent per year, while households grow 2.7 percent per year. It is assumed in these projections that the region will continue to be a favorable location for growth, because of the richness and diversity of its natural resources, the quality of the environment and labor force, the quality of the educational system, relatively lower electricity prices, and proximity to expanding markets in Japan and other Pacific Rim nations.

In the medium-high scenario, rapid growth in high-technology and commercial industries is coupled with moderate levels of activity in forest products, agriculture, and basic chemicals. Employment in non-manufacturing increases more than 70 percent. These changes result in employment growth of 2.1 percent per year, and population and household growth of 1.5 and 2.0 percent per year, respectively. Although the overall level of employment growth in the medium-high scenario is slower than the region experienced in the 1960s and 1970s, it still represents a case in which employment growth is 75 percent faster than national growth in the medium case.

In the medium-low growth forecast, traditional industries experience low levels of economic activity while other manufacturing and commercial industries experience moderate growth levels. Employment in lumber and wood products is projected to decrease by 25 percent. The region continues to increase its share of employment in electronics and non-manufacturing industries, however. Total employment is projected to increase 1.1 percent per year, with population and households increasing 0.9 percent and 1.3

1./ Wharton Econometric Forecasting Associates, Long-term Alternative Scenarios and 25-year Extension, July 1987 and February 1988.

percent per year, as shown in Table 1-1. In the medium-low scenario, employment growth is slightly slower than national growth in the medium case.

The regional outlook for the low case shows total employment increasing 0.4 percent per year, indicating a rate of growth 40 percent lower than the national rate of employment growth in the low case. Growth in non-manufacturing is offset by declines in many of the larger, traditional industries. Employment in aerospace is projected to decline by more than a third. Total population and households are projected to increase 0.5 percent and 0.4 percent per year, respectively. This slow level of growth implies net out-migration of population throughout the forecast period.

Employment and Production

Lumber and Wood Products

In 1986, the regional wood products industry accounted for 38 percent of U.S. lumber production and 42 percent of U.S. softwood plywood production. The bulk of production in the region--more than half of lumber production and more than 70 percent of the softwood plywood production--occurred in Oregon. Furthermore, a large proportion of production in both Oregon and Washington is west of the Cascades. The lumber and wood products industry is the largest manufacturing industry in the Pacific Northwest, accounting for 22 percent of manufacturing jobs in 1987.

In recent years, the industry has experienced wide swings in production and employment levels. A major factor contributing to volatility in this industry is new housing. New housing accounts for 40 percent of the market for lumber and wood products. Figure 1-2 is a graph showing U.S. housing starts, Pacific Northwest lumber production and plywood production for 1960 to 1986. The graph shows that regional lumber and plywood production follows a cyclical pattern similar to U.S. housing starts.

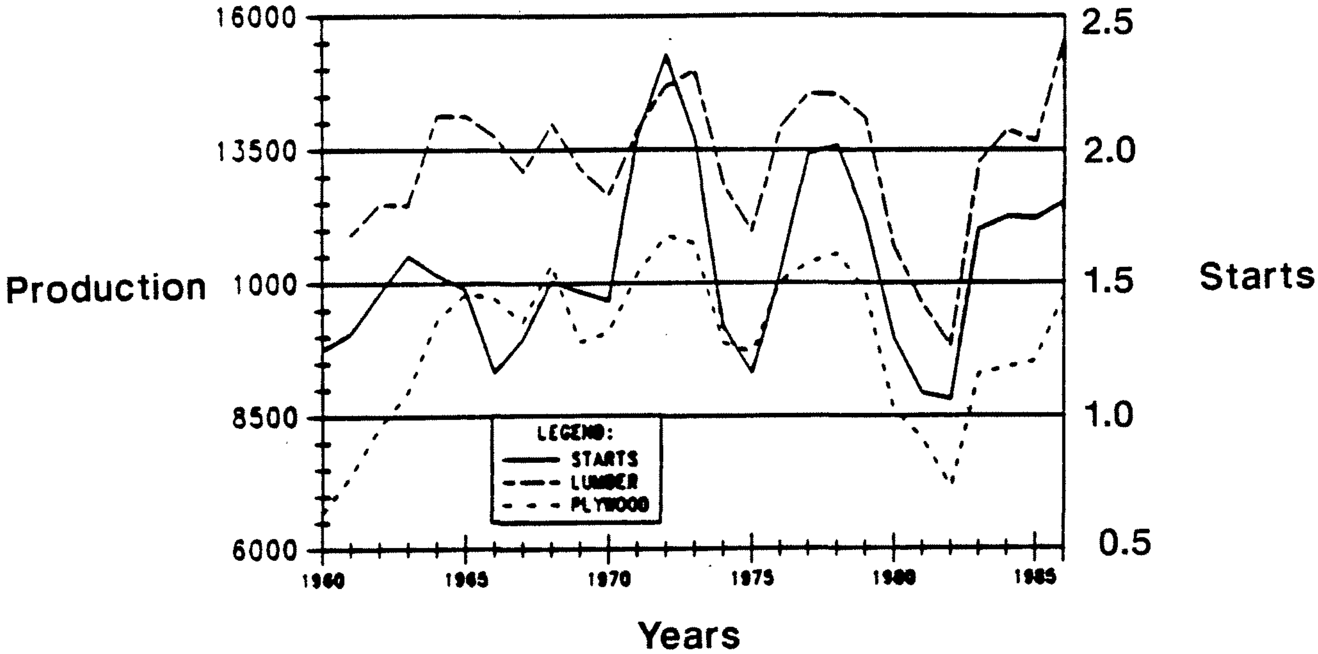

Figure 1-2
Comparison of Pacific Northwest Lumber and
Plywood Production with U.S. Housing Starts
1960-1986

Other factors affecting lumber and plywood demand include housing types, average unit-size growth in other end uses for lumber and plywood, and international demand. An average-sized single-family unit uses approximately three times as much lumber and wood products as a multifamily unit. From 1970 to 1974, the average share of single-family units to total units was 58 percent. This share increased to 73 percent for the years 1975 to 1979. The share of single-family units is affected by the cost of housing and demographic factors. An area of growing demand for lumber and plywood in the last few years has been in repair and remodeling use. Currently, repair and remodeling account for 30 percent of U.S. lumber consumption. The drop in the value of the dollar against other currencies over the last two years has had an impact on exports of lumber and wood products. Dramatic increases in exports through Northwest ports have occurred over the last year. Industry and government groups have escalated their efforts to increase exports through marketing programs in recent years.

The region's lumber industry has experienced increasing competition from lumber-producing areas in the Southeastern United States over the last several decades. Higher transportation, labor and stumpage costs have made it difficult for the Northwest to retain its historical market shares. Northwest lumber mills have responded by seeking lower wage rates and taking steps to improve labor productivity. Although production levels in 1986 and 1987 broke previous records established in the 1970s, employment was nearly 20 percent lower than in 1979. In spite of cost-cutting, Northwest production costs remain higher than costs faced by Southeastern competitors.

In the Southeast region, timber resources are owned primarily by the forest products industry and other private parties. The timber harvest can respond to fluctuations in demand, relieving pressure on stumpage prices. In addition, the tree growth cycle is faster in the Southeast, approximately 35 years compared to 50 years in the Northwest. In the Northwest, the federal government owns more than half of the commercial timberlands. Timber resources under the management of the U.S. Forest Service are governed by laws limiting the level of cuttings to a level that may be maintained over the long-term. During the early 1980s, stumpage prices were bid up dramatically, raising costs for some mills that relied extensively on timber from National Forest lands.

One area of uncertainty is in the estimates of future timber resources. Recent studies show that more privately held timberlands in the Southeast are being lost to other uses, such as agriculture or urban development, than previously thought. New studies indicate that southern timber inventories will soon begin to decline. In addition, the intensity of management applied by non-industry private timber owners is subject to uncertainty.

In the Northwest region, the U.S. Forest Service has released new draft resource plans that may increase or decrease the allowable timber harvest from lands under Forest Service management. Until final plans are adopted, the outlook for the industry is uncertain. Other factors that add to the uncertainty of future timber resources include natural disasters, improvement of timber management techniques, and changes in wilderness or recreational designations, to name a few.

Canadian producers increased their share of the U.S. market rapidly in the late 1970s and early 1980s. U.S. producers prevailed in a dispute involving Canadian government subsidies to private companies, which resulted in a 15-percent export tax on Canadian lumber destined for the U.S.

Competition to the region's plywood industry is provided by the introduction of low-cost substitute products. The substitutes include products such as waferboard and oriented strandboard. These products are fabricated from faster-growing trees and waste chips. Their main cost advantage is the use of lower-cost materials. Although there are mills currently in the region or under consideration that produce these products, most of the plants producing waferboard and oriented strandboard will be located in other regions of the country.

The production forecasts presented in this paper are based on recent U.S. Forest Service (USFS) forecasts. The U.S. Forest Service projects demand and supply from the timber-producing regions in the U.S. to the year 2030. These forecasts do not take into account reductions in timber harvest levels from U.S. Forest Service lands that may go into effect when the Forest Service finalizes its draft resource plans.

Changes in output per employee are used to convert production forecasts into employment. Production, employment and output-per-employee forecasts for the lumber and wood products industry are shown in Table 1-5.

Table 1-5
Forecasts of Production and Employment
Lumber and Wood Products
Pacific Northwest (1987 - 2010)

	PRODUCTION			AVERAGE ANNUAL RATE OF GROWTH (%)
	1987	1995	2010	1987 - 2010
Lumber (SIC 2421) (Billion board feet)				
High		15.9	16.2	-0.2
Medium-high		13.9	14.7	-0.6
Medium	17.1	13.9	14.7	-0.6
Medium-low		12.5	13.2	-1.1
Low		11.1	11.8	-1.6
Plywood (SIC 2436) (Billion square feet)				
High		9.8	10.9	-0.2
Medium-high		8.6	10.0	-0.6
Medium	11.6	8.6	10.0	-0.6
Medium-low		7.1	8.3	-1.4
Low		5.8	6.8	-2.3

Employment (in Thousands)

		2010				
	1987	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Lumber (SIC 2421)	45.9	36.2	34.4	34.4	30.9	27.5
Plywood (SIC 2436)	22.1	13.6	13.1	12.7	10.6	9.1
Other SIC 24	60.0	63.0	54.6	48.3	45.0	41.1
Total SIC 24	128.0	112.8	102.1	95.4	86.6	77.7

Output per Employee
Average Annual Rate of Growth (%)
1987-2010

	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Lumber (SIC 2421)	0.8	0.6	0.6	0.6	0.6
Plywood (SIC 2436)	1.8	1.5	1.5	1.5	1.3
Other SIC 24	1.6	1.4	1.0	1.0	1.0

Pulp and Paper

The pulp and paper industry is the second largest industrial consumer of electricity in the region. In 1977, firms in pulp and paper products accounted for 19 percent of the electricity consumed by industry as a whole. The pulp and paper industry employed 28,850 people in 1987.

The region's pulp and paper industry supplied an average of 14 percent of national pulp production and an average of 10 percent of national paper and paperboard production in the 1970s. The region's share of pulp production was down from an average of 17 percent during the 1960s.

Most of the raw material used in the pulp-making process is wood chips, a byproduct from lumber and plywood plants. Availability and cost of wood chips in the future will operate as a constraint on capacity expansion in this region. Competition for portions of the timber resource has increased because of improvements in yield from each log by sawmills and plywood plants, and timber management practices that produce more uniform logs. Another factor has been the growth of the export market for chips during the 1970s.

The long-term outlook for the Pacific Northwest industry is favorable with regard to proximity to markets in the West and in the Pacific Rim. Other factors, however, including fiber availability and comparative production costs (the cost of labor, for example) compare less favorably to the Southeastern producing areas. The Northwest's advantage in electricity costs has decreased to some extent as a result of large increases in electricity rates since 1979. Not only are electricity costs a major portion of direct operating costs, but electricity prices also affect the costs of chemicals used in the bleaching process. Chlorine and caustic soda are produced through an electrolytic process, which is highly electricity intensive.

Nationally, the demand for paper products is expected to be strong, with paper holding its own against petroleum-based plastic products. In addition, the Northwest has the largest inventory of preferred long-fiber softwoods, and access to ports to serve world markets.

The production forecasts for pulp (SIC 2611), paper (SIC 2621) and paperboard (SIC 2631) were based on work performed by Ekono, Inc., for Bonneville. Ekono supplied Bonneville with a range of projections by industry for the region, based on surveys collected from most of the region's companies and its own analysis of fiber availability and cost.[2]

The Northwest Pulp and Paper Association conducted a survey of regional pulp and paper producers in early 1982,[3] requesting information on raw material use in 1980, pulp and paper production and capacity in 1980, and projections of production increases for the next 20 years. Ekono estimated that participating companies represented approximately 75 percent of the installed capacity of pulp, paper and paperboard products in the region. The survey was compiled through Arthur Andersen Company to ensure the privacy of individual companies.

In developing the projections, Ekono relied on the survey results, along with estimates of capacity and production for 1980 and 1981 by product, trends in fiber availability, production costs, and regional market share in domestic and foreign markets. These projections were updated by Ekono in 1985 to reflect data on capacity and production provided by a 1985 Northwest Pulp and Paper Association survey for the years 1982 through 1984. The Ekono forecasts were used to develop the production and employment forecasts

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2./ Aho, William O., Review of Pulp and Paper Industry Forecasting Model, November 11, 1985.

3./ Northwest Pulp and Paper Association, Results of NWPPA/Ekono Survey, Heidi Schultz, April 2, 1982.

shown in this paper. They were updated by a 1988 survey provided by the Northwest Pulp and Paper Association for the years 1985 through 1987. Forecasts for regional production, employment and productivity growth in the pulp and paper industry are shown in Table 1-6.

Table 1-6
Forecasts of Production and Employment
Pulp and Paper Products (SIC 26)
Pacific Northwest
1987 - 2010

	PRODUCTION AVERAGE ANNUAL RATE OF GROWTH (%) 1987-2010			
INDUSTRY	HIGH	MEDIUM-HIGH	MEDIUM[a]	LOW
Pulp (SIC 2611)	1.9	1.6	0.7	0.4
Paper (SIC 2621)	2.6	2.2	1.6	1.4
Paperboard (SIC 2631)	2.0	1.3	1.2	0.5

		EMPLOYMENT (in thousands) 2010			
	1987	HIGH	MEDIUM-HIGH	MEDIUM[a]	LOW
Pulp (SIC 2611	2.1	1.8	1.7	1.4	1.4
Paper (SIC 2621)	13.4	12.2	11.6	11.0	11.0
Paperboard (SIC 2631)	4.9	3.9	3.5	3.7	3.3
Other Paper	7.9	8.9	8.0	7.5	6.6
Total SIC 26	28.3	26.7	24.8	23.7	22.3

Output per Employee
Average Annual Rate of Growth (%)
1987-2010

	HIGH	MEDIUM-HIGH	MEDIUM[a]	LOW
Pulp (SIC 2611)	2.7	2.6	2.4	2.2
Paper (SIC 2621)	3.0	2.8	2.4	2.2
Paperboard (SIC 2631)	3.0	2.8	2.4	2.2

a Medium case used in the medium scenario and medium-low scenario.

The residual category consists of miscellaneous converted paper products (SIC 264), paperboard containers and boxes (SIC 265), and building paper and board mills (SIC 266). These categories include the manufacture of bags, boxes and containers, writing paper, tissue paper and building board at sites where primary products are not produced. Industries within these categories locate close to population centers.

Chemicals

The manufacture of chemicals consumes approximately 12 percent of electricity purchased by the industrial sector in the region. Elemental phosphorus production accounts for approximately half of the electricity consumed by the chemicals industry, followed by chlorine and caustic soda, which accounts for approximately 20 percent. In the Council's forecasting models, the consumption of electricity by these industries is modeled on a plant-by-plant basis. Two of the chlorine and caustic soda plants are direct services industries (DSIs) of Bonneville.

The remainder of the chemicals industry in the region is dominated by nuclear fuels processing and agricultural chemicals (such as fertilizers). The nuclear fuels processing component has exhibited large swings in employment, as policies of the federal government have changed over the last 20 years. The agricultural chemicals component has increased at a steady rate in the last decade, but it is not likely to increase rapidly in the future.

The manufacture of chlorine and caustic soda involves the electrolytic separation of salt into two co-products: chlorine and sodium as sodium hydroxide (caustic soda). Approximately 1.12 pounds of caustic soda are produced per pound of chlorine.

The market outlook for the two products differs substantially. In the past, chlorine has held the stronger market and higher price. Expansion plans were based on growth in chlorine demand. As little as 10 years ago, caustic soda was considered an undesirable "byproduct," and for years producers sought to develop a commercial process to produce chlorine without producing caustic soda. In the last few years, the price of caustic soda has risen and supplies have tightened, while chlorine demand has dropped and prices have remained stable.

Industry experts have predicted growth rates for national chlorine demand to range from an average of 1 percent to 3 percent per year, whereas demand for caustic soda could increase at rates ranging from 2.5 percent to 5 percent. This is slower than the rate of growth in production from 1960 to 1980, which averaged 4.1 percent per year. From 1970 to 1980, however, production increased at an annual rate of only 1.6 percent. The outlook for chlorine has been affected by environmental regulations on effluent standards. Pulp and paper producers may substitute other chemicals in pulp bleaching to reduce emissions. The outlook for caustic soda is much more favorable because it has a broader base of end uses. One of the fastest growing end uses is in the neutralization of waste acids. Tougher environmental standards would enhance the outlook for caustic soda. Soda ash can be substituted for caustic soda, and although the initial investments required to handle soda ash are high, projections of relative price increases for caustic soda and soda ash favor some conversion to soda ash. Production of chlorine and caustic soda is likely to be constrained by the price of chlorine, since chlorine is more difficult to store.

Chlorine and caustic soda are produced at five plants in the region, four located in Washington and one in Oregon. Nationally, over half of the chlorine produced is used within the chemicals industry to manufacture a variety of organic and inorganic chemicals. An additional 13 percent is used by the pulp and paper industry as a bleaching agent in the production of paper. In the Pacific Northwest, a much larger portion of production goes to the pulp and paper industry. In fact, two of the five plants in the region are owned by pulp and paper companies.

The proportion of the product going to the pulp and paper industry in the Northwest varies from 32 percent to 80 percent, depending on the plant and temporary shifts in market conditions. This is a much larger proportion than nationally, although the pattern is similar in the Southeastern U.S. Although not all of the chlorine produced in the region is sold to pulp and paper producers, growth in the production of paper (SIC 2621) was chosen as a reasonable indicator of chlorine and caustic soda production growth. The projections presented here are within the range of projections for national production cited in the preceding paragraphs. Comparison of the production growth rates for chlorine and caustic soda and paper (SIC 2621) shows that the projection for chlorine and caustic soda is 0.4 percent per year higher in the high case to allow for higher rates of growth in other end uses. The medium-case growth rate is similar to the medium rate of growth in paper, and the low case is 0.4 percent per year lower than the low case paper projection to reflect lower rates of growth in other end uses or market penetration by British Columbia producers. Table 1-7 shows projections of production for SIC 2812, chlorine and caustic soda.

Table 1-7
Forecasts of Chemicals Industry Production
Pacific Northwest
1987-2010
Average Annual Rate of Growth (%)

	PRODUCTION				
INDUSTRY	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Chlorine/Caustic Soda (SIC 2812)	3.0	2.2	1.6	1.6	1.0
Elemental Phosphorus (SIC 2819)	1.5	0.9	0.4	0.0	0.0
Other Chemicals (SIC 28XX)	3.0	2.0	1.0	0.5	-0.5

	OUTPUT PER EMPLOYEE				
INDUSTRY	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Chlorine/Caustic Soda (SIC 2812)	3.0	2.2	1.5	1.5	1.5
Elemental Phosphorus (SIC 2819)	1.5	1.0	1.0	1.0	1.0
Other Chemicals (SIC 28XX)	2.5	2.0	1.3	1.0	0.3

Elemental phosphorus production is located in only four states (Idaho, Florida, Montana and Tennessee), near deposits of phosphate rock. Elemental phosphorus is extracted from phosphate rock in electric furnaces, and frequently converted nearby to phosphoric acid and other compounds.

Elemental phosphorus plants are classified under industrial inorganic chemicals, not elsewhere classified (SIC 2819). In the Northwest, firms producing elemental phosphorus, nuclear fuel, corn starch, chemical catalysts and a variety of other products are classified under SIC 2819. About half of total U.S. elemental phosphorus production capacity is located in the Northwest. Of this, 85 percent of capacity is located in Idaho, with the remainder in Montana.

The major end-use markets for elemental phosphorus are cleansers and detergents (45 percent), food and beverages (15 percent), metal treating (10 percent) and other chemicals and cleansers (30 percent). The outlook for elemental phosphorus production in the Northwest depends, in part, on the demand for these products.

The detergent market has been projected to remain stable or increase slightly over the forecast period, with growth rates ranging from 0 percent to 1 percent per year. Non-detergent uses, such as food and beverage products and other uses, have been forecast to increase at rates of 1.4 percent to 2.4 percent per year.

The problems facing elemental phosphorus producers in the region include the cost and availability of electricity and the maturity of their markets. The costs of additional electricity beyond current contracted amounts may lead to no expansion in capacity over the forecast period. This was assumed to be the case for the low scenario. The high case projection is a weighted average of the higher ranges of forecasts for detergent and non-detergent uses of elemental phosphorus. Projections of production are shown in Table 1-7.

The residual category for chemicals (SIC 28XX) includes a wide variety of products manufactured in the region. The larger groups in employment and energy use are the nuclear engineering, fuels and waste processing segments, and agricultural chemicals (primarily fertilizers and pesticides). There also are many other types of chemical products manufactured in the region. The forecasts for the other chemicals category are shown in Table 1-7.

The forecast range for the region can be compared to national forecasts for the chemicals industry. Wharton's forecast for chemicals range from 2 percent to 3 percent growth in output from 1987 to 2008. The forecasts for the region are lower because of the slower growth forecast for the agricultural chemicals and the nuclear fuels processing segments of the regional industry.

Agriculture and Food Processing

Over the past decade, agriculture has adjusted to changes in the national economy, federal programs and international markets. Northwest agriculture and food markets are increasingly national and international. Increasing sales of farm products from the Midwest and Northeast to large East Coast markets has put more pressure on Northwest producers to sell overseas, primarily in the Orient. A comprehensive study of Northwest agriculture concluded that if Northwest agriculture is to experience reasonable growth, it must continue to develop foreign markets. Regional agriculture has been fairly successful in doing so.

Agricultural production supports a large food processing industry. In 1987, some 72,400 persons were employed in food and kindred products (SIC 20), which represented 12 percent of regional manufacturing jobs. Activity in this industry is concentrated in frozen and canned fruits and vegetables (SIC 203), which accounted for nearly half of the employment in food and kindred products and over half of food processing electricity consumption. Processed potatoes are the major products in this category, accounting for over half of the value added in the regional food processing industry. Another portion of the industry important to coastal areas is the seafood canning and freezing industry. Poor commercial fishing conditions have closed a number of these plants.

The outlook for employment in frozen and canned fruit and vegetable products relies on future demand for processed foods in the United States and Pacific Rim countries. Changes in consumer lifestyle and preferences have prompted the industry to seek specialized market niches. The recession of the early 1980s forced most food manufacturers into more efficient use of labor, management and energy. These changes have become permanently incorporated into the industry structure and are important in the forecasts. The projections of employment in food processing for the region are shown in Table 1-8. Only the high case shows an increase in regional food processing employment.

Table 1-8
Forecasts of Employment
Food Processing
Pacific Northwest
1987-2010

	EMPLOYMENT (in thousands)		AVERAGE ANNUAL RATE OF GROWTH (%)
	1987	2010	1987-2010
Food Processing			
High		77.9	0.3
Medium-high		71.4	-0.1
Medium	72.3	65.9	-0.4
Medium-low		60.3	-0.8
Low		54.6	-1.2

The High-Technology Industries

A great deal of attention has been focused of late on the so-called high-technology industries. State and local governments in the U.S. and national governments around the world have initiated studies and programs designed to understand and attract economic development through encouraging growth in high-technology industries. In past years, the growth of electronics and software firms has been heralded by some as a panacea for stagnation in some of the region's resource-based industries.

The first step in a discussion of high-technology industries is to define the group of industries to be discussed. Several methods of defining high technology have been proposed, but general agreement does not exist on which definition is the most appropriate. To a certain extent, the nature of technology-intensive activity makes definition difficult, because the industries are changing so rapidly. New industries are created and others become obsolete, thus causing any definition of high-technology industries to be tied to a particular point in time.

Most definitions have looked at one or a combination of three factors: research and development expenditures as a proportion of value added, the percentage of scientific and technical personnel in industry employment, and product sophistication. The definition described in this chapter was adopted from a Battelle study[4] for the state of Washington and reflects a combination of all three factors. The

4./ Battelle Seattle Research Center, High Technology Employment, Education and Training in Washington State, June 1984.

Battelle study included a number of chemical industries in its definition of high-technology industries. These industries were excluded from the definition of high-technology industries used in this chapter. The chemical industry forecasts have been discussed in a previous section. The modified list of industries included in the high-technology groups and their SIC codes are shown in Table 1-9.

Even at the level of industry detail shown in Table 1-9, it is difficult to categorize industries as high-technology industries. At more detailed levels of categorization, however, data are not available to analyze the industries because of disclosure laws that protect companies' rights to proprietary information. In the U.S., the industries listed in Table 1-9 comprised approximately 5.3 percent of total wage and salary employment in 1985, compared to 5.5 percent for the region. The high-technology share of total employment was 7.0 percent in Washington, 4.5 percent in Oregon, 4.5 percent in Idaho, and 0.5 percent in the state of Montana.

Table 1-9
High-Technology Industries

SIC CODE	INDUSTRY NAME
	Machinery
351	Engine and Turbines
357	Office, Computing and Accounting Machines
	Electrical Equipment
361	Electric Transmission and Distribution Equipment
362	Electrical Industrial Apparatus
365	Radio and Television Receiving Equipment
366	Communication Equipment
367	Electronic Components and Accessories
369	Miscellaneous Electrical Machinery
	Transportation Equipment
372	Aircraft and Parts
376	Guided Missiles and Space Vehicles and Parts
	Professional Instruments
381	Scientific Instruments
382	Measuring and Controlling Instruments
383	Optical Instruments
384	Medical and Dental Instruments
386	Photographic Equipment and Supplies
	Business Services
737	Computer and Data Processing Services
7391	Research and Development Laboratories

In 1985, high-technology industries employed 143,650 persons in the region, with approximately 40 percent of the employment concentrated in the transportation equipment category. The second largest category was electrical equipment, with 21.8 percent, followed by professional instruments, with 14.4 percent of high-technology employment. Table 1-10 shows employment in 1985 by state for the major high-technology groupings.

Table 1-10
Employment in High Technology Industries, 1985

	UNITED STATES	PACIFIC NORTHWEST	WASHINGTON	OREGON	IDAHO	MONTANA
Machinery	541,700	14,900	5,550	5,900	3,450	0
(SIC 351, 357)						
Percent of high-tech	12.6%	10.4%	5.9%	15.8%	30.5%	0.0%
Electrical Equipment	1,783,600	31,300	13,700	13,600	3,525	475
(SIC 361, 362, 365, 366, 367, 369)						
Percent of high-tech	41.6%	21.8%	14.6%	36.3%	31.2%	43.2%
Transportation Equipment	733,900	56,975	55,350	1,600	25	0
(SIC 372, 376)						
Percent of high-tech	17.1%	39.7%	59.0%	4.3%	0.2%	0.0%
Professional Instruments	575,900	20,650	8,050	12,100	300	200
(SIC 381, 382, 383, 384, 386)						
Percent of high-tech	13.4%	14.4%	8.6%	32.3%	2.7%	18.1%
Business Services	656,000	19,825	11,150	4,250	4,000	425
(SIC 737, 7391)						
Percent of high-tech	15.3%	13.8%	11.9%	11.3%	35.4%	38.6%
Total High-Tech	4,291,100	143,650	93,800	37,450	11,300	1,100
Percent of Total Employment	5.3%	5.5%	7.0%	4.5%	4.5%	0.5%
TOTAL EMPLOYMENT	81,119,300	2,623,800	1,336,700	830,500	253,000	203,600

SOURCES: U.S. Census Bureau County Business Patterns, 1985. The employment figures shown in this table are based on a survey of employment during the pay period including March 12. As such, they are not comparable to annual average data used in other segments of this report. They are used for illustration purposes here because they are available at the level of industry detail needed.

The aerospace industry in the region is dominated by The Boeing Company, which has production facilities in Washington and Oregon. Aerospace employment in Washington has been extremely cyclical, dropping from 104,000 in 1968 to 40,000 by 1971. In 1981, it reached a level of 80,900, only to drop to 65,000 by 1983. From 1983 to 1987, aerospace employment increased more than 40 percent.

From 1970 to 1985, the high-technology industries increased employment at an average annual rate of 3.2 percent. This compares to a national growth rate of 2.3 percent over the same period. Removing aerospace from the calculation shows that non-aerospace high-technology employment increased at an average annual rate of 10.3 percent in the region, compared to a national rate of 3.2 percent.

The factors often cited as favorable for the region's growth in high technology include the quality of the region's labor force, available land, good educational facilities and an environment suitable for maintaining a high quality of life. A survey of high-technology companies regarding location factors was completed by the Congressional Joint Economic Committee in 1982. The results are shown in Table 1-11. The existing concentration of firms in the region also testifies to the importance of spin-off activity from Pacific Northwest firms and California firms.

Table 1-11
Factors That Influence Regional Location of High-Technology Companies

FACTOR	PERCENTAGE OF FIRMS CITING FACTORS AS SIGNIFICANT OR VERY SIGNIFICANT
Labor Skills and Availability	89.3
Labor Costs	72.2
Tax Climate	67.2
Academic Institutions	58.7
Cost of Living	58.5
Transportation	58.4
Access to Markets	58.1
Regulatory Practices	49.0
Energy Costs and Availability	41.4
Cultural Amenities	36.8
Climate	35.8
Access to Raw Materials	27.6

NOTE: Firms were asked to rate each factor as very significant, significant, somewhat significant, or not significant.

SOURCE: U.S., Congress, Joint Economic Committee. Location of High Technology Firms and Regional Economic Development, 1 June 1982, p. 23.; and from Battelle Seattle Research Center, High Technology Employment, Education and Training in Washington State, June 1984.

The factors often cited as unfavorable for the region's growth in high-technology industries include high labor costs, unfavorable tax policies, and complex regulatory practices that make it difficult to expand or locate facilities. There is also some question as to the region's commitment to improving or maintaining the quality of its educational systems in light of tax revolts and state and local budget crises. Many states and cities in the United States are competing aggressively to attract high-technology industries. Some areas of the country, such as New England and North Carolina's Research Triangle Park, enjoy advantages in their traditions of high-quality academic institutions.

Forecasts of employment for high-technology industries are shown in Table 1-12. The table shows forecasts for industries at the two-digit SIC level, which includes some businesses that are not classified as high-technology industries. Electrical equipment and professional instruments are the only categories in which nearly all of the employment is in the high-technology category. In machinery and business services, only 39 percent and 19 percent, respectively, of the employment are in the high-technology industries.

Table 1-12
Forecasts of Employment
High-Technology Industries
Pacific Northwest
Average Annual Rate of Growth (%)
1987-2010

	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Machinery (SIC 35)	3.5	2.4	1.8	1.1	0.2
Electrical Equipment (SIC 36)	3.5	2.1	1.4	0.7	0.0
Transportation Equipment (SIC 37)	1.2	0.4	-0.3	-1.0	-2.0
Professional Instruments (SIC 38)	3.0	2.2	1.5	0.8	-0.3
Business Services (SIC 73)	5.0	4.2	3.7	3.2	1.9

A rapidly growing sector of the machinery industry in the region has been the computer machinery category. Much of the remainder of the machinery industry is farm, construction, logging and other heavy machinery. These categories are not forecast to grow rapidly.

Aerospace employment, which is dominated by the Boeing Company, accounts for 75 percent of employment in the transportation equipment industry in the region. Commercial aircraft production represents the largest portion of production in the region. During the recent recession, annual average employment in aerospace declined almost 20 percent. Commercial aircraft orders had dropped substantially because of low profits in the airline industry and declines in passenger miles. Since then, Boeing has increased employment over 40 percent as orders increased, in response to improvements in economic conditions and the financial condition of airlines. Its primary competition is Airbus Industrie, a European aircraft consortium. The market for commercial aircraft is projected to be strong, although it will probably continue to be highly cyclical. Because employment in this category is dominated so much by one company, the forecasts encompass a wide range of uncertainty.

Other Manufacturing Industries

There are a number of smaller manufacturing industries that play a relatively minor role with respect to employment and electricity use in the region. The largest of these industries include printing and publishing, fabricated metals, and stone, clay and glass products. Recently, printing and publishing employment has increased rapidly, largely because of growth in the demand for computer software manuals and industry changes spurred by advances in desk-top publishing systems. The fabricated metals and stone, clay and glass industries are projected to grow slowly, in line with national trends. The forecasts for these industries are shown in Table 1-B-2 of Appendix 1-B.

Growth in Non-manufacturing Industries

Employment in non-manufacturing has grown faster in the last two decades than employment in manufacturing. Table 1-13 shows the shares of total employment by industry for the region and the United States. Non-manufacturing employment accounted for 83.9 percent of total employment in the region in 1987. The largest category of non-manufacturing employment in the region is wholesale and retail trade, followed by services (which includes such industries as health care, business services, and personal services). The third largest non-manufacturing industry is government.

Table 1-13
Total Employment Shares
U.S. and the Pacific Northwest
Percent of Total (%)

	PACIFIC NORTHWEST		U.S.	
	1970	1987	1970	1987
Total Employment	100.0	100.0	100.0	100.0
Manufacturing	20.5	16.1	25.1	18.1
Non-manufacturing	79.5	83.9	74.9	81.9
Mining	0.5	0.2	0.8	0.7
Agriculture	9.0	7.9	4.3	2.9
Construction	4.3	3.9	5.1	4.8
Transportation and Public Utilities	6.2	5.0	5.8	5.2
Wholesale and Retail Trade	20.6	22.9	20.7	22.8
Finance, Insurance and Real Estate	4.6	5.5	5.0	6.3
Services	14.3	19.8	16.0	22.9
Government	20.0	18.7	17.1	16.3

The growth in the non-manufacturing sectors has occurred at the national level, as well as at the regional level. A larger proportion of manufactured goods are produced in other countries, which has had a negative impact on the proportion of employment in manufacturing. Productivity gains in the past have occurred to a greater extent in manufacturing industries, and this has lowered employment relative to output. Computerization of some activities could lead to higher productivity gains in non-manufacturing, however.

A closer look at specific industries may add some insight into the growth in the non-manufacturing sectors. The services industry was the fastest growing industry in the region from 1970 through 1985, increasing employment at 5.4 percent per year. In 1985, health services accounted for 33 percent of the region's employment in services. Employment in health services increased at an annual rate of 5.4 percent from 1970 through 1985. Growth in this sector resulted from the expansion of health-care benefits for workers and elderly people and growing public interest in personal health.

The second largest service category, business services, accounted for 16 percent of the region's employment in services. This category was among the fastest growing sectors in services, increasing employment at an annual rate of 7.2 percent. This category includes a diverse group of industries, such as computer and data processing services, advertising agencies, building services companies, and personnel agencies.

Although it only accounted for 3 percent of services employment in 1985, the legal services industry was the fastest growing among services industries. Employment increased at an annual rate of 9.0 percent from 1970 through 1985.

Employment in construction increased 2.4 percent per year from 1970 through 1985. Even so, construction employment has not yet recovered to pre-recession levels, as a result of slower population growth and the cancellation or delay of construction on nuclear power plants.

The finance, insurance and real estate sector increased employment at an average annual rate of 3.6 percent from 1970 through 1985. The most rapidly growing sectors in this industry were investment offices and credit agencies (other than banks). Deregulation of the financial industry has led to the creation of a wide range of services by a diverse group of businesses. The combination of deregulation, high interest rates, and loan defaults has put a great deal of strain on financial institutions. This may result in an industry shakeout in the next few years, accompanied by slower employment growth.

Wholesale and retail trade accounted for the largest share of total employment in 1987, as shown in Table 1-13. Wholesale trade accounted for approximately one-fourth of employment in trade and increased at an annual rate of 2.7 percent from 1970 through 1985. Employment in retail trade increased at a rate of 3.6 percent per year during the same period.

Eating and drinking establishments accounted for 35 percent of employment in retail trade. This was also the fastest growing category of employment in retail trade, increasing at an annual rate of 6.0 percent from 1970 through 1985. The increase in household consumption of food away from home reflects the increase in household income and the increase in the participation of women in the labor force. A larger proportion of household budgets for persons aged 25 to 44 is spent on food away from home than for other groups. Since this age group is growing slower in the future than it has over the last 20 years, the rate of employment growth in this sector is expected to slow.

Other fast-growing retail-trade categories included apparel and accessory stores and miscellaneous retail stores, which includes sporting-goods stores and mail-order houses. Employment in these categories increased at average annual rates of 4.0 percent and 4.2 percent, respectively, from 1970 through 1985.

The public sector was the third largest employment category in the region in 1987, as shown in Table 1-13. State and local government accounted for more than 80 percent of employment in government. From 1970 through 1985, employment in the federal government increased 1.4 percent per year, while state and local government employment increased 3.2 percent per year. Education accounts for the largest proportion of state and local government employment. Since 1981, cutbacks in federal, state, and local budgets have led to decreases in public-sector employment. The outlook for future employment changes in this sector depends on the level of population growth and policy decisions.

Employment in transportation, communications and public utilities increased at an annual rate of 2.3 percent from 1970 to 1985. The fastest-growing category was transportation services, which include travel agencies, freight forwarding services, and shipping agents and brokers. Employment in transportation services increased at an average annual rate of 9.7 percent from 1970 to 1985. The largest categories of transportation and public utilities employment in 1985 were motor freight transportation and warehousing, and communication services, with 29 percent and 32 percent respectively. Motor freight transportation and warehousing employment increased at an average annual rate of 3.3 percent. Employment in communications increased at an average annual rate of 2.1 percent.

The discussion of non-manufacturing industries presented thus far has centered on industries as defined by the Standard Industrial Classification (SIC) system. Industries such as the travel industry and port activity are not separated from other economic data to allow historical analysis of their importance to the regional economy.

The travel industry, which includes tourism and business travel, has impacts on retail trade sectors, such as eating and drinking places, retail stores and service stations. It has an impact on transportation industries, such as transportation services, and air or rail transportation. It has an impact on the services industry, which includes hotels and lodging places, personal services, and amusement and recreation services. It also has an impact on the government sector, through parks and recreation, national parks, national and state forests, and the highway system. Because all of these services are consumed by the local population as well as out-of-state travelers, it is difficult to measure the impact of the travel industry on the economy.

Nevertheless, the travel industry is an important activity in the region. The beauty and diversity of the region's natural environment provide opportunities for a variety of recreational activities. Factors that will aid the growth of the travel industry in the future include increases in real income and changes in the age composition of the population. State and local governments in the region have developed programs to promote tourism and conventions, which will add to the industry's growth.

Another economic activity that appears to have increased in importance is port activity related to trade with Alaska and other countries. The expansion of the economies of the Pacific Rim countries and the region's proximity to these countries point to increased trade and transportation activity. The employment impacts are difficult to measure because they are spread across a number of SIC categories. Port activity has an impact on the transportation, wholesale trade, services, and financial industries. It has an impact on manufacturing industries as well, by providing markets for goods produced in the region. A study by the Port of Seattle[5] showed a direct impact of 55,800 jobs resulting from the harbor and airport facilities. This estimate was for 1982, which was a year of worldwide economic slowdown. In addition, the estimate included jobs in King County only, which would underestimate the impact of the port on the state of Washington and the region.

In recent years, more attention has focused on the non-manufacturing industries as an increasing source of jobs to the economy. The traditional approach to understanding regional economic development emphasized manufacturing, agriculture and extractive industries as the basis for economic growth. Other industries were treated as secondary, providing support services to these industries and to the local population. A recent study of the services sector in the central Puget Sound region[6] disputes this approach. The study interviewed firms from selected industries in the services sector and estimated that approximately one-third of the employment in these industries is linked to export markets. The study points out many areas where the dynamics of location and growth of non-manufacturing industries have remained largely unexplored.

In developing its range of forecasts of employment growth in the non-manufacturing industries, the Council and Bonneville have relied on national forecasts developed by Wharton and the Bureau of Labor Statistics, comparing them to historical regional growth rates by industry. Table 1-14 shows a comparison of the forecasts of non-manufacturing employment by industry with historical growth rates.

5./ Port of Seattle, 1982 Economic Impact Study, October 1984.

6./ Beyers, William B., Alvine, Michael J., and Johnsen, Erik G., The Service Economy: Export of Services in the Central Puget Sound Region, Central Puget Sound Economic Development District, April 1985.

Table 1-14
Non-manufacturing Employment Projections
Pacific Northwest
Average Annual Rate of Growth (%)

		1987-2010				
	1970-1985[a]	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Construction	2.4	3.1	2.6	1.7	1.0	0.7
Transportation, Communications and Public Utilities	2.3	1.9	1.1	0.7	0.4	-0.3
Trade	3.3	3.5	2.8	2.3	1.8	1.0
Wholesale Trade	2.7	3.3	2.7	2.2	1.7	1.0
Retail Trade	3.6	3.5	2.8	2.3	1.8	1.0
Food Stores	3.8	3.1	2.3	1.7	1.1	0.5
Eating and Drinking Places	6.0	4.1	3.6	3.2	2.9	1.8
Finance, Insurance and Real Estate	3.6	3.4	2.6	2.1	1.5	0.7
Services[b]	5.4	4.0	3.1	2.5	2.1	1.2
Hotels and Lodging Places	2.5	3.2	2.9	2.4	2.0	0.7
Business Services	7.2	5.0	4.2	3.7	3.2	1.9
Health Services	5.4	4.2	3.4	2.5	2.2	1.3
Government	1.8	2.6	1.9	1.3	0.7	0.2
Federal Government	1.1	1.9	1.3	0.8	0.4	-0.2
State and Local Government[c]	2.0	2.7	2.0	1.4	0.8	0.2

[a] Historical data is based on County Business Patterns. The employment figures shown in this table are based on a survey of employment during the pay period including March 12. As such, they are not comparable to annual average data used in other segments of this report. They are used for illustration purposes in this table and in the text because they are available at the level of industry detail needed.

[b] Forecast excludes Educational Services, SIC 82.

[c] Forecast includes Educational Services, SIC 82.

Changes in Productivity Growth

The early phases of an economic recovery often show large gains in productivity. The conditions may exist at this time, however, for a more sustained growth in labor productivity in the U.S. that could last well beyond the cyclical impacts of recession and recovery. Some of the factors encouraging higher productivity growth were brought about by the recession. Intense foreign competition and a high value of the U.S. dollar against foreign currencies in the early 1980s put downward pressure on prices. Efforts to increase profitability have focused on improving productivity.

Over the long-term, demographic factors will have an impact on productivity growth. With the maturation of the baby-boom generation, there will be fewer young, inexperienced workers in the labor force.

The impact of developments in high technology is just beginning to be observed in office automation, robotics, electronic technology and telecommunications. Spurred by foreign competition and tempted by numerous success stories, U.S. companies are turning to new technology to remain competitive in world markets.

Two factors that may have dampened productivity growth in the 1970s may contribute to productivity growth in the 1980s by their absence. These are energy price shocks and new federal regulations. The costs of adjusting to higher prices and higher environmental standards diverted funds from investments that contribute more directly to measures of productivity. These factors are not likely to be as prominent in the near future.

Table 1-15 shows rates of growth in real output per employee for all industries and for manufacturing. As shown, productivity growth in the 1970s was slow compared to previous decades. Wharton's forecasts for the next 20 years show a continuation of the rapid trends established in the 1950s and 1960s. Table 1-A-4 of Appendix 1-A shows productivity forecasts by industry for manufacturing industries.

Table 1-15
Real Output Per Employee, U.S.
Average Annual Rate of Growth (%)

YEARS	ALL INDUSTRIES	MANUFACTURING
1953-1963	1.9	2.6
1963-1973	1.8	3.1
1973-1983	0.3	1.8
1983-1987	0.8	3.5

	ALL INDUSTRIES			MANUFACTURING		
FORECAST	HIGH	BASE	LOW	HIGH	BASE	LOW
1987-2007	1.6	1.4	1.1	3.4	3.3	3.1

Population, Households and Housing Stock

Total population in the region was 8.0 million in 1980. Regional population increased at an average annual rate of 2.2 percent from 1970 to 1980, more than twice the rate of U.S. population growth (1.0 percent) in the same period. Population growth in the region was more than one-third faster in the 1970s than during the 1950s and 1960s. Idaho was the fastest growing state in the region during the 1970s, although it was the slowest growing in the 1960s. Table 1-16 summarizes historical data on population and households.

Table 1-16
Total Population and Households

	TOTAL POPULATION (Thousands)			AVERAGE ANNUAL RATE OF GROWTH(%)	
	1960	1970	1980	1960-70	1970-80
Washington	2,853.2	3,409.2	4,132.2	1.80	1.94
Oregon	1,768.7	2,091.4	2,633.1	1.69	2.33
Idaho	667.2	712.6	944.0	0.67	2.85
Western Montana	231.7	253.5	294.5	0.90	1.51
PNW	5,520.8	6,466.7	8,003.8	1.59	2.16
U.S.	180,671.0	204,878.0	227,020.0	1.27	1.03

	TOTAL HOUSEHOLDS (Thousands)			AVERAGE ANNUAL RATE OF GROWTH(%)	
	1960	1970	1980	1960-70	1970-80
Washington	894.0	1,106.0	1,540.5	2.15	3.37
Oregon	558.0	692.0	991.6	2.18	3.66
Idaho	194.0	219.0	324.1	1.22	4.00
Western Montana	70.0	79.0	106.4	1.25	3.47
PNW	1,716.0	2,096.0	2,962.6	2.02	3.52
U.S.	53,021.0	63,450.0	80,377.0	1.81	2.39

Persons per Household
(Total Population/Total Households)

	1960	1970	1980
PNW	3.22	3.09	2.70
U.S.	3.41	3.23	2.82

The number of households in the region and the nation grew at a higher rate than population. Although population growth was slower nationally in the 1970s than in the 1960s, because of lower birth rates, growth in the number of households was considerably higher in the later decade. During the 1970s, the baby-boom generation reached the 20-29 year age group, where household formation rates are high. Smaller families also became more common.

Householder rates, or the proportion of the population in an age group designated to represent a household, increased rapidly with the rise in divorce rates and single-person households. In the 1970s, householder rates have increased dramatically for females over the age of 65, as more women in this group have maintained their own household, rather than move in with family or to group quarters. In addition, women in the 20-29 age group have maintained households at a higher rate. The combination of shifts in age composition and of changes in householder rates has lowered average household size in the region from 3.1 in 1970 to 2.7 in 1980.

There were 2.963 million occupied housing units in the region in 1980. Results from the 1980 U.S. Census indicated that approximately 78 percent of the occupied housing stock was single-family units (1-4 units per building). An additional 14 percent was multifamily units, and 8 percent were manufactured homes.

In the four ranges, the forecast for population is derived from the forecast of total employment through an average employment-population ratio. Changes in the employment-population ratio reflect changes in labor force participation, unemployment rates and age composition of the population. The proportion of women in the labor force increased rapidly in the 1960s and 1970s. From 1960 to 1987, the percent of women in the labor force increased from 37 percent to 57 percent. The employment-population ratios in this forecast incorporate the impacts of continued increase in female labor-force participation, although at slower rates than in the past. The range of projections was based on national trends as forecast by Wharton and the U.S. Bureau of Labor Statistics. Changes in employment-population ratios implied in the national forecasts were tracked in the state-level forecasts, maintaining historical differences between the state and national ratios. Table 1-A-1 in Appendix 1-A shows employment-population ratios for each state for the ranges.

The forecast for total households is obtained from the forecast of population after dividing by average household size. Changes in average household size reflect changes in the age composition and householder rates. The projections are based on national trends as forecast by the U.S. Bureau of the Census. The high and medium cases assume that householder rates will continue to increase, but at much slower rates than in the 1970s. This results in part because of increases in the relative cost of housing and in a slowing of increases in the divorce rate. The low case assumes that householder rates do not increase, but average household size decreases slightly because of changes in age composition. Average household size projections by state for the ranges are shown in Table 1-A-2 of Appendix 1-A.

Table 1-17 shows the forecasts of population and households that result from the assumptions described. Change in the housing stock is the result of change in total households plus replacement of existing units. The proportion of new housing units by type is projected for each state. Table 1-A-3 in Appendix 1-A shows the proportion of housing additions by type for each state and scenario. Changes in the stock of housing by type are shown in Table 1-18.

Table 1-17
Forecast of Population and Households
Pacific Northwest
1987-2010

SCENARIO	1980	1987	2010	AVERAGE ANNUAL RATE OF GROWTH(%)
Total Population (in thousands)				
High			13,528.8	2.0
Medium-high			12,032.2	1.5
Medium	8,003.7	8,530.7	11,116.5	1.2
Medium-low			10,407.9	0.9
Low			9,451.1	0.4
Total Households (in thousands)				
High			6,149.6	2.7
Medium-high			5,182.0	2.0
Medium	2,962.6	3,305.5	4,786.8	1.6
Medium-low			4,481.1	1.3
Low			3,648.6	0.4

Table 1-18
Housing Stock Projections
Pacific Northwest
1980-2010
Share of Occupied Housing Units (%)

		2010				
	1980	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Single-family (1-4 units)	77.8	77.0	72.5	71.0	69.7	69.4
Multifamily (5 and more)	14.4	15.2	17.2	18.3	19.2	20.7
Manufactured Homes	7.8	7.8	10.3	10.7	11.1	9.9

Personal Income

Real per capita income is an important input to many econometric models of energy demand. It plays a far less critical role in the more structural end-use models used by the Council. The only sector it affects directly is the residential sector, where it influences the penetration rate of certain types of appliances, and the long-run expected use of appliances. In 1980, the personal income per capita of the Pacific Northwest was $10,351. That was 4.4 percent greater than the U.S. average of $9,916.

Table 1-19 shows historical and forecast growth of real personal income per capita in the Pacific Northwest and for the United States. During the 1960s, income per capita increased at a slightly slower rate in the region than in the United States. In fact, the region's real income per capita dipped below the United States in 1970. Income per capita increased faster in the region than in the United States during the 1970s. Over the entire 20-year period from 1960 to 1980, the region's per capita income increased at almost the identical rate as the United States average. From 1980 to 1987, real income per capita increased at a slower rate in the region than in the United States. The forecasts for 1987 to 2010 are shown in Table 1-19 as well.

Table 1-19
Growth Rates of Real Income per Capita
Average Annual Percent (%)

	PACIFIC NORTHWEST	UNITED STATES
Historical		
1960-70	2.9	3.2
1970-80	2.7	2.2
1980-87	0.9	1.7
Forecast 1987-2010		
High	2.9	2.0
Medium	1.8	1.6
Low	1.2	1.2

Alternative Fuel Prices

Assumptions about the future prices of natural gas, oil, and coal are important determinants of demand for electricity. These fuel price assumptions are important for two reasons. First, because these fuels are alternatives to electricity in many uses of energy, their prices will affect the demand for electricity. This is particularly true for the residential and commercial sectors, where electricity, natural gas and oil compete for space heating, water heating, air conditioning and cooking.

The second reason that fuel prices are important is that they are highly uncertain. In the last 19 years, crude oil prices have varied between a low of less than $3 per barrel in 1970 and a high of $37 per barrel in 1981.

Electricity demand forecasts are less sensitive to fuel prices than to economic activity. Sensitivity tests show that reducing fuel prices by one-half would reduce electricity demand by less than 5 percent. Nevertheless, the large uncertainty about fuel prices causes them to be a substantial factor in the risks facing electricity planning.

The forecasts of fuel prices reflect an assumption that natural gas prices will tend to follow oil prices in the long run. This occurs through the competition between residual oil and interruptible natural gas in the industrial sector boiler markets. Coal is not currently competitive in industrial markets in the Northwest; however, as oil and natural gas prices rise, coal could become a third competitor in the industrial market.

Prices of oil products, such as heating oil or gasoline, follow world crude oil prices. Thus, assumptions about world crude oil prices are the starting point for forecasts of alternative fuel prices. Shortly after the Council's 1986 plan was published, world oil prices collapsed to less than half their previous levels. This event demonstrated, in many analysts' minds, that oil prices more than $30 per barrel are not sustainable for long. At the same time, the relatively quick rebound of oil prices from their 1986 low back to $17 has led some to conclude that prices in the range of $17 to $20 may represent a sustainable range.

Nearly all analysts agree that prices are likely to be volatile. Events in the Middle East could cause prices to move temporarily above or below the proposed range of assumptions. The potential for such volatility is not reflected in the proposed assumptions. Instead, the assumptions are meant to bracket alternative trends in oil prices about which fluctuations would likely occur.

The range of world oil price assumptions proposed in this paper encompasses the recent forecasts of many analysts. The range is illustrated in Figure 1-3 and Table 1-20. Figure 1-3 also illustrates the historical pattern of oil prices from 1970 to 1987, including the large increases of 1973 and 1979 and the collapse in 1986. It is also clear from Figure 1-3 that the real oil price decreased dramatically between 1981 and 1985 even though that decrease did not cause the stir that resulted from the 1986 collapse.

Table 1-20
World Oil Prices (1988 dollars per barrel)

	LOW	MEDIUM-LOW	MEDIUM	MEDIUM-HIGH	HIGH
Prices					
1987	18	18	18	18	18
2000	16	21	28	32	45
2005	16	22	31	38	51
2010	16	22	34	42	56
Growth Rates					
1987-2010	-0.5	0.9	2.8	3.8	5.1

The medium forecast shows real world oil prices (in 1988 dollars) growing gradually about 2.8 percent per year from current levels, reaching $34 per barrel by the year 2010. The range about this medium forecast reflects a judgment that there is slightly more risk on the high side than the low side. In 2010 the high oil price is $22 above the medium, while the low oil price is $18 below the medium.

The low forecast assumes further collapse of prices and assumes they recover to only $16 per barrel, in January 1988 prices, by the end of the century and remain at that level. This scenario would be consistent with very favorable oil and natural gas supplies combined with significant progress in improved energy efficiency even with low price incentives. Under such conditions, the Organization of Petroleum Exporting Countries (OPEC) would not be able to exercise effective control of world oil markets.

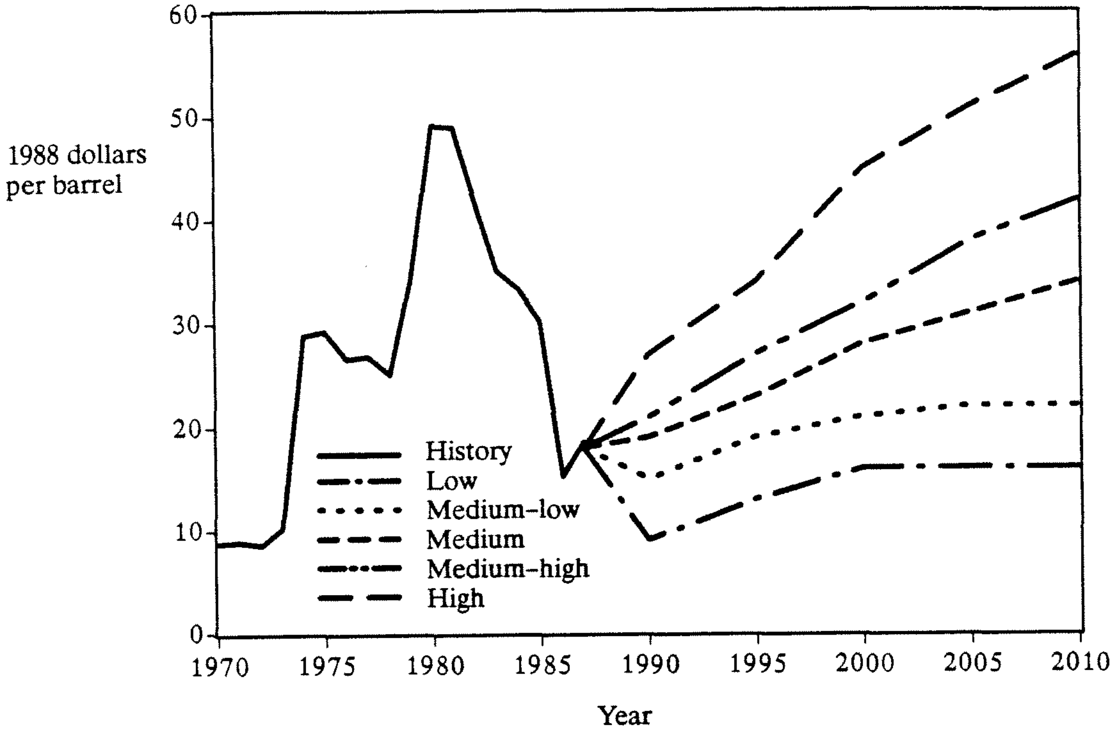

Figure 1-3
World Oil Prices
History and Forecast Range to 2010

In the high scenario, per barrel prices recover into the mid-20s by 1990 and continue to make significant real gains reaching $56 by 2010. Such a future could be consistent with OPEC having a fairly secure control of oil markets. That could happen if new oil and gas discoveries are disappointing and efficiency improvements are slow in being realized. The medium-low and medium-high forecasts bound a more likely long-term range that spans from $22 to $42 per barrel in 2010.

The range of oil price assumptions is significantly lower than those used for the Council's 1986 Power Plan. Figure 1-4 compares the new assumptions with the Council's 1986 plan range, which is shown with dashed lines. The medium forecast is close to Bonneville's 1986 medium forecast assumptions for the later years but is lower for the early years. The high and low assumptions are each well below Bonneville's 1986 respective high and low forecasts. Figure 1-5 compares the new assumptions to the Bonneville range for its 1986 forecast.

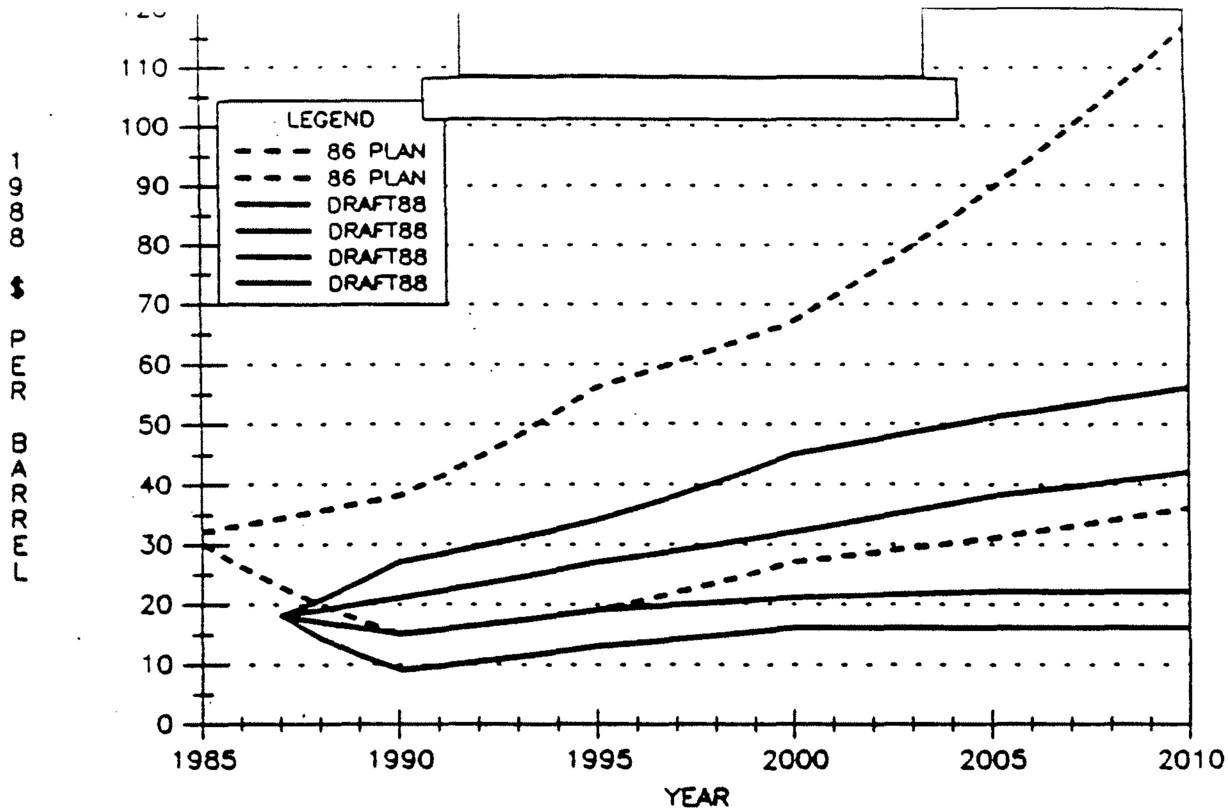

Figure 1-4
World Oil Prices
Compared to Council's 1986 Plan

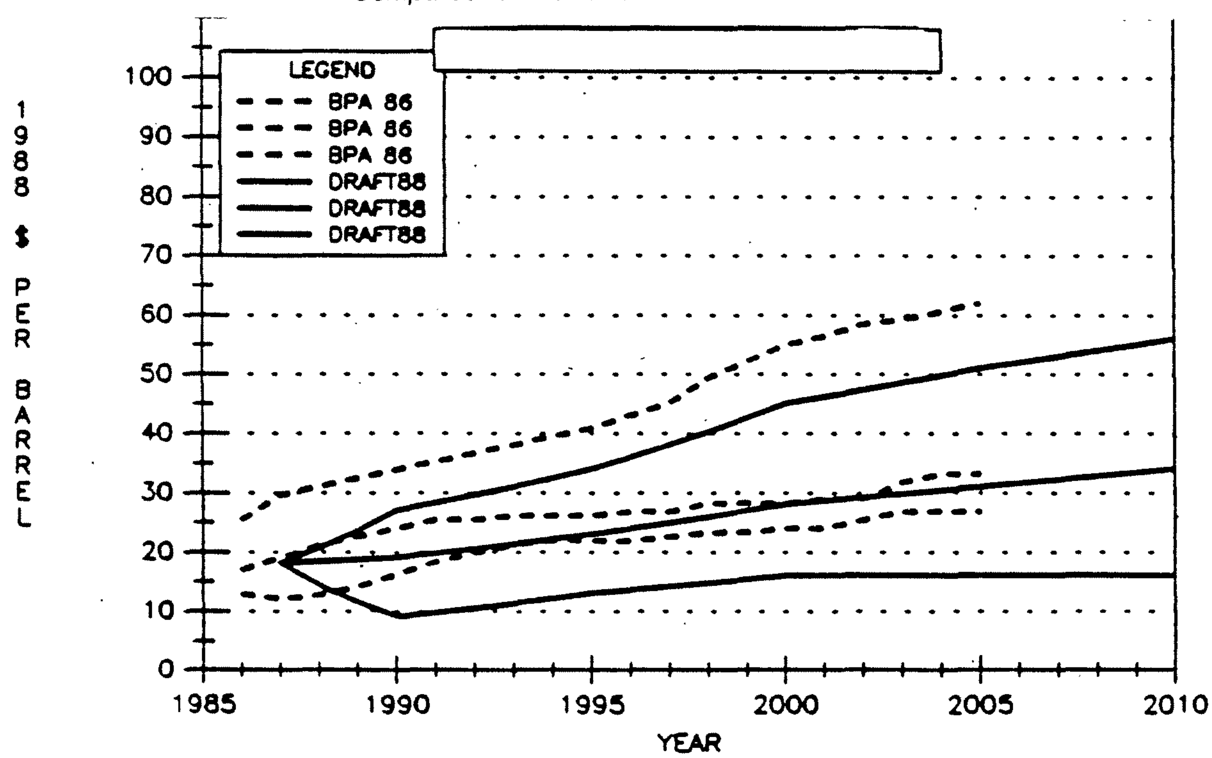

Figure 1-5
World Oil Prices
Compared to Bonneville's 1986 Forecast

The relative forecasts of crude oil prices and the retail prices of fuels are illustrated for the industrial sector medium forecast in Figure 1-6. Industrial residual oil prices move with crude oil prices. Industrial natural gas prices also move with crude oil prices but only after 1990, as the current surplus of natural gas is absorbed by growing demand. Coal prices are currently set at a floor that approximates the cost of coal production. There is currently a large amount of excess capacity in Western coal mining. This large surplus, combined with slow growth in coal demand, serves to keep coal prices depressed. Only in the later years of the higher oil price scenarios is there significant strengthening of coal prices.

Tables in Appendix 1-C summarize the fuel price forecasts for each sector and fuel type.

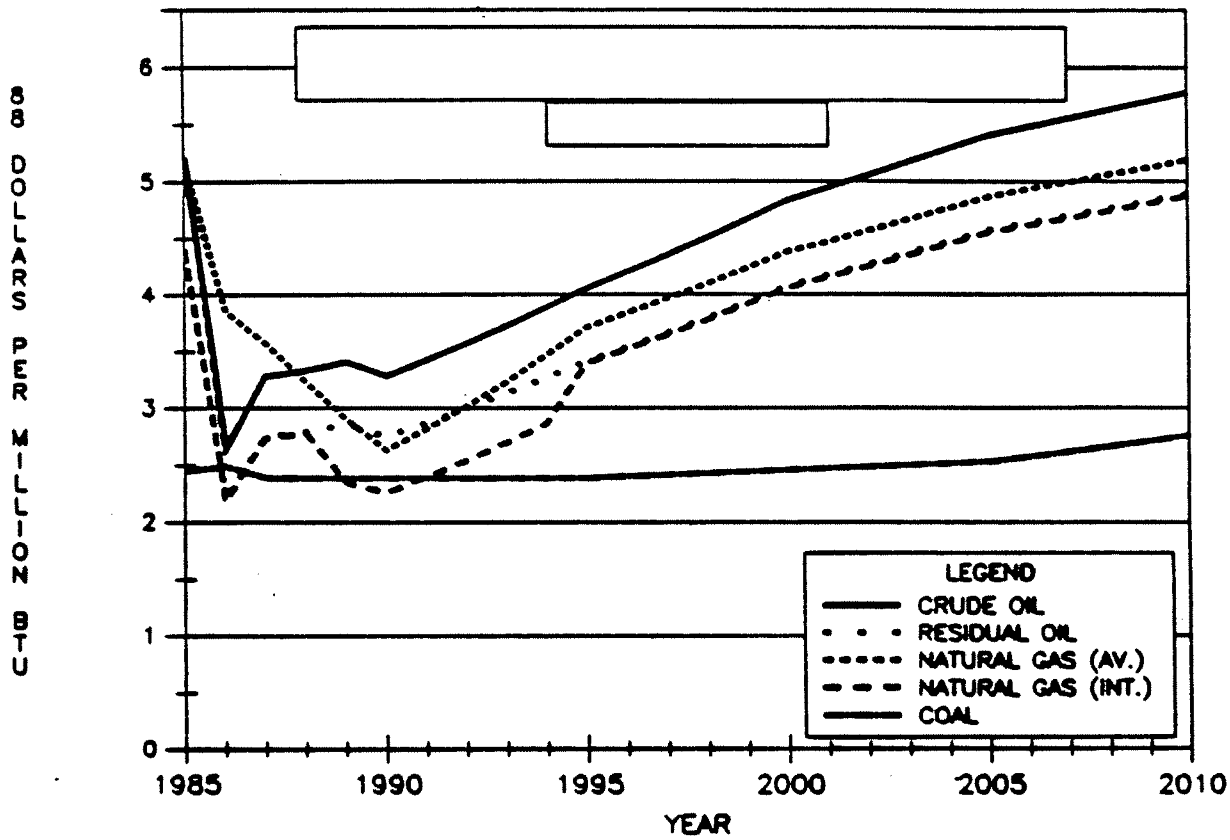

Figure 1-6
Industry Price Comparisons
Medium Forecast

Appendix 1-A

Detail on Economic Input Assumptions

Table 1-A-1
Employment-Population Ratios

	1985	1990	1995	2000	2005	2010
WASHINGTON						
High	.414	.455	.475	.495	.505	.515
Medium-high	.414	.447	.460	.472	.483	.493
Medium	.414	.438	.448	.456	.464	.472
Medium-low	.414	.424	.430	.440	.445	.451
Low	.414	.410	.412	.420	.421	.422
OREGON						
High	.422	.470	.490	.510	.520	.531
Medium-high	.422	.456	.475	.490	.500	.508
Medium	.422	.450	.461	.472	.480	.487
Medium-low	.422	.434	.442	.454	.460	.465
Low	.422	.421	.422	.430	.433	.435
IDAHO						
High	.400	.430	.445	.460	.470	.476
Medium-high	.400	.417	.435	.445	.450	.456
Medium	.400	.407	.416	.425	.431	.437
Medium-low	.400	.401	.398	.406	.412	.417
Low	.400	.389	.384	.388	.390	.391
WESTERN MONTANA						
High	.321	.341	.360	.380	.390	.395
Medium-high	.321	.331	.342	.353	.364	.374
Medium	.321	.327	.335	.343	.351	.358
Medium-low	.321	.321	.327	.333	.338	.342
Low	.321	.310	.313	.316	.318	.320

Table 1-A-2
Average Household Size

	1980	1985	1990	1995	2000	2005	2010
WASHINGTON							
High		2.61	2.50	2.40	2.30	2.22	2.18
Medium	2.68	2.61	2.52	2.42	2.36	2.31	2.29
Low		2.61	2.56	2.56	2.56	2.56	2.56
OREGON							
High		2.56	2.45	2.35	2.28	2.22	2.18
Medium	2.66	2.56	2.50	2.43	2.38	2.33	2.31
Low		2.56	2.50	2.52	2.53	2.54	2.55
IDAHO							
High		2.84	2.68	2.52	2.45	2.40	2.36
Medium	2.91	2.84	2.79	2.69	2.60	2.55	2.53
Low		2.84	2.80	2.82	2.84	2.85	2.86
WESTERN MONTANA							
High		2.70	2.48	2.34	2.24	2.24	2.24
Medium	2.77	2.70	2.62	2.50	2.39	2.34	2.32
Low		2.70	2.64	2.63	2.62	2.61	2.60

Table 1-A-3
Share of Housing Additions by Type of Housing Unit
1987-2010
(% of New Housing Starts)

STATE	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
WASHINGTON					
Single-family (1-4 units)	75	65	60	55	45
Multifamily (5 and more)	16	20	23.5	27	35
Manufactured Homes	9	15	16.5	18	20
OREGON					
Single-family (1-4 units)	76	68	65	62	51
Multifamily (5 and more)	13	16	17	18	27
Manufactured Homes	11	16	18	20	22
IDAHO					
Single-family (1-4 units)	81	71	67.5	64	55
Multifamily (5 and more)	8	10	11	12	17
Manufactured Homes	11	19	21.5	24	28
WESTERN MONTANA					
Single-family (1-4 units)	82	70	62.5	55	45
Multifamily (5 and more)	05	10	12.5	15	20
Manufactured Homes	13	20	25	30	35

Table 1-A-4
Production per Employee by Industry[a]
Average Annual Rates of Change (%)
1987-2010

SIC	HIGH	MEDIUM[b]	LOW
20	4.1	3.3	2.4
22	4.6	3.5	2.6
23	4.6	3.2	1.1
25	3.6	2.6	1.4
27	3.5	2.8	1.9
29	2.0	1.1	0.0
30	3.7	3.1	2.3
31	3.6	2.5	1.5
32	3.8	2.8	1.3
33XX	2.5	2.0	1.5
34	4.1	3.1	1.7
35	3.9	3.3	3.0
36	3.5	3.2	2.8
37	3.8	3.1	2.9
38	3.5	3.0	2.4
39	5.7	4.7	3.4

a Please refer to Table 1-B-1 in Appendix 1-B for a listing of SIC Codes.

b Growth rates shown are used in the medium-high, medium and medium-low cases except for the lumber, paper and chemicals industries. Forecasts for production per employee for the lumber, paper and chemicals industries are shown in the sections discussing the outlook for those industries.

Appendix 1-B

Manufacturing Forecasts

Table 1-B-1
SIC Code Listings

SIC CODE	INDUSTRY	SIC CODE	INDUSTRY
20	Food and kindred products	3334	Primary aluminum
22	Textiles	40-49	Transportation and public utilities
23	Apparel	50-51	Wholesale trade
25	Furniture	52,53+	Retail trade except food stores (54) and eating places (58)
27	Printing and publishing	54	Food stores
29	Petroleum refining	58	Eating and drinking places
30	Rubber and plastics	60-67	Finance, insurance and real estate
31	Leather and leather products	70	Hotels and lodging
32	Stone, clay, glass and concrete	72	Personal services
33XX	Primary metals except aluminum	73	Business services
34	Fabricated metals		
35	Machinery except electrical	76	Miscellaneous repair services
36	Electrical machinery		
37	Transportation equipment		
38	Professional instruments	80	Health services
39	Miscellaneous manufacturing	81	Legal services
2421	Sawmills and planing mills	82, 941	Educational services
2436	Softwood veneer and plywood	83	Social services
24XX	Other lumber and wood products		
2611	Pulp mills	75,78+	Other services
2621	Paper mills	89	Miscellaneous services
2631	Paperboard mills	90-99	Government except education (941)
26XX	Other paper products		
2812	Alkalies and chlorine		
2819	Elemental phosphorus		
28XX	Other chemicals		

Table 1-B-2
Forecasts of Manufacturing Employment
Average Annual Rate of Growth (%), 1987-2010

	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Printing and publishing	2.0	1.2	0.7	0.2	-0.7
Fabricated metals	2.1	1.0	0.6	0.3	-0.2
Stone, clay and glass	1.8	0.9	0.3	-0.3	-1.1
Petroleum	1.8	1.1	-0.1	-1.9	-2.6
Textiles	1.3	0.2	-0.3	-0.9	-2.3
Apparel	1.8	0.9	0.3	-0.3	-1.5
Furniture	2.0	1.0	0.6	0.1	-0.9
Rubber and plastics	2.1	1.1	0.6	0.1	-0.5
Leather products	1.9	0.9	0.3	-0.3	-2.0
Miscellaneous manufacturing	1.7	0.7	0.2	-0.4	-1.5

Appendix 1-C

Fuel Price Forecasts

Table 1-C-1
Residential Fuel Prices

	NATURAL GAS (1988 dollars per million British Thermal Units)				
	LOW	MEDIUM-LOW	MEDIUM	MEDIUM-HIGH	HIGH
Prices					
1987	6.14	6.14	6.14	6.14	6.14
2000	4.72	5.56	6.60	7.27	9.15
2010	4.72	5.74	7.45	8.82	10.86
Growth Rates (%)					
1987-2010	-1.1	-0.3	0.8	1.6	2.5

	HEATING OIL (1988 dollars per million British Thermal Units)				
	LOW	MEDIUM-LOW	MEDIUM	MEDIUM-HIGH	HIGH
Prices					
1987	4.48	4.48	4.48	4.48	4.48
2000	4.52	5.65	7.04	7.93	10.45
2010	4.52	5.89	8.17	10.01	12.74
Growth Rates (%)					
1987-2010	0.0	1.2	2.7	3.6	6.2

Table 1-C-2
Commercial Fuel Prices

	NATURAL GAS (1988 dollars per million British Thermal Units)				
	LOW	MEDIUM-LOW	MEDIUM	MEDIUM-HIGH	HIGH
Prices					
1987	5.27	5.27	5.27	5.27	5.27
2000	3.86	4.71	5.75	6.42	8.31
2010	3.86	4.88	6.59	7.97	10.02
Growth Rates (%)					
1987-2010	-1.3	-0.3	1.0	1.8	2.8

	OIL (1988 dollars per million British Thermal Units)				
	LOW	MEDIUM-LOW	MEDIUM	MEDIUM-HIGH	HIGH
Prices					
1987	4.14	4.14	4.14	4.14	4.14
2000	3.81	4.85	6.16	6.99	9.34
2010	3.81	5.09	7.22	8.93	11.47
Growth Rates (%)					
1987-2010	-0.4	0.9	2.5	3.4	4.5

Table 1-C-3
Industrial Fuel Prices

	NATURAL GAS (1988 dollars per million British Thermal Units)				
	LOW	MEDIUM-LOW	MEDIUM	MEDIUM-HIGH	HIGH
Prices					
1987	3.72	3.72	3.72	3.72	3.72
2000	2.67	3.51	4.56	5.22	7.11
2010	2.67	3.69	5.40	6.78	8.82
Growth Rates (%)					
1987-2010	-1.4	-0.0	1.6	2.6	3.8

	OIL (1988 dollars per million British Thermal Units)				
	LOW	MEDIUM-LOW	MEDIUM	MEDIUM-HIGH	HIGH
Prices					
1987	3.79	3.79	3.79	3.79	3.79
2000	3.26	4.21	5.38	6.13	8.25
2010	3.26	4.41	6.33	7.89	10.18
Growth Rates (%)					
1987-2010	-0.7	0.7	2.3	3.2	4.4

	COAL (1988 dollars per million British Thermal Units)				
	LOW	MEDIUM-LOW	MEDIUM	MEDIUM-HIGH	HIGH
Prices					
1987	2.38	2.38	2.38	2.38	2.38
2000	2.01	2.07	2.45	2.58	2.65
2010	2.01	2.19	2.76	2.88	3.12
Growth Rates (%)					
1987-2010	-0.7	-0.4	0.7	0.8	1.2

Appendix 1-D

Detailed Tables

High Scenario - Region
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	73.900	72.700	72.200	72.050	71.965	70.700	72.325	73.500	74.950	75.650	77.000	77.400	79.000	77.900
22	3.000	2.800	2.650	2.650	2.550	2.650	3.000	3.200	3.400	3.500	3.700	3.850	4.002	4.002
23	10.025	8.825	8.725	9.600	8.900	8.710	8.750	9.250	10.200	10.600	11.750	12.450	12.900	13.100
25	6.150	5.300	6.050	6.825	7.240	7.350	6.950	7.100	8.100	8.300	9.250	10.100	10.659	10.850
27	29.650	29.500	30.300	32.375	34.000	35.600	37.775	39.925	42.250	43.800	48.200	52.400	56.000	59.000
29	2.800	2.300	2.300	2.325	2.225	2.425	2.550	2.700	2.900	3.000	3.400	3.600	3.700	3.800
30	6.900	6.675	6.850	7.675	8.575	8.975	9.675	9.825	10.250	10.950	12.400	13.650	14.800	15.700
31	0.700	0.750	0.950	1.050	0.925	1.025	1.180	1.390	1.400	1.500	1.700	1.800	1.800	1.800
32	13.100	10.450	10.200	10.400	10.725	10.600	10.980	11.390	12.600	13.100	14.030	14.850	15.671	16.700
33XX	20.800	15.850	13.750	14.650	15.350	15.450	15.325	17.275	18.200	18.650	19.250	19.600	19.800	19.800
34	26.750	21.400	20.650	22.325	22.850	22.850	22.875	24.250	25.700	26.850	29.550	32.500	34.450	36.600
35	37.750	38.400	35.950	38.200	38.625	37.750	37.325	39.600	44.050	47.050	56.050	65.750	75.400	81.650
36	22.550	22.350	23.150	28.975	28.875	28.375	29.775	32.400	35.400	37.300	44.350	50.975	59.004	65.425
37	109.450	100.800	88.200	91.700	99.825	108.525	118.250	128.450	134.850	140.650	145.550	149.150	153.250	156.300
38	25.950	25.450	24.550	25.000	25.725	23.925	23.220	23.530	25.550	26.550	31.400	35.753	40.600	45.850
39	7.350	6.650	6.925	7.675	7.400	7.600	8.400	9.200	9.900	10.300	11.050	11.700	12.150	12.500
2421	52.427	43.030	46.440	47.725	44.300	44.200	45.850	45.400	45.192	44.697	39.899	38.621	37.661	36.206
2436	26.582	21.430	22.350	22.205	20.900	21.300	22.100	22.000	21.690	21.576	16.398	15.282	14.672	13.605
24XX	61.066	48.840	57.010	59.670	57.100	57.850	60.000	61.375	63.608	64.522	65.069	64.682	63.975	62.999
2611	2.974	2.300	2.050	2.075	2.100	2.100	2.100	2.100	2.096	2.090	2.041	1.956	1.860	1.757
2621	14.143	13.048	12.520	13.295	13.410	13.400	13.350	13.350	13.506	13.646	13.323	13.113	12.713	12.172
2631	5.037	4.999	5.050	4.639	5.000	5.025	4.900	4.800	4.856	4.838	4.676	4.440	4.182	3.911
26XX	7.896	7.453	7.730	7.466	7.815	7.825	7.900	8.000	8.231	8.283	8.882	9.257	9.350	8.879
2812	0.763	0.700	0.650	0.650	0.700	0.700	0.700	0.700	0.718	0.723	0.733	0.740	0.730	0.710
2819	6.567	7.250	7.775	8.200	8.890	8.880	8.780	7.680	8.295	8.941	9.069	9.009	8.912	8.781
28XX	7.470	7.375	7.425	7.400	7.650	8.300	7.650	7.850	7.896	7.981	8.299	8.578	8.680	8.643
3334	10.350	6.883	7.400	8.900	7.250	5.750	5.950	6.500	6.700	6.900	6.900	6.900	6.900	6.900
Subtotal	592.100	533.508	529.800	555.700	560.870	567.840	587.635	612.740	642.488	661.948	693.919	728.105	762.821	785.541

a See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

High Scenario - Region
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	179.500	171.400	168.800	173.500	176.500	178.600	181.250	187.700	195.235	200.812	230.028	252.853	268.690	282.077
50-51	194.000	188.400	187.950	193.800	195.700	198.325	203.575	211.975	225.057	234.164	287.741	338.631	385.307	433.276
52,53+	275.100	255.000	261.600	276.100	279.300	287.900	297.850	312.630	329.575	340.600	414.807	483.415	544.613	606.233
54	75.100	82.450	84.600	88.100	92.400	96.525	101.125	107.363	111.062	115.183	140.535	163.774	184.499	205.366
58	195.500	197.350	203.000	211.800	218.400	226.125	233.975	243.095	258.556	271.818	349.319	425.862	501.947	584.455
60-67	188.900	181.800	183.300	188.300	193.400	202.150	201.450	205.050	221.187	230.328	286.808	339.045	387.421	437.428
70	40.200	38.900	39.500	41.400	42.600	44.400	46.300	47.575	50.282	52.456	64.633	75.533	85.328	95.243
72	29.600	30.900	31.500	33.350	35.000	36.000	37.575	39.000	41.565	43.134	51.795	58.081	64.199	70.126
73	89.800	81.800	87.400	99.500	109.800	116.050	124.375	133.456	143.454	151.479	200.047	255.324	315.043	384.071
76	9.800	8.700	9.100	10.000	10.500	10.875	11.650	12.244	13.157	13.778	17.181	20.662	24.045	27.647
80	179.800	190.900	196.200	205.100	212.350	221.000	231.500	244.994	262.978	275.809	350.926	431.332	512.483	601.630
81	17.400	19.400	20.300	21.550	22.700	23.925	25.600	27.412	29.440	31.135	41.210	52.501	64.816	79.061
82,941	299.400	284.300	286.750	297.100	303.775	309.700	315.000	321.460	339.716	352.628	423.702	482.880	531.950	579.053
83	31.800	32.000	35.200	38.800	41.800	44.275	47.325	50.050	53.442	56.005	71.085	84.935	99.654	115.506
89	36.400	34.200	33.700	34.750	36.000	37.800	40.300	42.457	45.071	49.275	60.008	71.068	82.746	95.176
75,78+	122.600	125.900	132.800	136.125	141.125	148.925	158.950	166.313	174.774	181.577	220.879	253.332	283.451	313.377
90-99	230.300	226.100	226.000	229.300	236.100	241.100	248.300	252.950	267.464	277.651	333.747	380.513	419.350	456.664
Const	161.300	122.900	118.400	128.400	132.600	136.650	138.300	152.300	164.279	172.581	196.850	222.562	249.529	276.406
Agric	292.200	286.600	297.200	291.100	286.600	286.900	286.200	285.055	287.200	288.401	290.300	293.000	295.599	298.100
Mining	13.300	11.275	10.550	10.200	9.875	9.150	9.075	10.050	11.300	12.100	13.300	14.500	15.200	15.600
Fd Gvt	117.300	112.600	113.700	115.100	116.350	115.300	117.700	117.400	125.000	133.200	144.100	155.700	168.200	181.800
Subtotal	2,779.300	2,682.875	2,727.550	2,823.375	2,892.875	2,971.675	3,057.375	3,170.529	3,349.794	3,484.114	4,189.001	4,855.504	5,484.070	6,138.295
Total	3,371.400	3,216.383	3,257.350	3,379.075	3,453.746	3,539.515	3,645.010	3,783.269	3,992.282	4,146.062	4,882.920	5,583.609	6,246.891	6,923.836

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

High Scenario - Region
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							HOUSING							
SF[a]	2,303.987	2,366.045	2,368.271	2,402.532	2,429.137	2,454.883	2,497.650	2,549.162	2,681.107	2,771.238	3,284.765	3,760.189	4,265.079	4,736.632
MF[b]	427.934	458.244	462.080	478.017	491.921	505.730	514.439	524.922	549.093	566.000	660.562	749.896	845.919	934.509
MO[c]	230.752	254.912	257.349	270.351	280.342	289.888	293.411	297.873	312.777	321.690	371.647	409.771	446.876	478.487
Total	2,962.673	3,079.200	3,087.700	3,150.900	3,201.400	3,250.500	3,305.500	3,371.957	3,542.976	3,658.927	4,316.975	4,919.857	5,557.874	6,149.628

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							POPULATION							
	8,003.820	8,207.490	8,226.700	8,308.500	8,389.700	8,431.400	8,530.700	8,663.500	8,981.358	9,154.997	10,337.505	11,350.863	12,443.230	13,528.789

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							HOUSEHOLDS							
	2,962.673	3,079.200	3,087.700	3,150.900	3,201.400	3,250.500	3,305.500	3,371.956	3,542.976	3,658.927	4,316.975	4,919.856	5,557.873	6,149.626

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							INCOME[d]							
	10,347.04	9,914.80	10,132.77	10,303.97	10,478.86	10,839.25	11,164.11	11,496.52	11,836.82	12,192.25	14,086.99	16,277.79	18,814.69	21,741.99

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

High Scenario - Washington
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	31.900	31.800	31.100	30.800	31.100	31.100	31.900	32.500	33.000	33.100	33.700	34.100	34.800	34.300
22	1.000	0.900	0.900	0.900	0.900	1.000	1.100	1.100	1.200	1.300	1.400	1.450	1.502	1.502
23	6.500	5.700	5.900	6.500	6.200	6.100	5.900	6.100	6.900	7.200	8.000	8.500	8.800	9.000
25	3.300	2.900	3.200	3.500	3.800	3.900	3.700	3.700	4.300	4.400	4.900	5.300	5.606	5.800
27	15.800	15.800	16.000	16.900	17.600	18.700	20.100	21.200	22.300	22.900	25.000	27.000	29.000	30.500
29	2.100	1.800	1.800	1.800	1.800	1.900	2.000	2.100	2.200	2.300	2.600	2.800	2.900	3.000
30	3.500	3.525	3.600	4.200	4.500	4.600	4.900	5.100	5.400	5.800	6.400	7.100	7.800	8.250
31	0.400	0.400	0.400	0.400	0.400	0.500	0.500	0.600	0.600	0.600	0.700	0.800	0.800	0.800
32	6.900	6.000	6.000	6.500	6.400	6.200	6.500	6.600	7.200	7.400	8.000	8.500	9.000	9.600
33XX	9.000	8.500	7.200	6.400	6.900	7.200	6.700	7.500	8.200	8.500	9.000	9.300	9.500	9.600
34	11.800	9.900	9.400	9.900	9.700	10.000	10.400	11.000	11.700	12.100	13.500	15.000	16.000	17.000
35	15.000	16.600	15.300	16.400	17.100	17.600	16.300	17.600	19.500	21.000	25.000	29.500	35.000	37.000
36	11.200	10.600	10.300	11.800	12.100	12.700	13.100	13.600	15.300	16.000	19.000	22.000	26.000	29.000
37	98.350	92.100	80.200	82.200	89.600	97.500	106.000	114.300	120.000	125.000	129.000	132.000	135.500	138.000
38	6.400	8.400	9.400	10.200	10.700	10.400	10.700	11.000	12.100	12.800	15.300	17.300	19.600	21.500
39	4.600	4.000	4.200	4.600	4.500	4.600	4.700	5.100	5.400	5.600	6.100	6.600	7.000	7.300
2421	16.027	14.200	14.950	14.700	13.400	13.400	13.900	13.600	13.875	13.765	12.251	11.737	11.372	10.855
2436	4.982	4.100	4.250	4.200	4.200	4.200	4.300	4.100	4.191	4.161	3.200	2.978	2.877	2.689
24XX	25.991	20.700	23.000	22.400	20.700	20.800	21.800	22.300	23.013	23.158	23.381	23.242	22.988	22.637
2611	2.974	2.300	2.050	2.075	2.100	2.100	2.100	2.100	2.096	2.090	2.041	1.956	1.860	1.757
2621	8.818	8.100	7.900	8.900	9.000	9.000	8.900	9.000	9.012	9.058	8.842	8.702	8.438	8.078
2631	1.637	1.600	1.575	1.000	1.200	1.200	1.100	1.100	1.096	1.092	1.055	1.002	0.944	0.883
26XX	4.171	4.100	4.275	4.025	4.400	4.400	4.400	4.500	4.569	4.605	4.872	5.086	5.195	5.033
2812	0.513	0.500	0.450	0.450	0.500	0.500	0.500	0.500	0.513	0.516	0.524	0.528	0.522	0.507
2819	5.300	6.000	6.575	7.000	7.700	7.700	7.700	6.600	7.200	7.840	7.951	7.899	7.813	7.699
28XX	2.887	3.000	3.075	3.050	3.100	3.300	3.300	3.300	3.422	3.459	3.596	3.717	3.762	3.746
3334	7.700	5.200	5.400	7.000	5.800	4.400	4.500	4.800	5.000	5.200	5.200	5.200	5.200	5.200
Subtotal	308.750	288.725	278.400	287.800	295.400	305.000	317.000	331.000	349.287	360.943	380.513	399.297	419.777	431.235

a See Standard Industrial Classification codes in Appendix 1-B, Table 1-B-1.

High Scenario - Washington
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	91.400	89.000	87.900	90.900	93.600	96.200	98.400	103.000	106.236	109.901	125.451	138.362	147.520	155.381
50-51	100.500	100.900	100.500	104.700	105.700	107.300	110.500	114.500	120.946	126.534	158.137	187.458	214.796	243.185
52,53 +	141.000	133.900	137.700	143.900	146.900	153.500	159.700	167.370	176.496	183.461	223.805	261.808	296.068	330.808
54	38.200	43.850	44.700	47.000	49.200	51.400	53.500	56.863	58.256	60.790	74.975	87.707	99.184	110.822
58	101.600	106.750	111.000	116.000	118.900	124.300	129.400	134.545	143.453	151.041	194.836	238.424	282.080	329.680
60-67	91.800	90.700	92.300	95.700	99.600	105.200	107.000	108.300	117.160	122.596	153.363	181.975	208.715	236.532
70	17.800	17.700	18.600	19.600	20.100	21.000	22.500	23.065	24.542	25.632	31.759	37.322	42.391	47.574
72	16.000	17.400	17.800	19.100	19.900	20.800	22.300	23.348	24.995	25.890	30.805	33.847	37.151	40.298
73	52.900	46.500	49.000	55.600	61.000	63.700	68.400	73.206	79.432	84.266	110.832	141.982	175.837	215.147
76	5.500	4.700	5.000	5.300	5.600	5.800	6.200	6.494	7.039	7.383	9.152	11.061	12.922	14.914
80	95.800	102.300	105.800	112.800	117.400	121.900	129.400	138.994	148.916	156.774	197.424	243.545	290.375	342.114
81	9.200	10.500	11.000	11.600	12.400	12.900	13.800	14.812	16.097	17.081	22.452	28.836	35.797	43.905
82,941	154.900	142.200	145.850	152.800	155.600	158.900	162.100	165.730	175.091	181.973	220.017	252.304	279.658	306.258
83	15.600	16.500	18.700	20.800	22.600	23.600	25.300	26.900	29.000	30.456	38.834	46.098	54.302	63.189
89	19.500	19.100	19.200	19.900	21.100	22.000	23.600	24.957	26.734	30.043	35.838	42.102	49.188	56.768
75,78 +	66.800	72.600	77.300	81.000	83.500	87.200	93.600	98.013	103.906	108.218	132.070	151.347	170.235	189.189
90-99	117.400	119.300	120.700	124.100	129.100	132.700	135.900	138.500	146.792	152.561	184.456	211.524	234.457	256.758
Const	92.600	76.200	74.200	79.600	80.600	84.500	87.300	98.000	104.060	110.082	125.015	141.160	158.777	176.455
Agric	119.300	116.300	118.700	117.200	115.100	115.300	114.400	113.300	113.507	113.812	115.231	115.840	117.153	118.086
Mining	3.200	3.000	2.700	2.600	2.700	2.900	3.000	3.300	3.400	3.500	3.700	3.800	3.900	3.900
Fd Gvt	67.900	66.300	67.600	68.900	70.100	69.200	70.500	69.700	75.000	81.400	87.900	95.000	102.600	110.900
Subtotal	1,418.900	1,395.700	1,426.250	1,489.100	1,530.700	1,580.300	1,636.800	1,702.897	1,801.058	1,883.394	2,276.052	2,651.502	3,013.106	3,391.863
TOTAL	1,727.650	1,684.425	1,704.650	1,776.900	1,826.100	1,885.300	1,953.800	2,033.897	2,150.345	2,244.338	2,656.565	3,050.800	3,432.884	3,823.098

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

High Scenario - Washington
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	1,192.724	1,230.373	1,232.542	1,250.107	1,267.116	1,283.573	1,311.658	1,344.531	1,414.680	1,472.132	1,744.133	2,012.332	2,307.065	2,573.292
MF[b]	250.672	273.185	276.354	287.123	297.674	308.007	314.289	321.597	336.845	349.393	408.921	467.663	532.014	590.180
MO[c]	97.114	111.442	113.105	119.771	126.210	132.420	135.053	138.169	145.660	151.519	177.266	199.671	222.988	241.800
Total	1,540.510	1,615.000	1,622.000	1,657.000	1,691.000	1,724.000	1,761.000	1,804.297	1,897.184	1,973.044	2,330.320	2,679.666	3,062.067	3,405.271

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	4,132.160	4,279.000	4,304.000	4,349.000	4,406.000	4,463.000	4,538.000	4,619.000	4,799.876	4,932.610	5,592.768	6,163.231	6,797.789	7,423.492

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	1,540.510	1,615.000	1,622.000	1,657.000	1,691.000	1,724.000	1,761.000	1,804.297	1,897.184	1,973.044	2,330.320	2,679.666	3,062.067	3,405.271

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	10,727.00	10,440.00	10,629.00	10,780.00	10,977.00	11,414.00	11,723.80	12,042.10	12,369.00	12,704.80	14,525.40	16,606.90	18,986.70	21,707.60

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

High Scenario - Oregon
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	24.300	23.700	24.200	24.100	23.800	23.700	23.800	23.200	24.100	24.700	25.400	25.400	25.900	25.600
22	2.000	1.900	1.700	1.700	1.600	1.600	1.800	2.000	2.100	2.100	2.200	2.300	2.400	2.400
23	3.200	2.700	2.600	2.800	2.400	2.300	2.500	2.800	2.900	3.000	3.300	3.500	3.600	3.600
25	2.600	2.200	2.400	2.700	2.700	2.700	2.500	2.600	2.900	3.000	3.300	3.600	3.803	3.800
27	10.000	10.000	10.400	11.000	11.500	12.000	12.700	13.500	14.500	15.200	16.500	18.000	19.000	20.000
29	0.600	0.500	0.500	0.500	0.400	0.500	0.500	0.550	0.600	0.600	0.700	0.700	0.700	0.700
30	2.400	2.300	2.500	2.800	3.200	3.400	3.800	3.900	4.000	4.200	4.700	5.200	5.600	6.000
31	0.300	0.300	0.500	0.500	0.400	0.400	0.500	0.600	0.600	0.700	0.800	0.800	0.800	0.800
32	4.500	3.400	3.000	2.700	3.100	3.300	3.400	3.700	4.100	4.300	4.500	4.700	4.900	5.100
33XX	9.600	7.200	6.400	8.100	8.200	8.000	8.500	9.400	9.600	9.700	9.700	9.700	9.700	9.600
34	12.700	9.700	9.400	10.400	11.000	10.600	10.200	11.000	11.500	12.000	13.000	14.000	14.500	15.300
35	17.700	16.500	15.200	15.900	15.500	15.000	15.500	16.100	18.000	19.000	22.000	25.000	27.000	29.500
36	9.800	10.100	10.700	13.800	13.900	12.900	13.400	14.900	16.000	17.000	20.500	23.500	27.000	30.000
37	10.300	7.900	7.100	8.500	9.200	10.100	11.100	12.800	13.400	14.200	15.000	15.500	16.000	16.500
38	19.300	16.800	14.800	14.400	14.600	13.100	12.100	12.000	12.900	13.200	15.300	17.400	19.800	23.000
39	2.200	2.300	2.300	2.600	2.400	2.500	3.100	3.400	3.800	3.900	4.000	4.000	4.000	4.000
2421	23.800	18.630	20.390	21.925	20.500	20.600	21.600	21.700	21.197	20.893	18.279	17.477	16.927	16.150
2436	20.100	16.230	16.900	16.680	15.500	15.900	16.600	16.700	16.263	16.142	11.811	10.864	10.327	9.463
24XX	25.600	20.740	25.310	28.095	27.600	28.100	29.200	29.500	30.897	31.454	31.631	31.443	31.099	30.625
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	5.100	4.723	4.395	4.145	4.160	4.150	4.200	4.100	4.239	4.333	4.227	4.161	4.033	3.862
2631	2.000	1.949	1.925	1.939	2.100	2.100	2.100	2.000	2.043	2.036	1.968	1.869	1.760	1.646
26XX	3.300	2.928	2.980	2.916	2.840	2.850	2.900	2.900	3.032	3.046	3.301	3.418	3.401	3.132
2812	0.250	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.205	0.206	0.209	0.211	0.209	0.203
2819	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28XX	2.050	1.900	2.000	1.800	1.900	1.800	1.900	1.900	1.970	1.991	2.071	2.140	2.166	2.157
3334	1.400	0.900	1.100	1.000	0.600	0.600	0.700	0.900	0.800	0.800	0.800	0.800	0.800	0.800
Subtotal	215.100	185.700	188.900	201.200	199.300	198.400	204.800	212.350	221.648	227.702	235.198	245.683	255.426	263.938

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

High Scenario - Oregon
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	60.500	56.800	55.400	57.100	57.300	57.200	58.300	59.600	62.874	64.043	73.752	80.945	85.877	90.006
50-51	67.400	62.700	62.600	64.500	65.800	67.400	69.100	74.000	78.459	81.055	97.985	115.481	131.551	148.069
52,53 +	96.200	85.300	87.700	92.900	92.900	95.100	98.100	104.060	109.775	112.083	136.218	158.424	178.109	197.843
54	24.600	26.400	27.200	27.900	29.500	31.700	33.700	36.350	37.911	38.960	46.795	54.423	61.185	67.964
58	67.400	64.300	65.100	67.600	70.400	73.100	75.400	78.400	83.382	87.685	112.412	136.703	160.720	186.661
60-67	70.000	64.900	64.500	65.400	66.800	69.500	71.700	73.700	79.313	82.045	101.750	119.976	136.738	153.982
70	14.800	13.700	13.400	14.000	14.600	14.900	15.200	15.560	16.529	17.236	21.187	24.701	27.838	30.998
72	9.800	9.600	9.600	9.900	10.400	10.600	10.800	10.952	11.688	12.159	14.772	17.022	18.960	20.866
73	24.900	23.200	25.600	31.300	35.000	38.200	40.900	44.150	47.094	49.533	65.775	83.861	103.361	125.862
76	3.000	2.800	2.900	3.400	3.500	3.800	4.100	4.300	4.511	4.731	5.990	7.194	8.351	9.578
80	62.100	65.300	66.400	67.500	69.400	72.500	74.700	77.800	83.875	87.292	112.817	138.322	163.966	192.006
81	5.600	6.300	6.600	7.100	7.300	8.000	8.600	9.200	9.783	10.275	13.778	17.525	21.549	26.177
82,941	100.700	98.700	97.500	99.500	102.200	104.300	105.900	107.530	113.947	118.198	141.538	160.736	176.424	191.371
83	11.400	11.000	11.800	13.000	14.000	15.300	16.400	17.300	18.198	19.012	24.246	29.330	34.300	39.624
89	11.100	9.700	9.300	9.800	10.300	11.200	12.000	12.600	13.202	13.848	17.531	21.054	24.443	28.032
75,78 +	42.200	40.700	42.400	41.500	43.500	47.400	50.800	53.400	55.277	57.193	69.483	80.068	89.184	98.148
90-99	78.200	74.000	72.400	72.200	73.500	74.700	77.300	78.600	83.174	86.277	103.314	117.326	128.778	139.688
Const	46.500	28.900	27.000	30.200	33.100	34.300	34.500	37.400	40.937	42.541	48.188	54.377	60.568	66.655
Agric	96.300	96.800	103.400	100.100	98.800	99.000	99.700	100.300	102.095	103.272	103.760	105.318	106.177	107.098
Mining	2.300	1.800	1.600	1.600	1.500	1.400	1.400	1.400	1.900	2.000	2.300	2.500	2.700	2.800
Fd Gvt	30.800	29.100	29.000	29.300	29.600	29.600	30.200	30.500	31.800	33.000	35.900	38.800	41.900	45.200
Subtotal	925.800	872.000	881.400	905.800	929.400	959.200	988.800	1,027.102	1,085.724	1,122.438	1,349.491	1,564.086	1,762.679	1,968.628
Total	1,140.900	1,057.700	1,070.300	1,107.000	1,128.700	1,157.600	1,193.600	1,239.452	1,307.372	1,350.140	1,584.689	1,809.769	2,018.105	2,232.565

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

High Scenario - Oregon
Housing, Population, Households and Income

HOUSING

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
SF[a]	766.660	781.211	778.769	789.367	796.264	804.424	817.017	834.531	876.320	893.545	1,052.478	1,195.215	1,347.898	1,492.195
MF[b]	143.285	148.654	148.547	152.229	154.855	157.862	160.118	163.214	170.447	173.497	201.155	226.048	252.591	277.612
MO[c]	81.648	87.136	86.684	90.403	92.880	95.714	96.865	98.655	103.886	105.464	122.562	135.126	147.696	158.842
Total	991.593	1,017.000	1,014.000	1,032.000	1,044.000	1,058.000	1,074.000	1,096.400	1,150.653	1,172.506	1,376.195	1,556.389	1,748.185	1,928.649

POPULATION

1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
2,633.160	2,656.190	2,635.000	2,660.000	2,675.800	2,661.500	2,690.000	2,741.000	2,842.114	2,872.639	3,234.059	3,548.567	3,880.971	4,204.455

HOUSEHOLDS

1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
991.593	1,017.000	1,014.000	1,032.000	1,044.000	1,058.000	1,074.000	1,096.400	1,150.653	1,172.506	1,376.195	1,556.389	1,748.185	1,928.649

INCOME[d]

1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
9,864.00	9,204.00	9,448.00	9,685.00	9,858.00	10,135.00	10,459.30	10,794.00	11,139.40	11,495.90	13,456.80	15,752.10	18,439.00	21,584.20

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

High Scenario - Idaho
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	17.000	16.600	16.300	16.600	16.600	15.400	16.100	17.300	17.300	17.300	17.300	17.300	17.700	17.400
22	0.000	0.000	0.050	0.050	0.050	0.050	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
23	0.300	0.400	0.200	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
25	0.250	0.200	0.400	0.500	0.600	0.600	0.600	0.700	0.700	0.700	0.800	0.900	0.900	0.900
27	3.100	3.200	3.300	3.800	4.200	4.200	4.250	4.525	4.700	4.900	5.700	6.200	6.600	7.000
29	0.100	0.000	0.000	0.000	0.025	0.025	0.050	0.050	0.100	0.100	0.100	0.100	0.100	0.100
30	1.000	0.850	0.750	0.650	0.850	0.950	0.950	0.800	0.800	0.900	1.200	1.200	1.200	1.200
31	0.000	0.050	0.050	0.100	0.100	0.100	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
32	1.300	0.900	1.000	0.900	0.900	0.800	0.800	0.800	1.000	1.100	1.200	1.300	1.400	1.600
33XX	1.200	0.050	0.050	0.050	0.100	0.100	0.000	0.250	0.250	0.250	0.300	0.300	0.300	0.300
34	2.100	1.700	1.700	1.800	1.900	2.000	2.000	2.000	2.200	2.400	2.600	3.000	3.400	3.700
35	5.000	5.200	5.300	5.700	5.800	4.900	5.200	5.600	6.200	6.700	8.600	10.700	12.800	14.500
36	1.500	1.600	2.100	3.300	2.800	2.700	3.200	3.800	4.000	4.200	4.700	5.300	5.800	6.200
37	0.700	0.750	0.850	0.950	0.950	0.850	1.100	1.250	1.300	1.300	1.300	1.300	1.300	1.300
38	0.150	0.200	0.250	0.300	0.300	0.300	0.300	0.400	0.400	0.400	0.600	0.800	0.900	1.000
39	0.400	0.250	0.300	0.350	0.325	0.300	0.300	0.400	0.400	0.500	0.600	0.700	0.700	0.700
2421	8.100	6.500	7.100	7.100	6.400	6.200	6.200	6.300	6.150	6.101	5.756	5.779	5.751	5.653
2436	0.500	0.300	0.400	0.425	0.400	0.400	0.400	0.400	0.424	0.449	0.489	0.507	0.517	0.512
24XX	6.775	5.400	6.400	6.675	6.700	6.500	6.500	7.100	7.112	7.268	7.376	7.332	7.252	7.141
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	0.225	0.225	0.225	0.250	0.250	0.250	0.250	0.250	0.254	0.255	0.254	0.250	0.242	0.232
2631	0.850	0.850	0.900	0.950	0.950	0.950	0.950	0.950	0.960	0.956	0.924	0.877	0.826	0.773
26XX	0.425	0.425	0.475	0.525	0.575	0.575	0.600	0.600	0.630	0.631	0.709	0.754	0.754	0.714
2812	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2819	1.067	1.050	1.000	1.000	1.000	1.000	0.900	0.900	0.912	0.918	0.932	0.925	0.915	0.902
28XX	2.433	2.400	2.300	2.500	2.600	3.150	2.400	2.600	2.452	2.479	2.577	2.664	2.696	2.684
3334	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subtotal	54.475	49.100	51.400	54.725	54.625	52.550	53.600	57.525	58.794	60.357	64.566	68.737	72.603	75.060

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

High Scenario - Idaho
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	20.100	19.100	19.100	19.100	19.200	18.500	17.900	18.400	18.887	19.401	22.122	23.924	25.008	25.831
50-51	22.300	21.600	21.600	21.300	20.800	20.300	20.700	20.100	22.063	22.833	27.019	30.329	32.916	35.292
52,53 +	29.900	28.000	28.300	31.300	31.300	31.100	31.400	32.500	34.110	35.495	43.185	49.836	55.591	61.269
54	9.400	9.500	9.900	10.300	10.700	10.700	11.100	11.350	12.020	12.508	15.217	17.561	19.589	21.590
58	19.000	18.900	19.600	20.900	21.600	21.500	21.700	22.650	23.924	25.120	31.960	38.568	44.994	51.852
60-67	23.400	22.700	23.000	23.500	23.600	23.900	19.100	19.400	20.915	21.829	26.948	31.555	35.719	39.949
70	5.100	5.100	5.000	5.100	5.200	5.700	5.700	6.050	6.181	6.436	7.857	9.097	10.183	11.261
72	3.000	3.100	3.300	3.500	3.800	3.700	3.600	3.800	3.896	4.053	4.924	5.674	6.320	6.955
73	11.000	11.100	11.700	11.400	12.100	12.200	12.900	13.900	14.600	15.228	20.276	25.607	31.259	37.700
76	1.000	0.900	0.900	1.000	1.100	1.000	1.000	1.100	1.207	1.264	1.589	1.894	2.183	2.486
80	15.500	16.500	16.900	17.400	17.900	18.500	19.100	19.800	21.126	22.218	28.497	34.672	40.783	47.389
81	2.100	2.100	2.200	2.300	2.400	2.400	2.500	2.700	2.810	2.978	3.975	5.032	6.158	7.444
82,941	34.900	34.100	33.900	35.100	36.200	36.800	37.500	38.800	40.301	41.724	49.483	55.666	60.531	65.029
83	3.400	3.200	3.400	3.700	4.000	4.100	4.100	4.350	4.625	4.854	6.159	7.415	8.629	9.921
89	4.800	4.400	4.200	4.100	3.900	3.900	3.900	4.100	4.278	4.481	5.633	6.716	7.740	8.815
75,78 +	10.300	9.300	9.800	10.300	10.800	11.000	11.100	11.400	12.005	12.428	14.740	16.581	18.030	19.370
90-99	26.400	25.300	25.600	25.700	26.100	26.300	27.700	28.450	28.940	29.961	35.533	39.973	43.466	46.696
Const	17.400	13.800	13.200	14.600	15.100	14.600	13.700	14.200	16.003	16.530	19.377	21.980	24.423	26.796
Agric	69.100	66.100	67.800	66.500	65.400	65.300	64.800	64.155	64.226	63.911	63.868	64.403	64.662	65.147
Mining	4.700	3.800	4.100	4.200	3.800	2.900	2.600	3.250	3.500	4.000	4.500	5.000	5.100	5.100
Fd Gvt	13.000	12.000	11.900	11.800	11.800	11.800	12.100	12.300	13.100	13.600	14.700	15.900	17.200	18.600
Subtotal	345.800	330.600	335.400	343.100	346.800	346.200	344.200	352.755	368.717	380.852	447.562	507.383	560.484	614.492
Total	400.275	379.700	386.800	397.825	401.425	398.750	397.800	410.280	427.511	441.209	512.128	576.120	633.087	689.552

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

High Scenario - Idaho
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	262.388	270.920	272.697	277.681	280.759	281.932	283.047	283.207	295.472	305.070	367.295	414.696	459.020	505.457
MF[b]	25.082	26.965	27.448	28.533	29.265	29.645	29.778	29.818	31.045	32.010	38.232	42.997	47.453	52.104
MO[c]	36.700	40.114	40.855	42.786	43.976	44.423	44.175	43.761	44.974	45.781	51.159	53.505	54.774	56.269
Total	324.170	338.000	341.000	349.000	354.000	356.000	357.000	356.786	371.490	382.861	456.686	511.198	561.247	613.830

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION	944.000	978.000	988.000	999.000	1,004.000	1,002.000	998.000	999.000	1,017.883	1,026.067	1,150.849	1,252.436	1,346.993	1,448.639

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS	324.170	338.000	341.000	349.000	354.000	356.000	357.000	356.786	371.490	382.861	456.686	511.198	561.247	613.830

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]	8,570.00	8,058.00	8,293.00	8,329.00	8,437.00	8,535.00	8,798.50	9,070.10	9,350.10	9,638.80	11,221.30	13,063.70	15,208.60	17,705.70

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

High Scenario - Western Montana
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	0.700	0.600	0.600	0.550	0.465	0.500	0.525	0.500	0.550	0.550	0.600	0.600	0.600	0.600
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.025	0.025	0.025	0.050	0.050	0.060	0.050	0.050	0.100	0.100	0.150	0.150	0.200	0.200
25	0.000	0.000	0.050	0.125	0.140	0.150	0.150	0.100	0.200	0.200	0.250	0.300	0.350	0.350
27	0.750	0.500	0.600	0.675	0.700	0.700	0.725	0.700	0.750	0.800	1.000	1.200	1.400	1.500
29	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.025	0.025	0.025	0.025	0.025	0.050	0.050	0.100	0.150	0.200	0.250
31	0.000	0.000	0.000	0.050	0.025	0.025	0.030	0.040	0.050	0.050	0.050	0.050	0.050	0.050
32	0.400	0.150	0.200	0.300	0.325	0.300	0.280	0.290	0.300	0.300	0.330	0.350	0.371	0.400
33XX	1.000	0.100	0.100	0.100	0.150	0.150	0.125	0.125	0.150	0.200	0.250	0.300	0.300	0.300
34	0.150	0.100	0.150	0.225	0.250	0.250	0.275	0.250	0.300	0.350	0.450	0.500	0.550	0.600
35	0.050	0.100	0.150	0.200	0.225	0.250	0.325	0.300	0.350	0.350	0.450	0.550	0.600	0.650
36	0.050	0.050	0.050	0.075	0.075	0.075	0.075	0.100	0.100	0.100	0.150	0.175	0.204	0.225
37	0.100	0.050	0.050	0.050	0.075	0.075	0.050	0.100	0.150	0.150	0.250	0.350	0.450	0.500
38	0.100	0.050	0.100	0.100	0.125	0.125	0.120	0.130	0.150	0.150	0.200	0.253	0.300	0.350
39	0.150	0.100	0.125	0.125	0.175	0.200	0.300	0.300	0.300	0.300	0.350	0.400	0.450	0.500
2421	4.500	3.700	4.000	4.000	4.000	4.000	4.150	3.800	3.969	3.938	3.613	3.628	3.611	3.549
2436	1.000	0.800	0.800	0.900	0.800	0.800	0.800	0.800	0.813	0.825	0.898	0.932	0.950	0.941
24XX	2.700	2.000	2.300	2.500	2.100	2.450	2.500	2.475	2.585	2.642	2.681	2.665	2.636	2.596
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2631	0.550	0.600	0.650	0.750	0.750	0.775	0.750	0.750	0.758	0.754	0.729	0.692	0.652	0.610
26XX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2812	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2819	0.200	0.200	0.200	0.200	0.190	0.180	0.180	0.180	0.183	0.184	0.187	0.185	0.183	0.180
28XX	0.100	0.075	0.050	0.050	0.050	0.050	0.050	0.050	0.052	0.052	0.054	0.056	0.057	0.057
3334	1.250	0.783	0.900	0.900	0.850	0.750	0.750	0.800	0.900	0.900	0.900	0.900	0.900	0.900
Subtotal	13.775	9.983	11.100	11.975	11.545	11.890	12.235	11.865	12.759	12.945	13.642	14.387	15.015	15.308

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

High Scenario - Western Montana
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	7.500	6.500	6.400	6.400	6.400	6.700	6.650	6.700	7.238	7.467	8.703	9.622	10.285	10.859
50-51	3.800	3.200	3.250	3.300	3.400	3.325	3.275	3.375	3.589	3.742	4.600	5.363	6.044	6.730
52,53 +	8.000	7.800	7.900	8.000	8.200	8.200	8.650	8.700	9.194	9.561	11.599	13.347	14.845	16.313
54	2.900	2.700	2.800	2.900	3.000	2.725	2.825	2.800	2.875	2.925	3.548	4.083	4.541	4.990
58	7.500	7.400	7.300	7.300	7.500	7.225	7.475	7.500	7.797	7.972	10.111	12.167	14.153	16.262
60-67	3.700	3.500	3.500	3.700	3.400	3.550	3.650	3.650	3.799	3.858	4.747	5.539	6.249	6.965
70	2.500	2.400	2.500	2.700	2.700	2.800	2.900	2.900	3.030	3.152	3.830	4.413	4.916	5.410
72	0.800	0.800	0.800	0.850	0.900	0.900	0.875	0.900	0.986	1.032	1.294	1.538	1.768	2.007
73	1.000	1.000	1.100	1.200	1.700	1.950	2.175	2.200	2.328	2.452	3.164	3.874	4.586	5.362
76	0.300	0.300	0.300	0.300	0.300	0.275	0.350	0.350	0.400	0.400	0.450	0.513	0.589	0.669
80	6.400	6.800	7.100	7.400	7.650	8.100	8.300	8.400	9.061	9.525	12.188	14.793	17.359	20.121
81	0.500	0.500	0.500	0.550	0.600	0.625	0.700	0.700	0.750	0.801	1.005	1.108	1.312	1.535
82,941	8.900	9.300	9.500	9.700	9.775	9.700	9.500	9.400	10.377	10.733	12.664	14.174	15.337	16.395
83	1.400	1.300	1.300	1.300	1.200	1.275	1.525	1.500	1.619	1.683	1.846	2.092	2.423	2.772
89	1.000	1.000	1.000	0.950	0.700	0.700	0.800	0.800	0.857	0.903	1.006	1.196	1.375	1.561
75,78 +	3.300	3.300	3.300	3.325	3.325	3.325	3.450	3.500	3.586	3.738	4.586	5.336	6.002	6.670
90-99	8.300	7.500	7.300	7.300	7.400	7.400	7.400	7.400	8.558	8.852	10.444	11.690	12.649	13.522
Const	4.800	4.000	4.000	4.000	3.800	3.250	2.800	2.700	3.279	3.428	4.270	5.045	5.761	6.500
Agric	7.500	7.400	7.300	7.300	7.300	7.300	7.300	7.300	7.372	7.406	7.441	7.439	7.607	7.769
Mining	3.100	2.675	2.150	1.800	1.875	1.950	2.075	2.100	2.500	2.600	2.800	3.200	3.500	3.800
Fd Gvt	5.600	5.200	5.200	5.100	4.850	4.700	4.900	4.900	5.100	5.200	5.600	6.000	6.500	7.100
Subtotal	88.800	84.575	84.500	85.375	85.975	85.975	87.575	87.775	94.295	97.430	115.896	132.532	147.801	163.312
Total	102.575	94.558	95.600	97.350	97.520	97.865	99.810	99.640	107.054	110.375	129.538	146.919	162.816	178.620

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

High Scenario - Western Montana
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	82.214	83.540	84.263	85.377	84.997	84.954	85.928	86.893	94.635	100.491	120.859	137.946	151.095	165.687
MF[b]	8.895	9.440	9.731	10.132	10.127	10.216	10.254	10.292	10.756	11.100	12.253	13.187	13.861	14.613
MO[c]	15.291	16.220	16.706	17.391	17.276	17.331	17.318	17.288	18.257	18.926	20.660	21.469	21.418	21.576
Total	106.400	109.200	110.700	112.900	112.400	112.500	113.500	114.474	123.648	130.517	153.773	172.603	186.374	201.876

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	294.500	294.300	299.700	300.500	303.900	304.900	304.700	304.500	321.484	323.682	359.828	386.630	417.478	452.203

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	106.400	109.200	110.700	112.900	112.400	112.500	113.500	114.474	123.648	130.517	153.773	172.603	186.374	201.876

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	7,793.00	7,717.00	7,916.00	8,105.00	7,983.00	8,360.00	8,666.10	8,983.50	9,312.50	9,653.50	11,555.40	13,832.00	16,557.10	19,819.10

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium-high Scenario - Region
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	73.900	72.700	72.200	72.050	71.965	70.700	72.325	73.500	73.900	74.200	73.800	72.700	72.700	71.400
22	3.000	2.800	2.650	2.650	2.550	2.650	3.000	3.200	3.050	3.050	3.050	3.150	3.150	3.150
23	10.025	8.825	8.725	9.600	8.900	8.710	8.750	9.250	9.600	9.700	10.050	10.375	10.575	10.675
25	6.150	5.300	6.050	6.825	7.240	7.350	6.950	7.100	7.700	7.700	8.250	8.600	8.809	8.800
27	29.650	29.500	30.300	32.375	34.000	35.600	37.775	39.925	41.350	42.200	44.600	46.900	48.800	50.000
29	2.800	2.300	2.300	2.325	2.225	2.425	2.550	2.700	2.800	2.800	3.000	3.200	3.300	3.300
30	6.900	6.675	6.850	7.675	8.575	8.975	9.675	9.825	10.250	10.650	10.975	11.175	11.700	12.300
31	0.700	0.750	0.950	1.050	0.925	1.025	1.180	1.390	1.400	1.400	1.500	1.450	1.450	1.450
32	13.100	10.450	10.200	10.400	10.725	10.600	10.980	11.390	11.900	11.900	12.380	12.750	13.021	13.400
33XX	20.800	15.850	13.750	14.650	15.350	15.450	15.325	17.275	17.800	18.200	18.600	18.800	18.950	19.050
34	26.750	21.400	20.650	22.325	22.850	22.850	22.875	24.250	25.150	25.550	26.300	26.900	27.600	28.400
35	37.750	38.400	35.950	38.200	38.625	37.750	37.325	39.600	42.800	44.900	50.800	55.850	60.900	64.725
36	22.550	22.350	23.150	28.975	28.875	28.375	29.775	32.400	34.400	35.700	39.350	42.875	45.704	48.225
37	109.450	100.800	88.200	91.700	99.825	108.525	118.250	128.450	133.350	137.550	135.600	133.550	131.500	130.500
38	25.950	25.450	24.550	25.000	25.725	23.925	23.220	23.530	24.540	25.150	27.800	30.925	34.353	38.075
39	7.350	6.650	6.925	7.675	7.400	7.600	8.400	9.200	9.500	9.600	9.650	9.600	9.700	9.800
2421	52.427	43.030	46.440	47.725	44.300	44.200	45.850	45.400	43.623	42.265	35.433	34.658	34.387	34.386
2436	26.582	21.430	22.350	22.205	20.900	21.300	22.100	22.000	20.342	19.621	14.473	13.709	13.542	13.091
24XX	61.066	48.840	57.010	59.670	57.100	57.850	60.000	61.375	61.777	62.115	60.752	58.711	56.669	54.637
2611	2.974	2.300	2.050	2.075	2.100	2.100	2.100	2.100	2.074	2.060	1.976	1.881	1.780	1.677
2621	14.143	13.048	12.520	13.295	13.410	13.400	13.350	13.350	13.417	13.441	12.894	12.592	12.146	11.610
2631	5.037	4.999	5.050	4.639	5.000	5.025	4.900	4.800	4.775	4.721	4.418	4.096	3.783	3.484
26XX	7.896	7.453	7.730	7.466	7.815	7.825	7.900	8.000	8.099	8.106	8.378	8.558	8.557	8.031
2812	0.763	0.700	0.650	0.650	0.700	0.700	0.700	0.700	0.709	0.711	0.717	0.720	0.716	0.704
2819	6.567	7.250	7.775	8.200	8.890	8.880	8.780	7.680	7.882	8.084	8.587	8.777	8.686	8.578
28XX	7.470	7.375	7.425	7.400	7.650	8.300	7.650	7.850	7.740	7.764	7.823	7.848	7.800	7.690
3334	10.350	6.883	7.400	8.900	7.250	5.750	5.950	6.500	6.400	6.500	6.300	6.200	6.200	6.200
Subtotal	592.100	533.508	529.800	555.700	560.870	567.840	587.635	612.740	626.328	635.638	637.456	646.550	656.478	663.339

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-high Scenario - Region
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	179.500	171.400	168.800	173.500	176.500	178.600	181.250	187.700	192.871	196.211	206.698	216.237	223.826	230.716
50-51	194.000	188.400	187.950	193.800	195.700	198.325	203.575	211.975	220.952	228.693	262.914	300.463	337.748	378.109
52,53+	275.100	255.000	261.600	276.100	279.300	287.900	297.850	312.630	324.263	333.361	374.099	416.498	458.546	502.775
54	75.100	82.450	84.600	88.100	92.400	96.525	101.125	107.363	110.516	113.227	128.168	141.117	155.364	170.350
58	195.500	197.350	203.000	211.800	218.400	226.125	233.975	243.095	253.481	263.848	323.217	385.742	452.712	529.162
60-67	188.900	181.800	183.300	188.300	193.400	202.150	201.450	205.050	215.639	221.622	258.300	293.924	328.975	366.698
70	40.200	38.900	39.500	41.400	42.600	44.400	46.300	47.575	49.433	51.094	60.325	69.401	78.533	88.507
72	29.600	30.900	31.500	33.350	35.000	36.000	37.575	39.000	40.272	41.274	45.690	50.259	54.369	58.575
73	89.800	81.800	87.400	99.500	109.800	116.050	124.375	133.456	140.001	145.943	180.367	221.717	268.040	322.740
76	9.800	8.700	9.100	10.000	10.500	10.875	11.650	12.244	12.489	12.793	14.216	15.635	16.914	18.220
80	179.800	190.900	196.200	205.100	212.350	221.000	231.500	244.994	256.200	265.433	314.811	371.553	431.230	498.527
81	17.400	19.400	20.300	21.550	22.700	23.925	25.600	27.412	28.635	29.886	36.738	44.936	54.052	64.757
82,941	299.400	284.300	286.750	297.100	303.775	309.700	315.000	321.460	331.307	339.615	383.817	422.655	457.735	493.684
83	31.800	32.000	35.200	38.800	41.800	44.275	47.325	50.050	51.814	53.529	62.899	73.203	83.939	95.856
89	36.400	34.200	33.700	34.750	36.000	37.800	40.300	42.457	43.639	44.912	51.022	57.569	63.952	70.751
75,78+	122.600	125.900	132.800	136.125	141.125	148.925	158.950	166.313	170.489	174.636	192.713	209.880	226.005	242.362
90-99	230.300	226.100	226.000	229.300	236.100	241.100	248.300	252.950	261.543	268.174	303.448	335.070	363.883	393.552
Const	161.300	122.900	118.400	128.400	132.600	136.650	138.300	152.300	162.226	169.245	186.812	202.666	224.084	247.811
Agric	292.200	286.600	297.200	291.100	286.600	286.900	286.200	285.055	285.400	285.100	283.700	282.300	280.900	279.399
Mining	13.300	11.275	10.550	10.200	9.875	9.150	9.075	10.050	10.800	11.500	12.300	13.400	14.100	14.500
Fd Gvt	117.300	112.600	113.700	115.100	116.350	115.300	117.700	117.400	122.700	126.700	134.000	141.800	150.100	158.900
Subtotal	2,779.300	2,682.875	2,727.550	2,823.375	2,892.875	2,971.675	3,057.375	3,170.529	3,284.670	3,376.796	3,816.254	4,266.025	4,725.007	5,225.951
Total	3,371.400	3,216.383	3,257.350	3,379.075	3,453.746	3,539.515	3,645.010	3,783.269	3,910.998	4,012.435	4,453.709	4,912.575	5,381.486	5,889.290

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-high Scenario - Region
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF	2,303.987	2,366.045	2,368.271	2,402.532	2,429.137	2,454.883	2,490.564	2,533.916	2,607.261	2,661.811	2,928.592	3,199.375	3,483.388	3,756.171
MF	427.934	458.244	462.080	478.017	491.921	505.730	517.139	530.758	551.577	567.991	646.591	725.790	809.066	890.211
MO	230.752	254.912	257.349	270.351	280.342	289.888	297.797	307.282	323.899	335.758	390.559	440.811	490.068	535.615
Total	2,962.673	3,079.200	3,087.700	3,150.900	3,201.400	3,250.500	3,305.500	3,371.957	3,482.737	3,565.561	3,965.742	4,365.976	4,782.523	5,181.997

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	8,003.820	8,207.490	8,226.700	8,308.500	8,389.700	8,431.400	8,530.700	8,663.500	8,904.202	9,070.876	9,730.716	10,443.991	11,201.167	12,032.201

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	2,962.673	3,079.200	3,087.700	3,150.900	3,201.400	3,250.500	3,305.500	3,371.956	3,482.737	3,565.561	3,965.742	4,365.976	4,782.522	5,181.997

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	10,347.04	9,914.80	10,132.77	10,303.97	10,478.86	10,839.25	11,043.76	11,249.91	11,454.54	11,666.26	12,769.88	13,974.68	15,290.19	16,732.84

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium-high Scenario - Washington
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	31.900	31.800	31.100	30.800	31.100	31.100	31.900	32.500	32.500	32.500	32.600	32.300	32.300	31.700
22	1.000	0.900	0.900	0.900	0.900	1.000	1.100	1.100	1.100	1.100	1.200	1.300	1.300	1.300
23	6.500	5.700	5.900	6.500	6.200	6.100	5.900	6.100	6.500	6.600	7.000	7.300	7.500	7.600
25	3.300	2.900	3.200	3.500	3.800	3.900	3.700	3.700	4.200	4.200	4.600	5.000	5.206	5.200
27	15.800	15.800	16.000	16.900	17.600	18.700	20.100	21.200	21.800	22.200	23.000	23.900	24.800	25.600
29	2.100	1.800	1.800	1.800	1.800	1.900	2.000	2.100	2.100	2.100	2.300	2.500	2.600	2.600
30	3.500	3.525	3.600	4.200	4.500	4.600	4.900	5.100	5.400	5.700	5.900	6.100	6.400	6.800
31	0.400	0.400	0.400	0.400	0.400	0.500	0.500	0.600	0.600	0.600	0.700	0.700	0.700	0.700
32	6.900	6.000	6.000	6.500	6.400	6.200	6.500	6.600	6.700	6.700	7.000	7.200	7.400	7.700
33XX	9.000	8.500	7.200	6.400	6.900	7.200	6.700	7.500	8.000	8.300	8.600	8.800	9.000	9.100
34	11.800	9.900	9.400	9.900	9.700	10.000	10.400	11.000	11.500	11.700	12.000	12.300	12.600	13.000
35	15.000	16.600	15.300	16.400	17.100	17.600	16.300	17.600	19.000	20.000	22.500	24.500	26.500	28.500
36	11.200	10.600	10.300	11.800	12.100	12.700	13.100	13.600	14.800	15.500	17.000	18.500	19.500	20.300
37	98.350	92.100	80.200	82.200	89.600	97.500	106.000	114.300	119.000	123.000	121.000	119.000	117.000	116.000
38	6.400	8.400	9.400	10.200	10.700	10.400	10.700	11.000	11.700	12.100	13.400	14.900	16.700	18.400
39	4.600	4.000	4.200	4.600	4.500	4.600	4.700	5.100	5.200	5.300	5.500	5.600	5.700	5.800
2421	16.027	14.200	14.950	14.700	13.400	13.400	13.900	13.600	13.231	13.057	10.748	10.405	10.281	10.308
2436	4.982	4.100	4.250	4.200	4.200	4.200	4.300	4.100	3.948	3.796	2.791	2.640	2.631	2.571
24XX	25.991	20.700	23.000	22.400	20.700	20.800	21.800	22.300	22.424	22.320	21.830	21.097	20.363	19.633
2611	2.974	2.300	2.050	2.075	2.100	2.100	2.100	2.100	2.074	2.060	1.976	1.881	1.780	1.677
2621	8.818	8.100	7.900	8.900	9.000	9.000	8.900	9.000	8.972	8.925	8.558	8.357	8.061	7.706
2631	1.637	1.600	1.575	1.000	1.200	1.200	1.100	1.100	1.077	1.065	0.997	0.924	0.854	0.786
26XX	4.171	4.100	4.275	4.025	4.400	4.400	4.400	4.500	4.532	4.530	4.789	4.897	4.856	4.484
2812	0.513	0.500	0.450	0.450	0.500	0.500	0.500	0.500	0.506	0.508	0.512	0.515	0.511	0.503
2819	5.300	6.000	6.575	7.000	7.700	7.700	7.700	6.600	6.800	7.000	7.500	7.700	7.620	7.525
28XX	2.887	3.000	3.075	3.050	3.100	3.300	3.300	3.300	3.354	3.365	3.390	3.401	3.380	3.333
3334	7.700	5.200	5.400	7.000	5.800	4.400	4.500	4.800	4.800	4.900	4.700	4.700	4.700	4.700
Subtotal	308.750	288.725	278.400	287.800	295.400	305.000	317.000	331.000	341.818	349.125	352.092	356.417	360.243	363.524

[a] See Standard Industrial Classification codes in Appendix 1-B, Table 1-B-1.

Medium-high Scenario - Washington
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	91.400	89.000	87.900	90.900	93.600	96.200	98.400	103.000	105.534	108.001	113.023	117.871	122.237	126.236
50-51	100.500	100.900	100.500	104.700	105.700	107.300	110.500	114.500	118.005	121.946	143.467	164.463	185.440	208.236
52,53+	141.000	133.900	137.700	143.900	146.900	153.500	159.700	167.370	174.030	179.001	200.601	225.296	248.867	273.774
54	38.200	43.850	44.700	47.000	49.200	51.400	53.500	56.863	58.659	59.908	67.202	75.475	83.371	91.715
58	101.600	106.750	111.000	116.000	118.900	124.300	129.400	134.545	140.606	146.567	180.129	215.670	253.929	297.761
60-67	91.800	90.700	92.300	95.700	99.600	105.200	107.000	108.300	114.046	117.741	137.851	157.257	176.452	197.177
70	17.800	17.700	18.600	19.600	20.100	21.000	22.500	23.065	24.075	24.903	29.440	33.913	38.425	43.360
72	16.000	17.400	17.800	19.100	19.900	20.800	22.300	23.348	24.143	24.736	27.194	29.979	32.504	35.095
73	52.900	46.500	49.000	55.600	61.000	63.700	68.400	73.206	77.396	81.043	99.737	122.912	148.967	179.816
76	5.500	4.700	5.000	5.300	5.600	5.800	6.200	6.494	6.718	6.883	7.561	8.335	9.037	9.757
80	95.800	102.300	105.800	112.800	117.400	121.900	129.400	138.994	145.267	150.905	177.382	210.340	245.266	284.828
81	9.200	10.500	11.000	11.600	12.400	12.900	13.800	14.812	15.642	16.361	19.969	24.492	29.541	35.487
82,941	154.900	142.200	145.850	152.800	155.600	158.900	162.100	165.730	170.406	174.717	197.677	217.921	236.270	255.107
83	15.600	16.500	18.700	20.800	22.600	23.600	25.300	26.900	28.028	29.046	33.879	39.599	45.529	52.133
89	19.500	19.100	19.200	19.900	21.100	22.000	23.600	24.957	25.757	26.518	29.936	33.819	37.578	41.583
75,78+	66.800	72.600	77.300	81.000	83.500	87.200	93.600	98.013	101.004	103.001	113.255	124.243	134.043	144.018
90-99	117.400	119.300	120.700	124.100	129.100	132.700	135.900	138.500	143.142	146.907	167.024	185.034	201.603	218.750
Const	92.600	76.200	74.200	79.600	80.600	84.500	87.300	98.000	103.005	108.040	118.006	128.015	141.962	158.016
Agric	119.300	116.300	118.700	117.200	115.100	115.300	114.400	113.300	112.795	112.090	112.611	111.609	111.327	110.678
Mining	3.200	3.000	2.700	2.600	2.700	2.900	3.000	3.300	3.300	3.400	3.500	3.600	3.600	3.700
Fd Gvt	67.900	66.300	67.600	68.900	70.100	69.200	70.500	69.700	73.700	77.200	81.700	86.500	91.600	96.900
Subtotal	1,418.900	1,395.700	1,426.250	1,489.100	1,530.700	1,580.300	1,636.800	1,702.897	1,765.258	1,818.914	2,061.144	2,316.343	2,577.548	2,864.127
Total	1,727.650	1,684.425	1,704.650	1,776.900	1,826.100	1,885.300	1,953.800	2,033.897	2,107.076	2,168.039	2,413.236	2,672.760	2,937.791	3,227.652

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-high Scenario - Washington
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	1,192.724	1,230.373	1,232.542	1,250.107	1,267.116	1,283.573	1,306.945	1,334.446	1,375.499	1,411.547	1,567.589	1,717.449	1,869.696	2,017.297
MF[b]	250.672	273.185	276.354	287.123	297.674	308.007	316.147	325.575	339.175	351.261	404.572	456.437	509.415	561.267
MO[c]	97.114	111.442	113.105	119.771	126.210	132.420	137.907	144.275	153.700	161.874	195.675	225.531	253.955	280.371
Total	1,540.510	1,615.000	1,622.000	1,657.000	1,691.000	1,724.000	1,761.000	1,804.297	1,868.373	1,924.682	2,167.836	2,399.418	2,633.066	2,858.935

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	4,132.160	4,279.000	4,304.000	4,349.000	4,406.000	4,463.000	4,538.000	4,619.000	4,745.667	4,850.199	5,246.164	5,662.627	6,082.383	6,546.960

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	1,540.510	1,615.000	1,622.000	1,657.000	1,691.000	1,724.000	1,761.000	1,804.297	1,868.373	1,924.682	2,167.836	2,399.418	2,633.066	2,858.935

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	10,727.00	10,440.00	10,629.00	10,780.00	10,977.00	11,414.00	11,604.10	11,797.30	11,993.80	12,193.50	13,243.20	14,383.30	15,621.50	16,966.30

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium-high Scenario - Oregon
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	24.300	23.700	24.200	24.100	23.800	23.700	23.800	23.200	23.800	24.100	23.800	23.500	23.500	23.100
22	2.000	1.900	1.700	1.700	1.600	1.600	1.800	2.000	1.900	1.900	1.800	1.800	1.800	1.800
23	3.200	2.700	2.600	2.800	2.400	2.300	2.500	2.800	2.800	2.800	2.800	2.800	2.800	2.800
25	2.600	2.200	2.400	2.700	2.700	2.700	2.500	2.600	2.700	2.700	2.800	2.800	2.803	2.800
27	10.000	10.000	10.400	11.000	11.500	12.000	12.700	13.500	14.200	14.500	15.400	16.100	16.600	17.000
29	0.600	0.500	0.500	0.500	0.400	0.500	0.500	0.550	0.600	0.600	0.600	0.600	0.600	0.600
30	2.400	2.300	2.500	2.800	3.200	3.400	3.800	3.900	4.000	4.100	4.200	4.300	4.500	4.700
31	0.300	0.300	0.500	0.500	0.400	0.400	0.500	0.600	0.600	0.600	0.600	0.600	0.600	0.600
32	4.500	3.400	3.000	2.700	3.100	3.300	3.400	3.700	4.000	4.000	4.100	4.200	4.200	4.200
33XX	9.600	7.200	6.400	8.100	8.200	8.000	8.500	9.400	9.400	9.500	9.600	9.600	9.600	9.600
34	12.700	9.700	9.400	10.400	11.000	10.600	10.200	11.000	11.300	11.400	11.700	12.000	12.300	12.600
35	17.700	16.500	15.200	15.900	15.500	15.000	15.500	16.100	17.500	18.100	20.000	22.000	23.500	25.000
36	9.800	10.100	10.700	13.800	13.900	12.900	13.400	14.900	15.600	16.100	17.800	19.500	21.000	22.500
37	10.300	7.900	7.100	8.500	9.200	10.100	11.100	12.800	13.000	13.200	13.200	13.200	13.200	13.200
38	19.300	16.800	14.800	14.400	14.600	13.100	12.100	12.000	12.300	12.500	13.600	15.000	16.500	18.400
39	2.200	2.300	2.300	2.600	2.400	2.500	3.100	3.400	3.600	3.600	3.400	3.300	3.300	3.300
2421	23.800	18.630	20.390	21.925	20.500	20.600	21.600	21.700	20.688	19.879	16.047	15.496	15.303	15.338
2436	20.100	16.230	16.900	16.680	15.500	15.900	16.600	16.700	15.171	14.564	10.308	9.621	9.436	9.038
24XX	25.600	20.740	25.310	28.095	27.600	28.100	29.200	29.500	29.860	30.195	29.533	28.540	27.548	26.560
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	5.100	4.723	4.395	4.145	4.160	4.150	4.200	4.100	4.193	4.266	4.090	3.995	3.854	3.683
2631	2.000	1.949	1.925	1.939	2.100	2.100	2.100	2.000	2.010	1.987	1.860	1.724	1.592	1.466
26XX	3.300	2.928	2.980	2.916	2.840	2.850	2.900	2.900	2.946	2.949	2.942	3.001	3.034	2.893
2812	0.250	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.203	0.203	0.205	0.206	0.204	0.201
2819	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28XX	2.050	1.900	2.000	1.800	1.900	1.800	1.900	1.900	1.931	1.937	1.952	1.958	1.946	1.919
3334	1.400	0.900	1.100	1.000	0.600	0.600	0.700	0.900	0.800	0.800	0.800	0.700	0.700	0.700
Subtotal	215.100	185.700	188.900	201.200	199.300	198.400	204.800	212.350	215.101	216.480	213.136	216.542	220.420	223.999

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-high Scenario - Oregon
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	60.500	56.800	55.400	57.100	57.300	57.200	58.300	59.600	61.598	62.017	65.713	68.946	71.146	73.109
50-51	67.400	62.700	62.600	64.500	65.800	67.400	69.100	74.000	77.507	80.500	88.817	101.172	113.354	126.483
52,53 +	96.200	85.300	87.700	92.900	92.900	95.100	98.100	104.060	108.030	111.011	124.004	136.134	149.420	163.329
54	24.600	26.400	27.200	27.900	29.500	31.700	33.700	36.350	37.300	38.409	44.005	46.766	51.330	56.108
58	67.400	64.300	65.100	67.600	70.400	73.100	75.400	78.400	81.615	84.913	103.359	122.563	142.914	165.966
60-67	70.000	64.900	64.500	65.400	66.800	69.500	71.700	73.700	77.473	79.068	91.660	104.055	116.186	129.199
70	14.800	13.700	13.400	14.000	14.600	14.900	15.200	15.560	16.232	16.774	19.735	22.623	25.508	28.644
72	9.800	9.600	9.600	9.900	10.400	10.600	10.800	10.952	11.331	11.607	13.068	14.336	15.466	16.617
73	24.900	23.200	25.600	31.300	35.000	38.200	40.900	44.150	45.878	47.509	59.185	72.588	87.552	105.176
76	3.000	2.800	2.900	3.400	3.500	3.800	4.100	4.300	4.302	4.406	4.961	5.442	5.872	6.308
80	62.100	65.300	66.400	67.500	69.400	72.500	74.700	77.800	81.547	84.040	100.835	118.419	136.748	157.316
81	5.600	6.300	6.600	7.100	7.300	8.000	8.600	9.200	9.518	9.856	12.350	15.074	18.094	21.632
82,941	100.700	98.700	97.500	99.500	102.200	104.300	105.900	107.530	111.261	114.043	128.840	141.826	153.541	165.538
83	11.400	11.000	11.800	13.000	14.000	15.300	16.400	17.300	17.716	18.257	21.793	25.348	29.003	33.048
89	11.100	9.700	9.300	9.800	10.300	11.200	12.000	12.600	12.841	13.128	15.222	17.196	19.107	21.144
75,78 +	42.200	40.700	42.400	41.500	43.500	47.400	50.800	53.400	54.205	56.034	62.019	66.578	71.477	76.418
90-99	78.200	74.000	72.400	72.200	73.500	74.700	77.300	78.600	81.213	83.244	94.045	103.524	112.075	120.832
Const	46.500	28.900	27.000	30.200	33.100	34.300	34.500	37.400	40.129	41.543	46.063	49.439	54.934	60.788
Agric	96.300	96.800	103.400	100.100	98.800	99.000	99.700	100.300	101.455	102.338	101.401	101.472	100.897	100.380
Mining	2.300	1.800	1.600	1.600	1.500	1.400	1.400	1.400	1.800	1.900	2.100	2.300	2.500	2.500
Fd Gvt	30.800	29.100	29.000	29.300	29.600	29.600	30.200	30.500	31.300	31.500	33.300	35.300	37.400	39.600
Subtotal	925.800	872.000	881.400	905.800	929.400	959.200	988.800	1,027.102	1,064.251	1,092.097	1,232.475	1,371.101	1,514.524	1,670.135
Total	1,140.900	1,057.700	1,070.300	1,107.000	1,128.700	1,157.600	1,193.600	1,239.452	1,279.352	1,308.577	1,445.611	1,587.643	1,734.944	1,894.134

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-high Scenario - Oregon
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	766.660	781.211	778.769	789.367	796.264	804.424	815.206	830.382	852.995	865.408	937.415	1,013.609	1,103.367	1,191.057
MF[b]	143.285	148.654	148.547	152.229	154.855	157.862	160.797	164.771	170.497	173.840	193.004	213.325	236.963	260.198
MO[c]	81.648	87.136	86.684	90.403	92.880	95.714	97.997	101.247	106.178	108.627	122.005	134.447	148.892	162.862
Total	991.593	1,017.000	1,014.000	1,032.000	1,044.000	1,058.000	1,074.000	1,096.400	1,129.671	1,147.875	1,252.425	1,361.381	1,489.222	1,614.117

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION	2,633.160	2,656.190	2,635.000	2,660.000	2,675.800	2,661.500	2,690.000	2,741.000	2,824.177	2,869.686	3,043.392	3,240.087	3,469.888	3,728.610

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS	991.593	1,017.000	1,014.000	1,032.000	1,044.000	1,058.000	1,074.000	1,096.400	1,129.671	1,147.875	1,252.425	1,361.381	1,489.222	1,614.117

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]	9,864.00	9,204.00	9,448.00	9,685.00	9,858.00	10,135.00	10,337.70	10,544.50	10,755.30	10,970.40	12,112.30	13,372.90	14,764.80	16,301.50

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium-high Scenario - Idaho
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	17.000	16.600	16.300	16.600	16.600	15.400	16.100	17.300	17.100	17.100	16.900	16.400	16.400	16.100
22	0.000	0.000	0.050	0.050	0.050	0.050	0.100	0.100	0.050	0.050	0.050	0.050	0.050	0.050
23	0.300	0.400	0.200	0.250	0.250	0.250	0.300	0.300	0.250	0.250	0.200	0.200	0.200	0.200
25	0.250	0.200	0.400	0.500	0.600	0.600	0.600	0.700	0.700	0.700	0.700	0.600	0.600	0.600
27	3.100	3.200	3.300	3.800	4.200	4.200	4.250	4.525	4.600	4.700	5.200	5.800	6.200	6.200
29	0.100	0.000	0.000	0.000	0.025	0.025	0.050	0.050	0.100	0.100	0.100	0.100	0.100	0.100
30	1.000	0.850	0.750	0.650	0.850	0.950	0.950	0.800	0.800	0.800	0.800	0.700	0.700	0.700
31	0.000	0.050	0.050	0.100	0.100	0.100	0.150	0.150	0.150	0.150	0.150	0.100	0.100	0.100
32	1.300	0.900	1.000	0.900	0.900	0.800	0.800	0.800	0.900	0.900	0.950	1.000	1.050	1.100
33XX	1.200	0.050	0.050	0.050	0.100	0.100	0.000	0.250	0.250	0.250	0.250	0.250	0.200	0.200
34	2.100	1.700	1.700	1.800	1.900	2.000	2.000	2.000	2.100	2.200	2.300	2.300	2.400	2.500
35	5.000	5.200	5.300	5.700	5.800	4.900	5.200	5.600	6.000	6.500	8.000	9.000	10.500	10.800
36	1.500	1.600	2.100	3.300	2.800	2.700	3.200	3.800	3.900	4.000	4.400	4.700	5.000	5.200
37	0.700	0.750	0.850	0.950	0.950	0.850	1.100	1.250	1.250	1.250	1.250	1.150	1.050	1.000
38	0.150	0.200	0.250	0.300	0.300	0.300	0.300	0.400	0.400	0.400	0.600	0.800	0.900	1.000
39	0.400	0.250	0.300	0.350	0.325	0.300	0.300	0.400	0.400	0.400	0.500	0.500	0.500	0.500
2421	8.100	6.500	7.100	7.100	6.400	6.200	6.200	6.300	6.038	5.795	5.307	5.380	5.407	5.369
2436	0.500	0.300	0.400	0.425	0.400	0.400	0.400	0.400	0.410	0.417	0.492	0.518	0.529	0.531
24XX	6.775	5.400	6.400	6.675	6.700	6.500	6.500	7.100	6.963	7.041	6.886	6.655	6.423	6.193
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	0.225	0.225	0.225	0.250	0.250	0.250	0.250	0.250	0.252	0.251	0.246	0.240	0.231	0.221
2631	0.850	0.850	0.900	0.950	0.950	0.950	0.950	0.950	0.943	0.933	0.873	0.809	0.747	0.688
26XX	0.425	0.425	0.475	0.525	0.575	0.575	0.600	0.600	0.622	0.627	0.647	0.660	0.667	0.654
2812	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2819	1.067	1.050	1.000	1.000	1.000	1.000	0.900	0.900	0.902	0.903	0.906	0.897	0.888	0.877
28XX	2.433	2.400	2.300	2.500	2.600	3.150	2.400	2.600	2.404	2.411	2.429	2.437	2.422	2.388
3334	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subtotal	54.475	49.100	51.400	54.725	54.625	52.550	53.600	57.525	57.483	58.128	60.135	61.247	63.265	63.272

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-high Scenario - Idaho
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	20.100	19.100	19.100	19.100	19.200	18.500	17.900	18.400	18.702	19.034	20.176	21.169	21.844	22.447
50-51	22.300	21.600	21.600	21.300	20.800	20.300	20.700	20.100	21.944	22.648	26.478	30.161	33.793	37.707
52,53 +	29.900	28.000	28.300	31.300	31.300	31.100	31.400	32.500	33.276	34.201	39.169	43.713	47.979	52.445
54	9.400	9.500	9.900	10.300	10.700	10.700	11.100	11.350	11.726	12.052	13.803	15.403	16.907	18.481
58	19.000	18.900	19.600	20.900	21.600	21.500	21.700	22.650	23.534	24.508	29.976	35.718	41.851	48.838
60-67	23.400	22.700	23.000	23.500	23.600	23.900	19.100	19.400	20.425	21.066	24.545	27.864	31.113	34.597
70	5.100	5.100	5.000	5.100	5.200	5.700	5.700	6.050	6.124	6.309	7.458	8.591	9.734	10.985
72	3.000	3.100	3.300	3.500	3.800	3.700	3.600	3.800	3.857	3.969	4.356	4.779	5.155	5.539
73	11.000	11.100	11.700	11.400	12.100	12.200	12.900	13.900	14.445	15.012	18.522	22.717	27.400	32.916
76	1.000	0.900	0.900	1.000	1.100	1.000	1.000	1.100	1.154	1.182	1.331	1.460	1.575	1.693
80	15.500	16.500	16.900	17.400	17.900	18.500	19.100	19.800	20.595	21.386	25.782	30.278	34.965	40.224
81	2.100	2.100	2.200	2.300	2.400	2.400	2.500	2.700	2.775	2.915	3.590	4.382	5.260	6.288
82,941	34.900	34.100	33.900	35.100	36.200	36.800	37.500	38.800	39.503	40.491	45.745	50.356	54.515	58.774
83	3.400	3.200	3.400	3.700	4.000	4.100	4.100	4.350	4.511	4.676	5.581	6.492	7.428	8.464
89	4.800	4.400	4.200	4.100	3.900	3.900	3.900	4.100	4.241	4.407	4.947	5.589	6.210	6.872
75,78 +	10.300	9.300	9.800	10.300	10.800	11.000	11.100	11.400	11.728	12.001	13.446	14.679	15.759	16.848
90-99	26.400	25.300	25.600	25.700	26.100	26.300	27.700	28.450	28.827	29.476	32.849	36.160	39.146	42.205
Const	17.400	13.800	13.200	14.600	15.100	14.600	13.700	14.200	15.926	16.410	19.027	21.075	22.659	24.068
Agric	69.100	66.100	67.800	66.500	65.400	65.300	64.800	64.155	63.824	63.333	62.416	62.051	61.447	61.060
Mining	4.700	3.800	4.100	4.200	3.800	2.900	2.600	3.250	3.400	3.700	4.000	4.500	4.700	4.700
Fd Gvt	13.000	12.000	11.900	11.800	11.800	11.800	12.100	12.300	12.700	12.900	13.700	14.500	15.300	16.200
Subtotal	345.800	330.600	335.400	343.100	346.800	346.200	344.200	352.755	363.217	371.676	416.897	461.637	504.740	551.351
Total	400.275	379.700	386.800	397.825	401.425	398.750	397.800	410.280	420.700	429.804	477.033	522.884	568.005	614.623

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-high Scenario - Idaho
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	262.388	270.920	272.697	277.681	280.759	281.932	282.712	282.652	288.666	292.811	320.039	353.084	385.658	414.456
MF[b]	25.082	26.965	27.448	28.533	29.265	29.645	29.845	29.929	30.866	31.542	35.859	41.027	46.161	50.792
MO[c]	36.700	40.114	40.855	42.786	43.976	44.423	44.442	44.205	45.574	46.405	51.770	57.820	63.175	67.502
Total	324.170	338.000	341.000	349.000	354.000	356.000	357.000	356.786	365.105	370.758	407.668	451.931	494.994	532.750

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION	944.000	978.000	988.000	999.000	1,004.000	1,002.000	998.000	999.000	1,018.643	1,030.706	1,096.626	1,175.020	1,262.234	1,347.858

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS	324.170	338.000	341.000	349.000	354.000	356.000	357.000	356.786	365.105	370.758	407.668	451.931	494.994	532.750

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]	8,570.00	8,058.00	8,293.00	8,329.00	8,437.00	8,535.00	8,710.50	8,889.60	9,072.40	9,258.90	10,250.70	11,348.70	12,564.40	13,910.30

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium-high Scenario - Western Montana
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	0.700	0.600	0.600	0.550	0.465	0.500	0.525	0.500	0.500	0.500	0.500	0.500	0.500	0.500
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.025	0.025	0.025	0.050	0.050	0.060	0.050	0.050	0.050	0.050	0.050	0.075	0.075	0.075
25	0.000	0.000	0.050	0.125	0.140	0.150	0.150	0.100	0.100	0.100	0.150	0.200	0.200	0.200
27	0.750	0.500	0.600	0.675	0.700	0.700	0.725	0.700	0.750	0.800	1.000	1.100	1.200	1.200
29	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.025	0.025	0.025	0.025	0.025	0.050	0.050	0.075	0.075	0.100	0.100
31	0.000	0.000	0.000	0.050	0.025	0.025	0.030	0.040	0.050	0.050	0.050	0.050	0.050	0.050
32	0.400	0.150	0.200	0.300	0.325	0.300	0.280	0.290	0.300	0.300	0.330	0.350	0.371	0.400
33XX	1.000	0.100	0.100	0.100	0.150	0.150	0.125	0.125	0.150	0.150	0.150	0.150	0.150	0.150
34	0.150	0.100	0.150	0.225	0.250	0.250	0.275	0.250	0.250	0.250	0.300	0.300	0.300	0.300
35	0.050	0.100	0.150	0.200	0.225	0.250	0.325	0.300	0.300	0.300	0.300	0.350	0.400	0.425
36	0.050	0.050	0.050	0.075	0.075	0.075	0.075	0.100	0.100	0.100	0.150	0.175	0.204	0.225
37	0.100	0.050	0.050	0.050	0.075	0.075	0.050	0.100	0.100	0.100	0.150	0.200	0.250	0.300
38	0.100	0.050	0.100	0.100	0.125	0.125	0.120	0.130	0.140	0.150	0.200	0.225	0.253	0.275
39	0.150	0.100	0.125	0.125	0.175	0.200	0.300	0.300	0.300	0.300	0.250	0.200	0.200	0.200
2421	4.500	3.700	4.000	4.000	4.000	4.000	4.150	3.800	3.666	3.534	3.331	3.377	3.396	3.371
2436	1.000	0.800	0.800	0.900	0.800	0.800	0.800	0.800	0.813	0.844	0.881	0.928	0.947	0.951
24XX	2.700	2.000	2.300	2.500	2.100	2.450	2.500	2.475	2.531	2.559	2.503	2.419	2.335	2.251
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2631	0.550	0.600	0.650	0.750	0.750	0.775	0.750	0.750	0.745	0.736	0.689	0.639	0.590	0.543
26XX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2812	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2819	0.200	0.200	0.200	0.200	0.190	0.180	0.180	0.180	0.181	0.181	0.181	0.180	0.178	0.176
28XX	0.100	0.075	0.050	0.050	0.050	0.050	0.050	0.050	0.051	0.051	0.051	0.052	0.051	0.051
3334	1.250	0.783	0.900	0.900	0.850	0.750	0.750	0.800	0.800	0.800	0.800	0.800	0.800	0.800
Subtotal	13.775	9.983	11.100	11.975	11.545	11.890	12.235	11.865	11.926	11.905	12.092	12.344	12.550	12.543

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-high Scenario - Western Montana
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	7.500	6.500	6.400	6.400	6.400	6.700	6.650	6.700	7.037	7.159	7.786	8.251	8.599	8.924
50-51	3.800	3.200	3.250	3.300	3.400	3.325	3.275	3.375	3.496	3.599	4.152	4.667	5.161	5.683
52,53 +	8.000	7.800	7.900	8.000	8.200	8.200	8.650	8.700	8.927	9.148	10.325	11.355	12.280	13.227
54	2.900	2.700	2.800	2.900	3.000	2.725	2.825	2.800	2.831	2.858	3.158	3.473	3.756	4.046
58	7.500	7.400	7.300	7.300	7.500	7.225	7.475	7.500	7.726	7.860	9.753	11.791	14.018	16.597
60-67	3.700	3.500	3.500	3.700	3.400	3.550	3.650	3.650	3.695	3.747	4.244	4.748	5.224	5.725
70	2.500	2.400	2.500	2.700	2.700	2.800	2.900	2.900	3.002	3.108	3.692	4.274	4.866	5.518
72	0.800	0.800	0.800	0.850	0.900	0.900	0.875	0.900	0.941	0.962	1.072	1.165	1.244	1.324
73	1.000	1.000	1.100	1.200	1.700	1.950	2.175	2.200	2.282	2.379	2.923	3.500	4.121	4.832
76	0.300	0.300	0.300	0.300	0.300	0.275	0.350	0.350	0.315	0.322	0.363	0.398	0.430	0.462
80	6.400	6.800	7.100	7.400	7.650	8.100	8.300	8.400	8.791	9.102	10.812	12.516	14.251	16.159
81	0.500	0.500	0.500	0.550	0.600	0.625	0.700	0.700	0.700	0.754	0.829	0.988	1.157	1.350
82,941	8.900	9.300	9.500	9.700	9.775	9.700	9.500	9.400	10.137	10.364	11.555	12.552	13.409	14.265
83	1.400	1.300	1.300	1.300	1.200	1.275	1.525	1.500	1.559	1.550	1.646	1.764	1.979	2.211
89	1.000	1.000	1.000	0.950	0.700	0.700	0.800	0.800	0.800	0.859	0.917	0.965	1.057	1.152
75,78 +	3.300	3.300	3.300	3.325	3.325	3.325	3.450	3.500	3.552	3.600	3.993	4.380	4.726	5.078
90-99	8.300	7.500	7.300	7.300	7.400	7.400	7.400	7.400	8.361	8.547	9.530	10.352	11.059	11.765
Const	4.800	4.000	4.000	4.000	3.800	3.250	2.800	2.700	3.166	3.252	3.716	4.137	4.529	4.939
Agric	7.500	7.400	7.300	7.300	7.300	7.300	7.300	7.300	7.326	7.339	7.272	7.168	7.229	7.281
Mining	3.100	2.675	2.150	1.800	1.875	1.950	2.075	2.100	2.300	2.500	2.700	3.000	3.300	3.600
Fd Gvt	5.600	5.200	5.200	5.100	4.850	4.700	4.900	4.900	5.000	5.100	5.300	5.500	5.800	6.200
Subtotal	88.800	84.575	84.500	85.375	85.975	85.975	87.575	87.775	91.944	94.109	105.738	116.944	128.195	140.338
Total	102.575	94.558	95.600	97.350	97.520	97.865	99.810	99.640	103.870	106.014	117.830	129.288	140.745	152.881

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-high Scenario - Western Montana
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	82.214	83.540	84.263	85.377	84.997	84.954	85.700	86.436	90.101	92.046	103.548	115.232	124.666	133.361
MF[b]	8.895	9.440	9.731	10.132	10.127	10.216	10.350	10.483	11.040	11.348	13.156	15.000	16.527	17.954
MO[c]	15.291	16.220	16.706	17.391	17.276	17.331	17.451	17.555	18.448	18.852	21.109	23.013	24.047	24.880
Total	106.400	109.200	110.700	112.900	112.400	112.500	113.500	114.474	119.588	122.246	137.813	153.245	165.240	176.195

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	294.500	294.300	299.700	300.500	303.900	304.900	304.700	304.500	315.713	320.284	344.533	366.256	386.662	408.772

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	106.400	109.200	110.700	112.900	112.400	112.500	113.500	114.474	119.588	122.246	137.813	153.245	165.240	176.195

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	7,793.00	7,717.00	7,916.00	8,105.00	7,983.00	8,360.00	8,527.20	8,697.80	8,871.70	9,049.10	9,991.00	11,030.90	12,179.00	13,446.70

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium Scenario - Region
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	73.900	72.700	72.200	72.050	71.965	70.700	72.325	73.500	73.250	72.400	70.675	68.825	67.650	65.850
22	3.000	2.800	2.650	2.650	2.550	2.650	3.000	3.200	3.150	2.950	2.850	2.800	2.800	2.800
23	10.025	8.825	8.725	9.600	8.900	8.710	8.750	9.250	9.400	9.450	9.400	9.375	9.425	9.425
25	6.150	5.300	6.050	6.825	7.240	7.350	6.950	7.100	7.200	7.400	7.650	7.875	7.980	7.975
27	29.650	29.500	30.300	32.375	34.000	35.600	37.775	39.925	40.900	41.625	42.750	43.750	44.250	44.550
29	2.800	2.300	2.300	2.325	2.225	2.425	2.550	2.700	2.675	2.675	2.575	2.575	2.525	2.475
30	6.900	6.675	6.850	7.675	8.575	8.975	9.675	9.825	9.788	9.988	10.450	10.750	10.963	11.013
31	0.700	0.750	0.950	1.050	0.925	1.025	1.180	1.390	1.326	1.326	1.276	1.276	1.276	1.276
32	13.100	10.450	10.200	10.400	10.725	10.600	10.980	11.390	11.495	11.500	11.540	11.575	11.711	11.800
33XX	20.800	15.850	13.750	14.650	15.350	15.450	15.325	17.275	17.525	17.625	17.750	17.850	17.950	18.000
34	26.750	21.400	20.650	22.325	22.850	22.850	22.875	24.250	24.700	24.850	25.225	25.450	25.900	26.325
35	37.750	38.400	35.950	38.200	38.625	37.750	37.325	39.600	41.950	43.350	46.500	49.800	53.050	56.225
36	22.550	22.350	23.150	28.975	28.875	28.375	29.775	32.400	33.200	33.450	35.600	37.225	39.404	41.375
37	109.450	100.800	88.200	91.700	99.825	108.525	118.250	128.450	131.900	134.600	128.125	121.200	112.325	111.500
38	25.950	25.450	24.550	25.000	25.725	23.925	23.220	23.530	23.240	23.500	25.425	27.775	30.353	32.975
39	7.350	6.650	6.925	7.675	7.400	7.600	8.400	9.200	9.200	9.150	8.900	8.675	8.725	8.775
2421	52.427	43.030	46.440	47.725	44.300	44.200	45.850	45.400	42.406	40.944	35.433	34.658	34.387	34.386
2436	26.582	21.430	22.350	22.205	20.900	21.300	22.100	22.000	20.041	19.046	14.048	13.306	13.145	12.707
24XX	61.066	48.840	57.010	59.670	57.100	57.850	60.000	61.375	60.299	59.578	56.028	53.308	50.721	48.259
2611	2.974	2.300	2.050	2.075	2.100	2.100	2.100	2.100	2.027	1.995	1.835	1.689	1.553	1.427
2621	14.143	13.048	12.520	13.295	13.410	13.400	13.350	13.350	13.242	13.124	12.427	12.023	11.561	11.048
2631	5.037	4.999	5.050	4.639	5.000	5.025	4.900	4.800	4.753	4.697	4.428	4.189	3.950	3.711
26XX	7.896	7.453	7.730	7.466	7.815	7.825	7.900	8.000	7.872	7.807	7.862	7.813	7.814	7.513
2812	0.763	0.700	0.650	0.650	0.700	0.700	0.700	0.700	0.701	0.702	0.705	0.713	0.717	0.716
2819	6.567	7.250	7.775	8.200	8.890	8.880	8.780	7.680	6.264	6.258	6.226	6.197	6.168	6.139
28XX	7.470	7.375	7.425	7.400	7.650	8.300	7.650	7.850	7.592	7.570	7.458	7.367	7.258	7.134
3334	10.350	6.883	7.400	8.900	7.250	5.750	5.950	6.500	6.200	6.100	5.900	5.650	5.600	5.600
Subtotal	592.100	533.508	529.800	555.700	560.870	567.840	587.635	612.740	612.296	613.659	599.042	593.691	589.161	590.979

a See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium Scenario - Region
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	179.500	171.400	168.800	173.500	176.500	178.600	181.250	187.700	191.135	193.425	200.176	206.655	211.124	213.911
50-51	194.000	188.400	187.950	193.800	195.700	198.325	203.575	211.975	216.668	220.859	246.628	276.361	305.383	336.067
52,53 +	275.100	255.000	261.600	276.100	279.300	287.900	297.850	312.630	315.923	321.011	348.599	378.728	408.116	437.912
54	75.100	82.450	84.600	88.100	92.400	96.525	101.125	107.363	108.547	109.556	117.430	128.314	138.267	148.358
58	195.500	197.350	203.000	211.800	218.400	226.125	233.975	243.095	249.403	257.231	306.809	361.689	420.417	486.845
60-67	188.900	181.800	183.300	188.300	193.400	202.150	201.450	205.050	211.244	214.929	241.620	269.160	295.709	323.449
70	40.200	38.900	39.500	41.400	42.600	44.400	46.300	47.575	48.618	49.765	57.100	64.501	72.036	80.124
72	29.600	30.900	31.500	33.350	35.000	36.000	37.575	39.000	39.544	40.168	42.988	46.454	49.501	52.533
73	89.800	81.800	87.400	99.500	109.800	116.050	124.375	133.456	137.311	141.605	169.116	203.807	242.190	286.665
76	9.800	8.700	9.100	10.000	10.500	10.875	11.650	12.244	12.242	12.417	13.317	14.350	15.249	16.137
80	179.800	190.900	196.200	205.100	212.350	221.000	231.500	244.994	250.927	255.795	287.602	327.009	367.046	410.593
81	17.400	19.400	20.300	21.550	22.700	23.925	25.600	27.412	28.098	28.911	34.455	41.317	48.855	57.541
82,941	299.400	284.300	286.750	297.100	303.775	309.700	315.000	321.460	324.748	329.375	358.388	384.945	408.263	431.260
83	31.800	32.000	35.200	38.800	41.800	44.275	47.325	50.050	50.991	52.289	59.344	68.148	77.168	87.028
89	36.400	34.200	33.700	34.750	36.000	37.800	40.300	42.457	43.028	43.793	49.022	55.154	61.188	67.601
75,78 +	122.600	125.900	132.800	136.125	141.125	148.925	158.950	166.313	168.968	171.515	180.961	195.066	207.353	219.505
90-99	230.300	226.100	226.000	229.300	236.100	241.100	248.300	252.950	256.270	259.785	283.395	304.598	323.115	341.834
Const	161.300	122.900	118.400	128.400	132.600	136.650	138.300	152.300	160.162	160.967	171.022	181.059	190.785	201.419
Agric	292.200	286.600	297.200	291.100	286.600	286.900	286.200	285.055	284.201	283.351	278.950	274.551	270.151	265.850
Mining	13.300	11.275	10.550	10.200	9.875	9.150	9.075	10.050	10.400	10.450	10.800	11.150	11.500	11.700
Fd Gvt	117.300	112.600	113.700	115.100	116.350	115.300	117.700	117.400	118.900	119.400	124.350	129.200	134.500	140.950
Subtotal	2,779.300	2,682.875	2,727.550	2,823.375	2,892.875	2,971.675	3,057.375	3,170.529	3,227.328	3,276.597	3,582.072	3,922.216	4,257.916	4,617.283
Total	3,371.400	3,216.383	3,257.350	3,379.075	3,453.746	3,539.515	3,645.010	3,783.269	3,839.624	3,890.256	4,181.114	4,515.906	4,847.077	5,208.262

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium Scenario - Region
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	2,303.987	2,366.045	2,368.271	2,402.532	2,429.137	2,454.883	2,487.248	2,526.792	2,576.427	2,614.986	2,806.716	3,008.648	3,209.937	3,396.174
MF[b]	427.934	458.244	462.080	478.017	491.921	505.730	519.151	535.076	554.000	569.347	643.834	722.294	801.292	876.607
MO[c]	230.752	254.912	257.349	270.351	280.342	289.888	299.102	310.088	323.973	334.574	384.405	431.904	475.331	514.001
Total	2,962.673	3,079.200	3,087.700	3,150.900	3,201.400	3,250.500	3,305.500	3,371.957	3,454.401	3,518.907	3,834.955	4,162.846	4,486.560	4,786.782

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	8,003.820	8,207.490	8,226.700	8,308.500	8,389.700	8,431.400	8,530.700	8,663.500	8,835.346	8,956.604	9,412.091	9,959.786	10,509.549	11,116.451

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	2,962.673	3,079.200	3,087.700	3,150.900	3,201.400	3,250.500	3,305.500	3,371.956	3,454.400	3,518.907	3,834.955	4,162.846	4,486.560	4,786.782

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	10,347.04	9,914.80	10,132.77	10,303.97	10,478.86	10,839.25	11,043.76	11,249.91	11,456.00	11,665.08	12,762.73	13,967.64	15,282.79	16,723.54

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium Scenario - Washington
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	31.900	31.800	31.100	30.800	31.100	31.100	31.900	32.500	32.100	31.600	31.200	30.450	29.950	29.150
22	1.000	0.900	0.900	0.900	0.900	1.000	1.100	1.100	1.100	1.100	1.100	1.150	1.150	1.150
23	6.500	5.700	5.900	6.500	6.200	6.100	5.900	6.100	6.300	6.450	6.650	6.750	6.800	6.800
25	3.300	2.900	3.200	3.500	3.800	3.900	3.700	3.700	3.900	4.150	4.350	4.550	4.653	4.650
27	15.800	15.800	16.000	16.900	17.600	18.700	20.100	21.200	21.700	22.100	22.400	22.600	22.800	23.000
29	2.100	1.800	1.800	1.800	1.800	1.900	2.000	2.100	2.100	2.100	2.000	2.050	2.050	2.000
30	3.500	3.525	3.600	4.200	4.500	4.600	4.900	5.100	5.300	5.500	5.800	5.900	6.000	6.050
31	0.400	0.400	0.400	0.400	0.400	0.500	0.500	0.600	0.600	0.600	0.600	0.600	0.600	0.600
32	6.900	6.000	6.000	6.500	6.400	6.200	6.500	6.600	6.600	6.600	6.700	6.700	6.800	6.900
33XX	9.000	8.500	7.200	6.400	6.900	7.200	6.700	7.500	7.800	8.000	8.100	8.200	8.300	8.350
34	11.800	9.900	9.400	9.900	9.700	10.000	10.400	11.000	11.300	11.300	11.400	11.400	11.600	11.850
35	15.000	16.600	15.300	16.400	17.100	17.600	16.300	17.600	18.500	19.400	20.500	21.800	23.100	24.950
36	11.200	10.600	10.300	11.800	12.100	12.700	13.100	13.600	13.900	14.050	14.750	15.150	16.400	17.600
37	98.350	92.100	80.200	82.200	89.600	97.500	106.000	114.300	117.700	120.400	115.000	108.950	100.350	99.500
38	6.400	8.400	9.400	10.200	10.700	10.400	10.700	11.000	11.300	11.850	12.650	13.650	14.900	16.050
39	4.600	4.000	4.200	4.600	4.500	4.600	4.700	5.100	5.100	5.100	5.100	5.100	5.150	5.200
2421	16.027	14.200	14.950	14.700	13.400	13.400	13.900	13.600	13.231	13.057	10.748	10.405	10.281	10.308
2436	4.982	4.100	4.250	4.200	4.200	4.200	4.300	4.100	3.890	3.685	2.709	2.563	2.554	2.495
24XX	25.991	20.700	23.000	22.400	20.700	20.800	21.800	22.300	21.801	21.600	20.132	19.155	18.226	17.341
2611	2.974	2.300	2.050	2.075	2.100	2.100	2.100	2.100	2.027	1.995	1.835	1.689	1.553	1.427
2621	8.818	8.100	7.900	8.900	9.000	9.000	8.900	9.000	8.862	8.711	8.247	7.980	7.674	7.332
2631	1.637	1.600	1.575	1.000	1.200	1.200	1.100	1.100	1.072	1.060	0.999	0.945	0.891	0.837
26XX	4.171	4.100	4.275	4.025	4.400	4.400	4.400	4.500	4.404	4.369	4.425	4.399	4.401	4.218
2812	0.513	0.500	0.450	0.450	0.500	0.500	0.500	0.500	0.501	0.501	0.504	0.509	0.512	0.511
2819	5.300	6.000	6.575	7.000	7.700	7.700	7.700	6.600	5.200	5.200	5.200	5.200	5.200	5.200
28XX	2.887	3.000	3.075	3.050	3.100	3.300	3.300	3.300	3.290	3.280	3.232	3.193	3.145	3.092
3334	7.700	5.200	5.400	7.000	5.800	4.400	4.500	4.800	4.700	4.700	4.500	4.300	4.300	4.300
Subtotal	308.750	288.725	278.400	287.800	295.400	305.000	317.000	331.000	334.278	338.458	330.832	325.337	319.340	320.862

[a] See Standard Industrial Classification codes in Appendix 1-B, Table 1-B-1.

Medium Scenario - Washington
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	91.400	89.000	87.900	90.900	93.600	96.200	98.400	103.000	105.020	107.041	111.019	114.198	116.460	117.362
50-51	100.500	100.900	100.500	104.700	105.700	107.300	110.500	114.500	115.687	118.371	134.631	151.340	167.748	185.170
52,53 +	141.000	133.900	137.700	143.900	146.900	153.500	159.700	167.370	168.101	170.280	186.817	204.783	221.371	238.315
54	38.200	43.850	44.700	47.000	49.200	51.400	53.500	56.863	57.443	58.041	62.584	68.603	74.160	79.836
58	101.600	106.750	111.000	116.000	118.900	124.300	129.400	134.545	138.242	142.887	170.969	202.189	235.761	273.869
60-67	91.800	90.700	92.300	95.700	99.600	105.200	107.000	108.300	111.738	114.185	129.050	144.189	158.885	174.307
70	17.800	17.700	18.600	19.600	20.100	21.000	22.500	23.065	23.644	24.237	27.831	31.592	35.361	39.418
72	16.000	17.400	17.800	19.100	19.900	20.800	22.300	23.348	23.701	24.160	25.599	27.732	29.626	31.518
73	52.900	46.500	49.000	55.600	61.000	63.700	68.400	73.206	75.911	78.720	93.563	113.077	134.755	159.938
76	5.500	4.700	5.000	5.300	5.600	5.800	6.200	6.494	6.589	6.685	7.089	7.661	8.164	8.664
80	95.800	102.300	105.800	112.800	117.400	121.900	129.400	138.994	142.000	144.407	161.547	184.023	207.192	232.594
81	9.200	10.500	11.000	11.600	12.400	12.900	13.800	14.812	15.343	15.894	18.732	22.530	26.720	31.561
82,941	154.900	142.200	145.850	152.800	155.600	158.900	162.100	165.730	166.868	169.304	184.625	199.025	211.570	223.974
83	15.600	16.500	18.700	20.800	22.600	23.600	25.300	26.900	27.542	28.293	32.033	36.897	41.908	47.406
89	19.500	19.100	19.200	19.900	21.100	22.000	23.600	24.957	25.427	26.011	28.852	32.512	36.125	39.975
75,78 +	66.800	72.600	77.300	81.000	83.500	87.200	93.600	98.013	100.148	102.104	107.027	115.659	123.253	130.802
90-99	117.400	119.300	120.700	124.100	129.100	132.700	135.900	138.500	140.035	142.150	155.395	167.928	178.954	189.914
Const	92.600	76.200	74.200	79.600	80.600	84.500	87.300	98.000	102.029	102.023	108.890	115.760	121.243	127.005
Agric	119.300	116.300	118.700	117.200	115.100	115.300	114.400	113.300	112.321	111.402	110.726	108.545	107.066	105.311
Mining	3.200	3.000	2.700	2.600	2.700	2.900	3.000	3.300	3.300	3.100	3.100	3.150	3.250	3.300
Fd Gvt	67.900	66.300	67.600	68.900	70.100	69.200	70.500	69.700	70.800	71.100	75.000	78.000	81.000	85.000
Subtotal	1,418.900	1,395.700	1,426.250	1,489.100	1,530.700	1,580.300	1,636.800	1,702.897	1,731.889	1,760.395	1,935.079	2,129.393	2,320.572	2,525.239
Total	1,727.650	1,684.425	1,704.650	1,776.900	1,826.100	1,885.300	1,953.800	2,033.897	2,066.167	2,098.853	2,265.911	2,454.730	2,639.912	2,846.101

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium Scenario - Washington
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF	1,192.724	1,230.373	1,232.542	1,250.107	1,267.116	1,283.573	1,304.571	1,329.366	1,359.946	1,385.426	1,493.330	1,603.609	1,709.047	1,807.381
MF	250.672	273.185	276.354	287.123	297.674	308.007	317.844	329.205	342.868	354.570	405.974	459.156	511.218	561.171
MO	97.114	111.442	113.105	119.771	126.210	132.420	138.585	145.726	154.381	161.553	190.711	218.243	242.708	264.580
Total	1,540.510	1,615.000	1,622.000	1,657.000	1,691.000	1,724.000	1,761.000	1,804.297	1,857.196	1,901.549	2,090.015	2,281.009	2,462.972	2,633.133
POPULATION														
	4,132.160	4,279.000	4,304.000	4,349.000	4,406.000	4,463.000	4,538.000	4,619.000	4,717.277	4,791.902	5,057.837	5,383.180	5,689.465	6,029.874
HOUSEHOLDS														
	1,540.510	1,615.000	1,622.000	1,657.000	1,691.000	1,724.000	1,761.000	1,804.297	1,857.196	1,901.549	2,090.015	2,281.009	2,462.972	2,633.133
INCOME[d]														
	10,727.00	10,440.00	10,629.00	10,780.00	10,977.00	11,414.00	11,604.10	11,797.30	11,993.80	12,193.50	13,243.20	14,383.30	15,621.50	16,966.30

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium Scenario - Oregon
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	24.300	23.700	24.200	24.100	23.800	23.700	23.800	23.200	23.700	23.600	23.050	22.450	22.050	21.450
22	2.000	1.900	1.700	1.700	1.600	1.600	1.800	2.000	2.000	1.800	1.700	1.600	1.600	1.600
23	3.200	2.700	2.600	2.800	2.400	2.300	2.500	2.800	2.800	2.700	2.500	2.400	2.400	2.400
25	2.600	2.200	2.400	2.700	2.700	2.700	2.500	2.600	2.600	2.600	2.600	2.600	2.602	2.600
27	10.000	10.000	10.400	11.000	11.500	12.000	12.700	13.500	13.900	14.200	14.700	15.000	15.000	15.050
29	0.600	0.500	0.500	0.500	0.400	0.500	0.500	0.550	0.500	0.500	0.500	0.450	0.400	0.400
30	2.400	2.300	2.500	2.800	3.200	3.400	3.800	3.900	3.900	3.900	4.100	4.300	4.400	4.400
31	0.300	0.300	0.500	0.500	0.400	0.400	0.500	0.600	0.600	0.600	0.550	0.550	0.550	0.550
32	4.500	3.400	3.000	2.700	3.100	3.300	3.400	3.700	3.800	3.800	3.700	3.700	3.700	3.650
33XX	9.600	7.200	6.400	8.100	8.200	8.000	8.500	9.400	9.400	9.300	9.300	9.300	9.300	9.300
34	12.700	9.700	9.400	10.400	11.000	10.600	10.200	11.000	11.100	11.200	11.400	11.600	11.800	11.900
35	17.700	16.500	15.200	15.900	15.500	15.000	15.500	16.100	17.300	17.700	18.800	20.000	21.000	21.950
36	9.800	10.100	10.700	13.800	13.900	12.900	13.400	14.900	15.300	15.400	16.500	17.500	18.300	18.950
37	10.300	7.900	7.100	8.500	9.200	10.100	11.100	12.800	12.900	13.000	12.000	11.200	11.000	11.000
38	19.300	16.800	14.800	14.400	14.600	13.100	12.100	12.000	11.400	11.100	12.100	13.300	14.550	15.950
39	2.200	2.300	2.300	2.600	2.400	2.500	3.100	3.400	3.400	3.400	3.200	3.000	3.000	3.000
2421	23.800	18.630	20.390	21.925	20.500	20.600	21.600	21.700	19.998	19.194	16.047	15.496	15.303	15.338
2436	20.100	16.230	16.900	16.680	15.500	15.900	16.600	16.700	14.947	14.137	10.006	9.339	9.159	8.773
24XX	25.600	20.740	25.310	28.095	27.600	28.100	29.200	29.500	29.306	28.876	27.236	25.914	24.656	23.460
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	5.100	4.723	4.395	4.145	4.160	4.150	4.200	4.100	4.132	4.167	3.944	3.815	3.667	3.505
2631	2.000	1.949	1.925	1.939	2.100	2.100	2.100	2.000	2.001	1.977	1.864	1.763	1.663	1.562
26XX	3.300	2.928	2.980	2.916	2.840	2.850	2.900	2.900	2.872	2.847	2.825	2.826	2.817	2.718
2812	0.250	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.201	0.202	0.204	0.205	0.204
2819	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28XX	2.050	1.900	2.000	1.800	1.900	1.800	1.900	1.900	1.894	1.889	1.861	1.838	1.811	1.780
3334	1.400	0.900	1.100	1.000	0.600	0.600	0.700	0.900	0.800	0.700	0.700	0.650	0.600	0.600
Subtotal	215.100	185.700	188.900	201.200	199.300	198.400	204.800	212.350	210.751	208.787	201.384	200.795	201.533	202.090

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium Scenario - Oregon
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	60.500	56.800	55.400	57.100	57.300	57.200	58.300	59.600	60.584	60.580	62.346	64.589	65.990	67.159
50-51	67.400	62.700	62.600	64.500	65.800	67.400	69.100	74.000	76.003	76.953	83.079	92.645	101.887	111.589
52,53 +	96.200	85.300	87.700	92.900	92.900	95.100	98.100	104.060	106.044	108.006	115.325	123.250	132.188	141.146
54	24.600	26.400	27.200	27.900	29.500	31.700	33.700	36.350	36.814	37.025	38.930	42.340	45.410	48.487
58	67.400	64.300	65.100	67.600	70.400	73.100	75.400	78.400	80.241	82.776	98.093	114.888	132.670	152.625
60-67	70.000	64.900	64.500	65.400	66.800	69.500	71.700	73.700	75.855	76.578	85.467	94.795	103.690	112.920
70	14.800	13.700	13.400	14.000	14.600	14.900	15.200	15.560	15.929	16.307	18.592	20.950	23.278	25.759
72	9.800	9.600	9.600	9.900	10.400	10.600	10.800	10.952	11.107	11.263	12.252	13.176	13.971	14.754
73	24.900	23.200	25.600	31.300	35.000	38.200	40.900	44.150	44.949	46.057	55.304	66.357	78.508	92.533
76	3.000	2.800	2.900	3.400	3.500	3.800	4.100	4.300	4.212	4.270	4.633	4.970	5.257	5.538
80	62.100	65.300	66.400	67.500	69.400	72.500	74.700	77.800	80.022	82.014	92.353	104.741	117.066	130.268
81	5.600	6.300	6.600	7.100	7.300	8.000	8.600	9.200	9.325	9.554	11.545	13.786	16.231	19.039
82,941	100.700	98.700	97.500	99.500	102.200	104.300	105.900	107.530	109.079	110.247	119.575	128.167	135.440	142.574
83	11.400	11.000	11.800	13.000	14.000	15.300	16.400	17.300	17.514	18.044	20.524	23.468	26.461	29.714
89	11.100	9.700	9.300	9.800	10.300	11.200	12.000	12.600	12.700	12.832	14.556	16.323	18.049	19.874
75,78 +	42.200	40.700	42.400	41.500	43.500	47.400	50.800	53.400	53.791	54.201	57.405	61.578	65.137	68.616
90-99	78.200	74.000	72.400	72.200	73.500	74.700	77.300	78.600	79.601	80.473	87.282	93.553	98.862	104.070
Const	46.500	28.900	27.000	30.200	33.100	34.300	34.500	37.400	39.528	40.029	41.506	42.969	45.526	48.659
Agric	96.300	96.800	103.400	100.100	98.800	99.000	99.700	100.300	101.029	101.710	99.703	98.687	97.036	95.512
Mining	2.300	1.800	1.600	1.600	1.500	1.400	1.400	1.400	1.600	1.650	1.750	1.850	1.950	1.950
Fd Gvt	30.800	29.100	29.000	29.300	29.600	29.600	30.200	30.500	30.800	30.900	31.450	32.450	34.050	35.700
Subtotal	925.800	872.000	881.400	905.800	929.400	959.200	988.800	1,027.102	1,046.727	1,061.469	1,151.670	1,255.532	1,358.657	1,468.486
Total	1,140.900	1,057.700	1,070.300	1,107.000	1,128.700	1,157.600	1,193.600	1,239.452	1,257.478	1,270.256	1,353.054	1,456.327	1,560.190	1,670.576

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium Scenario - Oregon
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	766.660	781.211	778.769	789.367	796.264	804.424	814.530	828.830	842.491	849.692	901.442	958.903	1024.304	1084.861
MF[b]	143.285	148.654	148.547	152.229	154.855	157.862	161.031	165.309	169.430	171.872	188.359	206.579	227.080	246.471
MO[c]	81.648	87.136	86.684	90.403	92.880	95.714	98.439	102.261	105.837	107.551	119.346	130.920	143.636	155.190
Total	991.593	1,017.000	1,014.000	1,032.000	1,044.000	1,058.000	1,074.000	1,096.400	1,117.758	1,129.116	1,209.147	1,296.402	1,395.019	1,486.522

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	2,633.160	2,656.190	2,635.000	2,660.000	2,675.800	2,661.500	2,690.000	2,741.000	2,794.395	2,822.791	2,938.227	3,085.438	3,250.395	3,433.866

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	991.593	1,017.000	1,014.000	1,032.000	1,044.000	1,058.000	1,074.000	1,096.400	1,117.758	1,129.116	1,209.147	1,296.402	1,395.019	1,486.522

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	9,864.00	9,204.00	9,448.00	9,685.00	9,858.00	10,135.00	10,337.70	10,544.50	10,755.30	10,970.40	12,112.30	13,372.90	14,764.80	16,301.50

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium Scenario - Idaho
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	17.000	16.600	16.300	16.600	16.600	15.400	16.100	17.300	16.950	16.700	15.950	15.450	15.200	14.800
22	0.000	0.000	0.050	0.050	0.050	0.050	0.100	0.100	0.050	0.050	0.050	0.050	0.050	0.050
23	0.300	0.400	0.200	0.250	0.250	0.250	0.300	0.300	0.250	0.250	0.200	0.150	0.150	0.150
25	0.250	0.200	0.400	0.500	0.600	0.600	0.600	0.700	0.600	0.550	0.550	0.550	0.550	0.550
27	3.100	3.200	3.300	3.800	4.200	4.200	4.250	4.525	4.600	4.600	4.800	5.150	5.400	5.450
29	0.100	0.000	0.000	0.000	0.025	0.025	0.050	0.050	0.075	0.075	0.075	0.075	0.075	0.075
30	1.000	0.850	0.750	0.650	0.850	0.950	0.950	0.800	0.550	0.550	0.500	0.500	0.500	0.500
31	0.000	0.050	0.050	0.100	0.100	0.100	0.150	0.150	0.088	0.088	0.088	0.088	0.088	0.088
32	1.300	0.900	1.000	0.900	0.900	0.800	0.800	0.800	0.800	0.800	0.825	0.850	0.875	0.900
33XX	1.200	0.050	0.050	0.050	0.100	0.100	0.000	0.250	0.200	0.200	0.200	0.200	0.200	0.200
34	2.100	1.700	1.700	1.800	1.900	2.000	2.000	2.000	2.050	2.100	2.150	2.175	2.225	2.300
35	5.000	5.200	5.300	5.700	5.800	4.900	5.200	5.600	5.900	6.000	6.900	7.650	8.550	8.900
36	1.500	1.600	2.100	3.300	2.800	2.700	3.200	3.800	3.900	3.900	4.200	4.400	4.500	4.600
37	0.700	0.750	0.850	0.950	0.950	0.850	1.100	1.250	1.200	1.100	1.000	0.900	0.800	0.800
38	0.150	0.200	0.250	0.300	0.300	0.300	0.300	0.400	0.400	0.400	0.475	0.600	0.650	0.700
39	0.400	0.250	0.300	0.350	0.325	0.300	0.300	0.400	0.400	0.400	0.400	0.400	0.400	0.400
2421	8.100	6.500	7.100	7.100	6.400	6.200	6.200	6.300	5.621	5.381	5.307	5.380	5.407	5.369
2436	0.500	0.300	0.400	0.425	0.400	0.400	0.400	0.400	0.404	0.405	0.478	0.503	0.513	0.516
24XX	6.775	5.400	6.400	6.675	6.700	6.500	6.500	7.100	6.742	6.675	6.351	6.043	5.749	5.470
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	0.225	0.225	0.225	0.250	0.250	0.250	0.250	0.250	0.248	0.246	0.237	0.229	0.220	0.210
2631	0.850	0.850	0.900	0.950	0.950	0.950	0.950	0.950	0.939	0.927	0.875	0.828	0.780	0.733
26XX	0.425	0.425	0.475	0.525	0.575	0.575	0.600	0.600	0.596	0.591	0.612	0.589	0.596	0.577
2812	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2819	1.067	1.050	1.000	1.000	1.000	1.000	0.900	0.900	0.887	0.881	0.855	0.831	0.806	0.782
28XX	2.433	2.400	2.300	2.500	2.600	3.150	2.400	2.600	2.358	2.351	2.316	2.288	2.254	2.216
3334	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subtotal	54.475	49.100	51.400	54.725	54.625	52.550	53.600	57.525	55.807	55.221	55.393	55.878	56.540	56.336

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium Scenario - Idaho
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	20.100	19.100	19.100	19.100	19.200	18.500	17.900	18.400	18.607	18.817	19.395	20.088	20.626	21.097
50-51	22.300	21.600	21.600	21.300	20.800	20.300	20.700	20.100	21.537	22.022	24.962	27.972	30.914	34.024
52,53 +	29.900	28.000	28.300	31.300	31.300	31.100	31.400	32.500	33.006	33.813	36.676	40.084	43.204	46.359
54	9.400	9.500	9.900	10.300	10.700	10.700	11.100	11.350	11.490	11.690	12.924	14.125	15.224	16.336
58	19.000	18.900	19.600	20.900	21.600	21.500	21.700	22.650	23.320	23.927	28.560	33.694	39.194	45.419
60-67	23.400	22.700	23.000	23.500	23.600	23.900	19.100	19.400	20.001	20.459	23.066	25.709	28.260	30.927
70	5.100	5.100	5.000	5.100	5.200	5.700	5.700	6.050	6.100	6.200	7.200	8.003	8.958	9.986
72	3.000	3.100	3.300	3.500	3.800	3.700	3.600	3.800	3.810	3.806	4.116	4.448	4.740	5.031
73	11.000	11.100	11.700	11.400	12.100	12.200	12.900	13.900	14.201	14.499	17.442	21.029	25.000	29.600
76	1.000	0.900	0.900	1.000	1.100	1.000	1.000	1.100	1.132	1.149	1.253	1.351	1.436	1.520
80	15.500	16.500	16.900	17.400	17.900	18.500	19.100	19.800	20.307	20.569	23.614	26.820	30.050	33.570
81	2.100	2.100	2.200	2.300	2.400	2.400	2.500	2.700	2.750	2.800	3.382	4.058	4.801	5.657
82,941	34.900	34.100	33.900	35.100	36.200	36.800	37.500	38.800	39.201	40.018	43.470	46.070	48.925	51.758
83	3.400	3.200	3.400	3.700	4.000	4.100	4.100	4.350	4.435	4.557	5.297	6.087	6.896	7.782
89	4.800	4.400	4.200	4.100	3.900	3.900	3.900	4.100	4.150	4.203	4.768	5.373	5.970	6.606
75,78 +	10.300	9.300	9.800	10.300	10.800	11.000	11.100	11.400	11.529	11.698	12.756	13.751	14.618	15.475
90-99	26.400	25.300	25.600	25.700	26.100	26.300	27.700	28.450	28.623	28.843	31.713	33.482	35.132	37.166
Const	17.400	13.800	13.200	14.600	15.100	14.600	13.700	14.200	15.514	15.778	17.216	18.657	20.098	21.588
Agric	69.100	66.100	67.800	66.500	65.400	65.300	64.800	64.155	63.556	62.945	61.371	60.348	59.096	58.099
Mining	4.700	3.800	4.100	4.200	3.800	2.900	2.600	3.250	3.300	3.500	3.550	3.600	3.650	3.700
Fd Gvt	13.000	12.000	11.900	11.800	11.800	11.800	12.100	12.300	12.300	12.400	12.700	13.350	13.950	14.650
Subtotal	345.800	330.600	335.400	343.100	346.800	346.200	344.200	352.755	358.869	363.693	395.431	428.099	460.742	496.350
Total	400.275	379.700	386.800	397.825	401.425	398.750	397.800	410.280	414.676	418.914	450.824	483.977	517.282	552.686

a See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium Scenario - Idaho
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							HOUSING							
SF[a]	262.388	270.920	272.697	277.681	280.759	281.932	282.597	282.461	286.073	290.720	314.192	338.981	362.436	383.510
MF[b]	25.082	26.965	27.448	28.533	29.265	29.645	29.882	29.990	30.712	31.605	36.148	40.965	45.619	49.931
MO[c]	36.700	40.114	40.855	42.786	43.976	44.423	44.521	44.335	45.314	46.590	52.527	58.043	62.608	66.451
Total	324.170	338.000	341.000	349.000	354.000	356.000	357.000	356.786	362.099	368.915	402.867	437.988	470.663	499.893

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							POPULATION							
	944.000	978.000	988.000	999.000	1,004.000	1,002.000	998.000	999.000	1,013.878	1,029.272	1,083.711	1,138.770	1,200.190	1,264.729

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							HOUSEHOLDS							
	324.170	338.000	341.000	349.000	354.000	356.000	357.000	356.786	362.099	368.915	402.867	437.988	470.663	499.893

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							INCOME[d]							
	8,570.00	8,058.00	8,293.00	8,329.00	8,437.00	8,535.00	8,710.50	8,889.60	9,072.20	9,258.90	10,250.70	11,348.70	12,564.40	13,910.30

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium Scenario - Western Montana
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	0.700	0.600	0.600	0.550	0.465	0.500	0.525	0.500	0.500	0.500	0.475	0.475	0.450	0.450
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.025	0.025	0.025	0.050	0.050	0.060	0.050	0.050	0.050	0.050	0.050	0.075	0.075	0.075
25	0.000	0.000	0.050	0.125	0.140	0.150	0.150	0.100	0.100	0.100	0.150	0.175	0.175	0.175
27	0.750	0.500	0.600	0.675	0.700	0.700	0.725	0.700	0.700	0.725	0.850	1.000	1.050	1.050
29	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.025	0.025	0.025	0.025	0.025	0.038	0.038	0.050	0.050	0.063	0.063
31	0.000	0.000	0.000	0.050	0.025	0.025	0.030	0.040	0.038	0.038	0.038	0.038	0.038	0.038
32	0.400	0.150	0.200	0.300	0.325	0.300	0.280	0.290	0.295	0.300	0.315	0.325	0.336	0.350
33XX	1.000	0.100	0.100	0.100	0.150	0.150	0.125	0.125	0.125	0.125	0.150	0.150	0.150	0.150
34	0.150	0.100	0.150	0.225	0.250	0.250	0.275	0.250	0.250	0.250	0.275	0.275	0.275	0.275
35	0.050	0.100	0.150	0.200	0.225	0.250	0.325	0.300	0.250	0.250	0.300	0.350	0.400	0.425
36	0.050	0.050	0.050	0.075	0.075	0.075	0.075	0.100	0.100	0.100	0.150	0.175	0.204	0.225
37	0.100	0.050	0.050	0.050	0.075	0.075	0.050	0.100	0.100	0.100	0.125	0.150	0.175	0.200
38	0.100	0.050	0.100	0.100	0.125	0.125	0.120	0.130	0.140	0.150	0.200	0.225	0.253	0.275
39	0.150	0.100	0.125	0.125	0.175	0.200	0.300	0.300	0.300	0.250	0.200	0.175	0.175	0.175
2421	4.500	3.700	4.000	4.000	4.000	4.000	4.150	3.800	3.555	3.313	3.331	3.377	3.396	3.371
2436	1.000	0.800	0.800	0.900	0.800	0.800	0.800	0.800	0.800	0.819	0.855	0.901	0.919	0.923
24XX	2.700	2.000	2.300	2.500	2.100	2.450	2.500	2.475	2.451	2.426	2.309	2.196	2.090	1.988
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2631	0.550	0.600	0.650	0.750	0.750	0.775	0.750	0.750	0.741	0.732	0.691	0.653	0.616	0.579
26XX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2812	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2819	0.200	0.200	0.200	0.200	0.190	0.180	0.180	0.180	0.178	0.176	0.171	0.166	0.161	0.157
28XX	0.100	0.075	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.049	0.048	0.048	0.047
3334	1.250	0.783	0.900	0.900	0.850	0.750	0.750	0.800	0.700	0.700	0.700	0.700	0.700	0.700
Subtotal	13.775	9.983	11.100	11.975	11.545	11.890	12.235	11.865	11.461	11.193	11.434	11.680	11.749	11.691

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium Scenario - Western Montana
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	7.500	6.500	6.400	6.400	6.400	6.700	6.650	6.700	6.924	6.987	7.416	7.780	8.048	8.293
50-51	3.800	3.200	3.250	3.300	3.400	3.325	3.275	3.375	3.441	3.513	3.956	4.404	4.834	5.284
52,53 +	8.000	7.800	7.900	8.000	8.200	8.200	8.650	8.700	8.772	8.912	9.781	10.611	11.353	12.092
54	2.900	2.700	2.800	2.900	3.000	2.725	2.825	2.800	2.800	2.800	2.992	3.246	3.473	3.699
58	7.500	7.400	7.300	7.300	7.500	7.225	7.475	7.500	7.600	7.641	9.187	10.918	12.792	14.932
60-67	3.700	3.500	3.500	3.700	3.400	3.550	3.650	3.650	3.650	3.707	4.037	4.467	4.874	5.295
70	2.500	2.400	2.500	2.700	2.700	2.800	2.900	2.900	2.945	3.021	3.477	3.956	4.439	4.961
72	0.800	0.800	0.800	0.850	0.900	0.900	0.875	0.900	0.926	0.939	1.021	1.098	1.164	1.230
73	1.000	1.000	1.100	1.200	1.700	1.950	2.175	2.200	2.250	2.329	2.807	3.344	3.927	4.594
76	0.300	0.300	0.300	0.300	0.300	0.275	0.350	0.350	0.309	0.313	0.342	0.368	0.392	0.415
80	6.400	6.800	7.100	7.400	7.650	8.100	8.300	8.400	8.598	8.805	10.088	11.425	12.738	14.161
81	0.500	0.500	0.500	0.550	0.600	0.625	0.700	0.700	0.680	0.663	0.796	0.943	1.103	1.284
82,941	8.900	9.300	9.500	9.700	9.775	9.700	9.500	9.400	9.600	9.806	10.718	11.683	12.328	12.954
83	1.400	1.300	1.300	1.300	1.200	1.275	1.525	1.500	1.500	1.395	1.490	1.696	1.903	2.126
89	1.000	1.000	1.000	0.950	0.700	0.700	0.800	0.800	0.751	0.747	0.846	0.946	1.044	1.146
75,78 +	3.300	3.300	3.300	3.325	3.325	3.325	3.450	3.500	3.500	3.512	3.773	4.078	4.345	4.612
90-99	8.300	7.500	7.300	7.300	7.400	7.400	7.400	7.400	8.011	8.319	9.005	9.635	10.167	10.684
Const	4.800	4.000	4.000	4.000	3.800	3.250	2.800	2.700	3.091	3.137	3.410	3.673	3.918	4.167
Agric	7.500	7.400	7.300	7.300	7.300	7.300	7.300	7.300	7.295	7.294	7.150	6.971	6.953	6.928
Mining	3.100	2.675	2.150	1.800	1.875	1.950	2.075	2.100	2.200	2.200	2.400	2.550	2.650	2.750
Fd Gvt	5.600	5.200	5.200	5.100	4.850	4.700	4.900	4.900	5.000	5.000	5.200	5.400	5.500	5.600
Subtotal	88.800	84.575	84.500	85.375	85.975	85.975	87.575	87.775	89.843	91.040	99.892	109.192	117.945	127.207
Total	102.575	94.558	95.600	97.350	97.520	97.865	99.810	99.640	101.304	102.233	111.326	120.872	129.694	138.898

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium Scenario - Western Montana
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	82.214	83.540	84.263	85.377	84.997	84.954	85.549	86.135	87.916	89.148	97.753	107.155	114.151	120.421
MF[b]	8.895	9.440	9.731	10.132	10.127	10.216	10.394	10.572	10.990	11.300	13.354	15.594	17.377	19.033
MO[c]	15.291	16.220	16.706	17.391	17.276	17.331	17.557	17.766	18.441	18.880	21.820	24.698	26.379	27.780
Total	106.400	109.200	110.700	112.900	112.400	112.500	113.500	114.474	117.347	119.328	132.926	147.447	157.906	167.234

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	294.500	294.300	299.700	300.500	303.900	304.900	304.700	304.500	309.797	312.638	332.316	352.398	369.499	387.982

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	106.400	109.200	110.700	112.900	112.400	112.500	113.500	114.474	117.347	119.328	132.926	147.447	157.906	167.234

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	7,793.00	7,717.00	7,916.00	8,105.00	7,983.00	8,360.00	8,527.20	8,697.80	8,871.70	9,049.10	9,991.00	11,030.90	12,179.00	13,446.70

[a] Single-family homes
[b] Multifamily homes
[c] Manufactured homes
[d] Per-capita income in 1980 dollars

Medium-low Scenario - Region
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	73.900	72.700	72.200	72.050	71.965	70.700	72.325	73.500	71.700	70.500	67.950	64.950	62.600	60.300
22	3.000	2.800	2.650	2.650	2.550	2.650	3.000	3.200	2.850	2.450	2.450	2.450	2.450	2.450
23	10.025	8.825	8.725	9.600	8.900	8.710	8.750	9.250	8.750	8.450	8.200	8.175	8.175	8.175
25	6.150	5.300	6.050	6.825	7.240	7.350	6.950	7.100	6.750	6.700	6.850	6.950	7.050	7.150
27	29.650	29.500	30.300	32.375	34.000	35.600	37.775	39.925	38.200	36.700	37.500	38.300	38.700	39.100
29	2.800	2.300	2.300	2.325	2.225	2.425	2.550	2.700	2.400	2.250	2.150	1.950	1.750	1.650
30	6.900	6.675	6.850	7.675	8.575	8.975	9.675	9.825	9.225	9.025	9.425	9.625	9.825	9.925
31	0.700	0.750	0.950	1.050	0.925	1.025	1.180	1.390	1.105	1.100	1.100	1.100	1.100	1.100
32	13.100	10.450	10.200	10.400	10.725	10.600	10.980	11.390	10.690	10.200	10.200	10.200	10.200	10.200
33XX	20.800	15.850	13.750	14.650	15.350	15.450	15.325	17.275	16.450	15.850	16.300	16.700	16.900	16.900
34	26.750	21.400	20.650	22.325	22.850	22.850	22.875	24.250	23.450	22.950	23.350	23.800	24.000	24.250
35	37.750	38.400	35.950	38.200	38.625	37.750	37.325	39.600	38.450	37.650	39.900	42.350	45.100	47.725
36	22.550	22.350	23.150	28.975	28.875	28.375	29.775	32.400	31.600	30.900	32.050	32.975	33.904	34.925
37	109.450	100.800	88.200	91.700	99.825	108.525	118.250	128.450	127.400	111.500	101.900	98.900	95.800	92.900
38	25.950	25.450	24.550	25.000	25.725	23.925	23.220	23.530	22.840	22.250	23.150	24.625	26.153	27.875
39	7.350	6.650	6.925	7.675	7.400	7.600	8.400	9.200	8.450	7.700	7.750	7.750	7.750	7.750
2421	52.427	43.030	46.440	47.725	44.300	44.200	45.850	45.400	33.750	33.251	31.865	31.192	30.948	30.930
2436	26.582	21.430	22.350	22.205	20.900	21.300	22.100	22.000	14.954	14.002	11.581	10.963	10.984	10.619
24XX	61.066	48.840	57.010	59.670	57.100	57.850	60.000	61.375	59.118	58.357	54.697	51.278	48.062	45.037
2611	2.974	2.300	2.050	2.075	2.100	2.100	2.100	2.100	2.027	1.995	1.835	1.689	1.553	1.427
2621	14.143	13.048	12.520	13.295	13.410	13.400	13.350	13.350	13.024	12.924	12.427	12.023	11.561	11.048
2631	5.037	4.999	5.050	4.639	5.000	5.025	4.900	4.800	4.753	4.697	4.428	4.189	3.950	3.711
26XX	7.896	7.453	7.730	7.466	7.815	7.825	7.900	8.000	7.872	7.807	7.862	7.813	7.814	7.513
2812	0.763	0.700	0.650	0.650	0.700	0.700	0.700	0.700	0.701	0.702	0.705	0.700	0.692	0.716
2819	6.567	7.250	7.775	8.200	8.890	8.880	8.780	7.680	5.856	5.545	4.995	4.946	4.900	4.857
28XX	7.470	7.375	7.425	7.400	7.650	8.300	7.650	7.850	7.540	7.502	7.319	7.144	6.968	6.794
3334	10.350	6.883	7.400	8.900	7.250	5.750	5.950	6.500	5.700	4.900	4.600	4.500	4.500	4.500
Subtotal	592.100	533.508	529.800	555.700	560.870	567.840	587.635	612.740	575.604	547.857	532.539	527.236	523.390	519.526

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-low Scenario - Region
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	179.500	171.400	168.800	173.500	176.500	178.600	181.250	187.700	187.019	183.819	186.699	191.627	195.206	198.087
50-51	194.000	188.400	187.950	193.800	195.700	198.325	203.575	211.975	213.605	213.673	231.122	253.861	275.689	298.164
52,53 +	275.100	255.000	261.600	276.100	279.300	287.900	297.850	312.630	313.711	311.935	325.426	345.716	363.232	380.786
54	75.100	82.450	84.600	88.100	92.400	96.525	101.125	107.363	101.726	107.844	111.170	116.511	122.846	128.990
58	195.500	197.350	203.000	211.800	218.400	226.125	233.975	243.095	245.065	250.799	291.120	339.025	390.355	447.723
60-67	188.900	181.800	183.300	188.300	193.400	202.150	201.450	205.050	206.917	208.206	225.854	246.198	265.357	284.833
70	40.200	38.900	39.500	41.400	42.600	44.400	46.300	47.575	47.987	48.465	53.714	59.879	65.998	72.448
72	29.600	30.900	31.500	33.350	35.000	36.000	37.575	39.000	39.179	38.885	40.427	42.914	45.045	47.086
73	89.800	81.800	87.400	99.500	109.800	116.050	124.375	133.456	133.094	134.800	158.553	187.317	218.797	254.553
76	9.800	8.700	9.100	10.000	10.500	10.875	11.650	12.244	11.799	11.848	12.468	13.162	13.739	14.281
80	179.800	190.900	196.200	205.100	212.350	221.000	231.500	244.994	247.147	248.815	275.272	308.146	342.450	379.636
81	17.400	19.400	20.300	21.550	22.700	23.925	25.600	27.412	27.685	28.252	32.298	37.969	44.132	51.092
82,941	299.400	284.300	286.750	297.100	303.775	309.700	315.000	321.460	322.786	319.723	333.415	350.272	363.859	376.411
83	31.800	32.000	35.200	38.800	41.800	44.275	47.325	50.050	49.486	49.736	56.037	63.380	70.878	78.941
89	36.400	34.200	33.700	34.750	36.000	37.800	40.300	42.457	42.289	42.187	47.122	52.802	58.503	64.553
75,78 +	122.600	125.900	132.800	136.125	141.125	148.925	158.950	166.313	163.977	162.522	170.761	181.206	190.143	198.694
90-99	230.300	226.100	226.000	229.300	236.100	241.100	248.300	252.950	252.770	251.998	262.361	275.901	286.674	296.634
Const	161.300	122.900	118.400	128.400	132.600	136.650	138.300	152.300	149.217	141.356	150.408	159.723	167.720	175.388
Agric	292.200	286.600	297.200	291.100	286.600	286.900	286.200	285.055	283.000	281.601	274.200	266.800	259.400	252.300
Mining	13.300	11.275	10.550	10.200	9.875	9.150	9.075	10.050	9.500	9.300	9.200	9.300	9.300	9.300
Fd Gvt	117.300	112.600	113.700	115.100	116.350	115.300	117.700	117.400	116.600	115.600	114.900	119.100	123.400	127.900
Subtotal	2,779.300	2,682.875	2,727.550	2,823.375	2,892.875	2,971.675	3,057.375	3,170.529	3,164.560	3,161.365	3,362.527	3,620.810	3,872.723	4,137.800
Total	3,371.400	3,216.383	3,257.350	3,379.075	3,453.746	3,539.515	3,645.010	3,783.269	3,740.164	3,709.222	3,895.066	4,148.046	4,396.113	4,657.326

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-low Scenario - Region
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	2,303.987	2,366.045	2,368.271	2,402.532	2,429.137	2,454.883	2,483.974	2,519.758	2,542.417	2,566.845	2,706.972	2,842.769	2,994.441	3,122.597
MF[b]	427.934	458.244	462.080	478.017	491.921	505.730	521.079	539.214	551.746	565.248	637.060	709.136	789.568	861.777
MO[c]	230.752	254.912	257.349	270.351	280.342	289.888	300.448	312.984	321.146	329.791	377.220	418.526	461.503	496.772
Total	2,962.673	3,079.200	3,087.700	3,150.900	3,201.400	3,250.500	3,305.500	3,371.957	3,415.309	3,461.884	3,721.253	3,970.430	4,245.512	4,481.146

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION	8,003.820	8,207.490	8,226.700	8,308.500	8,389.700	8,431.400	8,530.700	8,663.500	8,735.608	8,811.176	9,134.497	9,501.436	9,946.170	10,407.907

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS	2,962.673	3,079.200	3,087.700	3,150.900	3,201.400	3,250.500	3,305.500	3,371.956	3,415.309	3,461.884	3,721.252	3,970.430	4,245.511	4,481.146

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]	10,347.04	9,914.80	10,132.77	10,303.97	10,478.86	10,839.25	11,043.76	11,249.91	11,454.09	11,663.36	12,755.72	13,958.30	15,276.88	16,716.72

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium-low Scenario - Washington
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	31.900	31.800	31.100	30.800	31.100	31.100	31.900	32.500	31.500	30.700	29.800	28.600	27.600	26.600
22	1.000	0.900	0.900	0.900	0.900	1.000	1.100	1.100	1.000	1.000	1.000	1.000	1.000	1.000
23	6.500	5.700	5.900	6.500	6.200	6.100	5.900	6.100	6.000	6.000	6.000	6.000	6.000	6.000
25	3.300	2.900	3.200	3.500	3.800	3.900	3.700	3.700	3.700	3.700	3.800	3.900	4.000	4.100
27	15.800	15.800	16.000	16.900	17.600	18.700	20.100	21.200	20.000	19.000	19.400	19.800	20.100	20.400
29	2.100	1.800	1.800	1.800	1.800	1.900	2.000	2.100	1.900	1.800	1.700	1.600	1.500	1.400
30	3.500	3.525	3.600	4.200	4.500	4.600	4.900	5.100	4.900	4.900	5.100	5.200	5.300	5.300
31	0.400	0.400	0.400	0.400	0.400	0.500	0.500	0.600	0.500	0.500	0.500	0.500	0.500	0.500
32	6.900	6.000	6.000	6.500	6.400	6.200	6.500	6.600	6.300	6.100	6.100	6.100	6.100	6.100
33XX	9.000	8.500	7.200	6.400	6.900	7.200	6.700	7.500	7.200	7.000	7.200	7.400	7.600	7.600
34	11.800	9.900	9.400	9.900	9.700	10.000	10.400	11.000	10.500	10.200	10.300	10.500	10.600	10.700
35	15.000	16.600	15.300	16.400	17.100	17.600	16.300	17.600	17.000	16.700	17.700	18.800	20.200	21.400
36	11.200	10.600	10.300	11.800	12.100	12.700	13.100	13.600	13.300	13.000	13.500	13.800	14.300	14.900
37	98.350	92.100	80.200	82.200	89.600	97.500	106.000	114.300	115.000	100.000	91.000	88.400	85.600	83.000
38	6.400	8.400	9.400	10.200	10.700	10.400	10.700	11.000	11.200	11.200	11.400	12.000	12.700	13.500
39	4.600	4.000	4.200	4.600	4.500	4.600	4.700	5.100	4.800	4.500	4.600	4.600	4.600	4.600
2421	16.027	14.200	14.950	14.700	13.400	13.400	13.900	13.600	10.278	10.217	9.675	9.363	9.253	9.276
2436	4.982	4.100	4.250	4.200	4.200	4.200	4.300	4.100	3.142	2.686	2.236	2.111	2.136	2.088
24XX	25.991	20.700	23.000	22.400	20.700	20.800	21.800	22.300	21.243	20.970	19.654	18.426	17.270	16.183
2611	2.974	2.300	2.050	2.075	2.100	2.100	2.100	2.100	2.027	1.995	1.835	1.689	1.553	1.427
2621	8.818	8.100	7.900	8.900	9.000	9.000	8.900	9.000	8.644	8.576	8.247	7.980	7.674	7.332
2631	1.637	1.600	1.575	1.000	1.200	1.200	1.100	1.100	1.072	1.060	0.999	0.945	0.891	0.837
26XX	4.171	4.100	4.275	4.025	4.400	4.400	4.400	4.500	4.404	4.369	4.425	4.399	4.401	4.218
2812	0.513	0.500	0.450	0.450	0.500	0.500	0.500	0.500	0.501	0.501	0.504	0.496	0.487	0.511
2819	5.300	6.000	6.575	7.000	7.700	7.700	7.700	6.600	4.800	4.500	4.000	4.000	4.000	4.000
28XX	2.887	3.000	3.075	3.050	3.100	3.300	3.300	3.300	3.267	3.251	3.172	3.096	3.020	2.944
3334	7.700	5.200	5.400	7.000	5.800	4.400	4.500	4.800	4.400	3.800	3.500	3.400	3.400	3.400
Subtotal	308.750	288.725	278.400	287.800	295.400	305.000	317.000	331.000	318.578	298.224	287.347	284.104	281.786	279.318

[a] See Standard Industrial Classification codes in Appendix 1-B, Table 1-B-1.

Medium-low Scenario - Washington
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	91.400	89.000	87.900	90.900	93.600	96.200	98.400	103.000	102.000	100.000	101.382	104.759	107.031	108.928
50-51	100.500	100.900	100.500	104.700	105.700	107.300	110.500	114.500	114.569	114.832	126.168	139.038	151.488	164.372
52,53+	141.000	133.900	137.700	143.900	146.900	153.500	159.700	167.370	167.511	168.029	173.860	185.986	196.735	207.241
54	38.200	43.850	44.700	47.000	49.200	51.400	53.500	56.863	51.041	57.015	58.244	62.306	65.907	69.426
58	101.600	106.750	111.000	116.000	118.900	124.300	129.400	134.545	135.898	139.268	162.210	189.470	218.796	251.705
60-67	91.800	90.700	92.300	95.700	99.600	105.200	107.000	108.300	109.453	110.701	120.737	132.077	142.846	153.855
70	17.800	17.700	18.600	19.600	20.100	21.000	22.500	23.065	23.217	23.583	26.290	29.401	32.508	35.797
72	16.000	17.400	17.800	19.100	19.900	20.800	22.300	23.348	23.564	23.297	24.086	25.639	26.987	28.288
73	52.900	46.500	49.000	55.600	61.000	63.700	68.400	73.206	73.816	74.265	87.764	104.013	121.873	142.219
76	5.500	4.700	5.000	5.300	5.600	5.800	6.200	6.494	6.261	6.292	6.644	7.037	7.371	7.688
80	95.800	102.300	105.800	112.800	117.400	121.900	129.400	138.994	139.538	140.034	153.586	173.444	193.664	215.356
81	9.200	10.500	11.000	11.600	12.400	12.900	13.800	14.812	15.120	15.440	17.570	20.722	24.163	28.061
82,941	154.900	142.200	145.850	152.800	155.600	158.900	162.100	165.730	166.007	164.004	172.326	181.633	189.297	196.463
83	15.600	16.500	18.700	20.800	22.600	23.600	25.300	26.900	26.260	26.754	30.265	34.345	38.537	43.063
89	19.500	19.100	19.200	19.900	21.100	22.000	23.600	24.957	24.900	24.810	27.793	31.233	34.704	38.402
75,78+	66.800	72.600	77.300	81.000	83.500	87.200	93.600	98.013	96.008	95.267	101.095	107.614	113.272	118.732
90-99	117.400	119.300	120.700	124.100	129.100	132.700	135.900	138.500	138.002	137.496	144.473	152.276	158.701	164.709
Const	92.600	76.200	74.200	79.600	80.600	84.500	87.300	98.000	94.033	88.854	94.291	100.371	105.648	110.740
Agric	119.300	116.300	118.700	117.200	115.100	115.300	114.400	113.300	111.847	110.714	108.841	105.481	102.806	99.943
Mining	3.200	3.000	2.700	2.600	2.700	2.900	3.000	3.300	3.100	2.900	2.900	2.900	2.900	2.900
Fd Gvt	67.900	66.300	67.600	68.900	70.100	69.200	70.500	69.700	70.000	70.100	70.100	72.700	75.300	78.000
Subtotal	1,418.900	1,395.700	1,426.250	1,489.100	1,530.700	1,580.300	1,636.800	1,702.897	1,692.145	1,693.655	1,810.625	1,962.445	2,110.534	2,265.888
Total	1,727.650	1,684.425	1,704.650	1,776.900	1,826.100	1,885.300	1,953.800	2,033.897	2,010.723	1,991.879	2,097.972	2,246.549	2,392.320	2,545.206

a See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-low Scenario - Washington
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	1,192.724	1,230.373	1,232.542	1,250.107	1,267.116	1,283.573	1,302.232	1,324.360	1,338.169	1,353.963	1,429.361	1,502.652	1,585.112	1,652.453
MF[b]	250.672	273.185	276.354	287.123	297.674	308.007	319.473	332.693	341.889	352.111	402.260	452.660	508.768	558.574
MO[c]	97.114	111.442	113.105	119.771	126.210	132.420	139.295	147.244	152.404	158.143	184.497	208.160	233.394	253.372
Total	1,540.510	1,615.000	1,622.000	1,657.000	1,691.000	1,724.000	1,761.000	1,804.297	1,832.461	1,864.218	2,016.117	2,163.472	2,327.273	2,464.398

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	4,132.160	4,279.000	4,304.000	4,349.000	4,406.000	4,463.000	4,538.000	4,619.000	4,654.452	4,697.828	4,879.004	5,105.793	5,376.000	5,643.472

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	1,540.510	1,615.000	1,622.000	1,657.000	1,691.000	1,724.000	1,761.000	1,804.297	1,832.461	1,864.218	2,016.117	2,163.472	2,327.273	2,464.398

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	10,727.00	10,440.00	10,629.00	10,780.00	10,977.00	11,414.00	11,604.10	11,797.30	11,993.80	12,193.50	13,243.20	14,383.30	15,621.50	16,966.30

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium-low Scenario - Oregon
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	24.300	23.700	24.200	24.100	23.800	23.700	23.800	23.200	23.000	22.900	22.300	21.400	20.600	19.800
22	2.000	1.900	1.700	1.700	1.600	1.600	1.800	2.000	1.800	1.400	1.400	1.400	1.400	1.400
23	3.200	2.700	2.600	2.800	2.400	2.300	2.500	2.800	2.500	2.200	2.000	2.000	2.000	2.000
25	2.600	2.200	2.400	2.700	2.700	2.700	2.500	2.600	2.400	2.400	2.400	2.400	2.400	2.400
27	10.000	10.000	10.400	11.000	11.500	12.000	12.700	13.500	13.000	12.500	12.700	12.900	13.000	13.100
29	0.600	0.500	0.500	0.500	0.400	0.500	0.500	0.550	0.450	0.400	0.400	0.300	0.200	0.200
30	2.400	2.300	2.500	2.800	3.200	3.400	3.800	3.900	3.800	3.600	3.800	3.900	4.000	4.100
31	0.300	0.300	0.500	0.500	0.400	0.400	0.500	0.600	0.500	0.500	0.500	0.500	0.500	0.500
32	4.500	3.400	3.000	2.700	3.100	3.300	3.400	3.700	3.400	3.100	3.100	3.100	3.100	3.100
33XX	9.600	7.200	6.400	8.100	8.200	8.000	8.500	9.400	9.000	8.600	8.800	9.000	9.000	9.000
34	12.700	9.700	9.400	10.400	11.000	10.600	10.200	11.000	10.700	10.500	10.800	11.000	11.100	11.200
35	17.700	16.500	15.200	15.900	15.500	15.000	15.500	16.100	15.600	15.100	16.000	16.900	17.900	18.900
36	9.800	10.100	10.700	13.800	13.900	12.900	13.400	14.900	14.400	14.000	14.500	15.000	15.400	15.800
37	10.300	7.900	7.100	8.500	9.200	10.100	11.100	12.800	11.300	10.500	10.000	9.700	9.500	9.200
38	19.300	16.800	14.800	14.400	14.600	13.100	12.100	12.000	11.200	10.600	11.200	12.000	12.800	13.700
39	2.200	2.300	2.300	2.600	2.400	2.500	3.100	3.400	3.100	2.700	2.700	2.700	2.700	2.700
2421	23.800	18.630	20.390	21.925	20.500	20.600	21.600	21.700	15.309	15.300	14.437	13.947	13.774	13.806
2436	20.100	16.230	16.900	16.680	15.500	15.900	16.600	16.700	10.762	10.332	8.256	7.705	7.661	7.338
24XX	25.600	20.740	25.310	28.095	27.600	28.100	29.200	29.500	28.738	28.368	26.589	24.927	23.364	21.893
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	5.100	4.723	4.395	4.145	4.160	4.150	4.200	4.100	4.132	4.101	3.944	3.815	3.667	3.505
2631	2.000	1.949	1.925	1.939	2.100	2.100	2.100	2.000	2.001	1.977	1.864	1.763	1.663	1.562
26XX	3.300	2.928	2.980	2.916	2.840	2.850	2.900	2.900	2.872	2.847	2.825	2.826	2.817	2.718
2812	0.250	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.201	0.202	0.204	0.205	0.204
2819	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28XX	2.050	1.900	2.000	1.800	1.900	1.800	1.900	1.900	1.881	1.872	1.826	1.782	1.739	1.695
3334	1.400	0.900	1.100	1.000	0.600	0.600	0.700	0.900	0.700	0.500	0.500	0.500	0.500	0.500
Subtotal	215.100	185.700	188.900	201.200	199.300	198.400	204.800	212.350	192.745	186.497	183.042	181.668	180.988	180.322

a See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-Low Scenario - Oregon
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	60.500	56.800	55.400	57.100	57.300	57.200	58.300	59.600	59.807	59.001	59.816	60.481	61.179	61.646
50-51	67.400	62.700	62.600	64.500	65.800	67.400	69.100	74.000	74.515	74.004	77.665	84.751	91.436	98.240
52,53 +	96.200	85.300	87.700	92.900	92.900	95.100	98.100	104.060	105.064	103.049	108.019	113.146	117.221	121.638
54	24.600	26.400	27.200	27.900	29.500	31.700	33.700	36.350	36.631	36.798	38.011	38.250	40.062	41.786
58	67.400	64.300	65.100	67.600	70.400	73.100	75.400	78.400	78.877	80.676	93.058	107.678	123.201	140.386
60-67	70.000	64.900	64.500	65.400	66.800	69.500	71.700	73.700	74.224	74.041	79.615	86.224	92.340	98.481
70	14.800	13.700	13.400	14.000	14.600	14.900	15.200	15.560	15.725	15.843	17.492	19.371	21.210	23.127
72	9.800	9.600	9.600	9.900	10.400	10.600	10.800	10.952	11.004	11.008	11.481	12.101	12.612	13.089
73	24.900	23.200	25.600	31.300	35.000	38.200	40.900	44.150	43.038	44.148	51.670	60.647	70.375	81.354
76	3.000	2.800	2.900	3.400	3.500	3.800	4.100	4.300	4.124	4.136	4.324	4.535	4.703	4.857
80	62.100	65.300	66.400	67.500	69.400	72.500	74.700	77.800	79.079	79.997	89.283	98.110	107.928	118.846
81	5.600	6.300	6.600	7.100	7.300	8.000	8.600	9.200	9.232	9.456	10.781	12.592	14.541	16.728
82,941	100.700	98.700	97.500	99.500	102.200	104.300	105.900	107.530	108.003	107.105	110.805	115.639	119.327	122.621
83	11.400	11.000	11.800	13.000	14.000	15.300	16.400	17.300	17.426	17.241	19.313	21.704	24.116	26.686
89	11.100	9.700	9.300	9.800	10.300	11.200	12.000	12.600	12.565	12.541	13.912	15.482	17.035	18.666
75,78 +	42.200	40.700	42.400	41.500	43.500	47.400	50.800	53.400	53.197	52.497	54.005	56.921	59.323	61.569
90-99	78.200	74.000	72.400	72.200	73.500	74.700	77.300	78.600	79.094	79.041	80.880	84.408	87.101	89.505
Const	46.500	28.900	27.000	30.200	33.100	34.300	34.500	37.400	38.000	34.905	36.676	38.657	40.288	41.814
Agric	96.300	96.800	103.400	100.100	98.800	99.000	99.700	100.300	100.602	101.082	98.005	95.901	93.174	90.644
Mining	2.300	1.800	1.600	1.600	1.500	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400
Fd Gvt	30.800	29.100	29.000	29.300	29.600	29.600	30.200	30.500	30.000	29.100	28.600	29.600	30.700	31.800
Subtotal	925.800	872.000	881.400	905.800	929.400	959.200	988.800	1027.102	1,031.607	1,027.069	1,084.811	1,157.598	1,229.272	1,304.883
Total	1,140.900	1,057.700	1,070.300	1,107.000	1,128.700	1,157.600	1,193.600	1,239.452	1,224.353	1,213.566	1,267.853	1,339.266	1,410.260	1,485.205

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-low Scenario - Oregon
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							HOUSING							
SF[a]	766.660	781.211	778.769	789.367	796.264	804.424	813.849	827.270	834.032	840.125	877.016	912.921	959.922	1,000.716
MF[b]	143.285	148.654	148.547	152.229	154.855	157.862	161.249	165.808	168.454	170.921	185.328	199.782	217.738	234.128
MO[c]	81.648	87.136	86.684	90.403	92.880	95.714	98.902	103.322	105.525	107.448	118.086	126.761	138.127	147.835
Total	991.593	1,017.000	1,014.000	1,032.000	1,044.000	1,058.000	1,074.000	1,096.400	1,108.011	1,118.494	1,180.430	1,239.464	1,315.787	1,382.679

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							POPULATION							
	2,633.160	2,656.190	2,635.000	2,660.000	2,675.800	2,661.500	2,690.000	2,741.000	2,770.028	2,796.236	2,868.446	2,949.925	3,065.783	3,193.989

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							HOUSEHOLDS							
	991.593	1,017.000	1,014.000	1,032.000	1,044.000	1,058.000	1,074.000	1,096.400	1,108.011	1,118.494	1,180.430	1,239.464	1,315.787	1,382.679

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							INCOME[d]							
	9,864.00	9,204.00	9,448.00	9,685.00	9,858.00	10,135.00	10,337.70	10,544.50	10,755.30	10,970.40	12,112.30	13,372.90	14,764.80	16,301.50

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium-low Scenario - Idaho
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	17.000	16.600	16.300	16.600	16.600	15.400	16.100	17.300	16.700	16.400	15.400	14.500	14.000	13.500
22	0.000	0.000	0.050	0.050	0.050	0.050	0.100	0.100	0.050	0.050	0.050	0.050	0.050	0.050
23	0.300	0.400	0.200	0.250	0.250	0.250	0.300	0.300	0.200	0.200	0.150	0.100	0.100	0.100
25	0.250	0.200	0.400	0.500	0.600	0.600	0.600	0.700	0.550	0.500	0.500	0.500	0.500	0.500
27	3.100	3.200	3.300	3.800	4.200	4.200	4.250	4.525	4.500	4.500	4.600	4.700	4.700	4.700
29	0.100	0.000	0.000	0.000	0.025	0.025	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
30	1.000	0.850	0.750	0.650	0.850	0.950	0.950	0.800	0.500	0.500	0.500	0.500	0.500	0.500
31	0.000	0.050	0.050	0.100	0.100	0.100	0.150	0.150	0.075	0.075	0.075	0.075	0.075	0.075
32	1.300	0.900	1.000	0.900	0.900	0.800	0.800	0.800	0.700	0.700	0.700	0.700	0.700	0.700
33XX	1.200	0.050	0.050	0.050	0.100	0.100	0.000	0.250	0.150	0.150	0.150	0.150	0.150	0.150
34	2.100	1.700	1.700	1.800	1.900	2.000	2.000	2.000	2.000	2.000	2.000	2.050	2.050	2.100
35	5.000	5.200	5.300	5.700	5.800	4.900	5.200	5.600	5.600	5.600	5.900	6.300	6.600	7.000
36	1.500	1.600	2.100	3.300	2.800	2.700	3.200	3.800	3.800	3.800	3.900	4.000	4.000	4.000
37	0.700	0.750	0.850	0.950	0.950	0.850	1.100	1.250	1.000	0.900	0.800	0.700	0.600	0.600
38	0.150	0.200	0.250	0.300	0.300	0.300	0.300	0.400	0.300	0.300	0.350	0.400	0.400	0.400
39	0.400	0.250	0.300	0.350	0.325	0.300	0.300	0.400	0.300	0.300	0.300	0.300	0.300	0.300
2421	8.100	6.500	7.100	7.100	6.400	6.200	6.200	6.300	4.830	4.768	4.756	4.842	4.866	4.814
2436	0.500	0.300	0.400	0.425	0.400	0.400	0.400	0.400	0.361	0.347	0.384	0.404	0.418	0.420
24XX	6.775	5.400	6.400	6.675	6.700	6.500	6.500	7.100	6.701	6.615	6.200	5.812	5.448	5.105
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	0.225	0.225	0.225	0.250	0.250	0.250	0.250	0.250	0.248	0.246	0.237	0.229	0.220	0.210
2631	0.850	0.850	0.900	0.950	0.950	0.950	0.950	0.950	0.939	0.927	0.875	0.828	0.780	0.733
26XX	0.425	0.425	0.475	0.525	0.575	0.575	0.600	0.600	0.596	0.591	0.612	0.589	0.596	0.577
2812	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2819	1.067	1.050	1.000	1.000	1.000	1.000	0.900	0.900	0.880	0.871	0.829	0.788	0.750	0.714
28XX	2.433	2.400	2.300	2.500	2.600	3.150	2.400	2.600	2.342	2.330	2.273	2.219	2.164	2.110
3334	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subtotal	54.475	49.100	51.400	54.725	54.625	52.550	53.600	57.525	53.370	52.721	51.590	50.786	50.018	49.409

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-low Scenario - Idaho
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	20.100	19.100	19.100	19.100	19.200	18.500	17.900	18.400	18.400	18.000	18.442	19.057	19.470	19.815
50-51	22.300	21.600	21.600	21.300	20.800	20.300	20.700	20.100	21.135	21.408	23.521	25.920	28.241	30.643
52,53+	29.900	28.000	28.300	31.300	31.300	31.100	31.400	32.500	32.436	32.157	34.293	36.685	38.805	40.877
54	9.400	9.500	9.900	10.300	10.700	10.700	11.100	11.350	11.354	11.331	12.084	12.927	13.674	14.404
58	19.000	18.900	19.600	20.900	21.600	21.500	21.700	22.650	22.790	23.355	27.202	31.774	36.691	42.210
60-67	23.400	22.700	23.000	23.500	23.600	23.900	19.100	19.400	19.640	19.864	21.665	23.700	25.632	27.608
70	5.100	5.100	5.000	5.100	5.200	5.700	5.700	6.050	6.156	6.104	6.660	7.448	8.235	9.069
72	3.000	3.100	3.300	3.500	3.800	3.700	3.600	3.800	3.700	3.664	3.888	4.139	4.357	4.567
73	11.000	11.100	11.700	11.400	12.100	12.200	12.900	13.900	14.022	14.107	16.424	19.464	22.807	26.614
76	1.000	0.900	0.900	1.000	1.100	1.000	1.000	1.100	1.111	1.116	1.179	1.249	1.308	1.364
80	15.500	16.500	16.900	17.400	17.900	18.500	19.100	19.800	20.035	20.138	22.670	25.601	28.586	31.787
81	2.100	2.100	2.200	2.300	2.400	2.400	2.500	2.700	2.700	2.706	3.183	3.754	4.377	5.083
82,941	34.900	34.100	33.900	35.100	36.200	36.800	37.500	38.800	39.000	38.800	39.972	42.131	43.908	45.571
83	3.400	3.200	3.400	3.700	4.000	4.100	4.100	4.350	4.400	4.441	5.024	5.702	6.397	7.149
89	4.800	4.400	4.200	4.100	3.900	3.900	3.900	4.100	4.100	4.100	4.593	5.161	5.735	6.346
75,78+	10.300	9.300	9.800	10.300	10.800	11.000	11.100	11.400	11.333	11.399	12.097	12.877	13.554	14.207
90-99	26.400	25.300	25.600	25.700	26.100	26.300	27.700	28.450	28.211	28.017	28.703	30.253	31.530	32.724
Const	17.400	13.800	13.200	14.600	15.100	14.600	13.700	14.200	14.678	15.044	16.201	17.246	18.153	19.028
Agric	69.100	66.100	67.800	66.500	65.400	65.300	64.800	64.155	63.287	62.556	60.326	58.644	56.744	55.138
Mining	4.700	3.800	4.100	4.200	3.800	2.900	2.600	3.250	3.000	3.000	2.800	2.700	2.700	2.700
Fd Gvt	13.000	12.000	11.900	11.800	11.800	11.800	12.100	12.300	12.100	11.900	11.700	12.200	12.600	13.100
Subtotal	345.800	330.600	335.400	343.100	346.800	346.200	344.200	352.755	353.588	353.207	372.627	398.632	423.504	450.004
Total	400.275	379.700	386.800	397.825	401.425	398.750	397.800	410.280	406.958	405.928	424.217	449.418	473.522	499.413

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-low Scenario - Idaho
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	262.388	270.920	272.697	277.681	280.759	281.932	282.478	282.263	284.100	286.016	307.419	326.782	343.492	358.620
MF[b]	25.082	26.965	27.448	28.533	29.265	29.645	29.912	30.040	30.555	31.088	36.011	40.634	44.837	48.813
MO[c]	36.700	40.114	40.855	42.786	43.976	44.423	44.610	44.483	45.103	45.724	52.805	58.330	62.387	65.940
Total	324.170	338.000	341.000	349.000	354.000	356.000	357.000	356.786	359.758	362.828	396.235	425.747	450.716	473.373

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	944.000	978.000	988.000	999.000	1,004.000	1,002.000	998.000	999.000	1,007.323	1,012.289	1,065.871	1,106.941	1,149.325	1,197.633

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	324.170	338.000	341.000	349.000	354.000	356.000	357.000	356.786	359.758	362.828	396.235	425.747	450.716	473.373

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	8,570.00	8,058.00	8,293.00	8,329.00	8,437.00	8,535.00	8,710.50	8,889.60	9,072.40	9,258.90	10,250.70	11,348.70	12,564.40	13,910.30

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Medium-low Scenario - Western Montana
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	0.700	0.600	0.600	0.550	0.465	0.500	0.525	0.500	0.500	0.500	0.450	0.450	0.400	0.400
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.025	0.025	0.025	0.050	0.050	0.060	0.050	0.050	0.050	0.050	0.050	0.075	0.075	0.075
25	0.000	0.000	0.050	0.125	0.140	0.150	0.150	0.100	0.100	0.100	0.150	0.150	0.150	0.150
27	0.750	0.500	0.600	0.675	0.700	0.700	0.725	0.700	0.700	0.700	0.800	0.900	0.900	0.900
29	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
31	0.000	0.000	0.000	0.050	0.025	0.025	0.030	0.040	0.030	0.025	0.025	0.025	0.025	0.025
32	0.400	0.150	0.200	0.300	0.325	0.300	0.280	0.290	0.290	0.300	0.300	0.300	0.300	0.300
33XX	1.000	0.100	0.100	0.100	0.150	0.150	0.125	0.125	0.100	0.100	0.150	0.150	0.150	0.150
34	0.150	0.100	0.150	0.225	0.250	0.250	0.275	0.250	0.250	0.250	0.250	0.250	0.250	0.250
35	0.050	0.100	0.150	0.200	0.225	0.250	0.325	0.300	0.250	0.250	0.300	0.350	0.400	0.425
36	0.050	0.050	0.050	0.075	0.075	0.075	0.075	0.100	0.100	0.100	0.150	0.175	0.204	0.225
37	0.100	0.050	0.050	0.050	0.075	0.075	0.050	0.100	0.100	0.100	0.100	0.100	0.100	0.100
38	0.100	0.050	0.100	0.100	0.125	0.125	0.120	0.130	0.140	0.150	0.200	0.225	0.253	0.275
39	0.150	0.100	0.125	0.125	0.175	0.200	0.300	0.300	0.250	0.200	0.150	0.150	0.150	0.150
2421	4.500	3.700	4.000	4.000	4.000	4.000	4.150	3.800	3.333	2.966	2.997	3.040	3.055	3.034
2436	1.000	0.800	0.800	0.900	0.800	0.800	0.800	0.800	0.690	0.638	0.705	0.743	0.769	0.772
24XX	2.700	2.000	2.300	2.500	2.100	2.450	2.500	2.475	2.436	2.405	2.254	2.113	1.980	1.856
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2631	0.550	0.600	0.650	0.750	0.750	0.775	0.750	0.750	0.741	0.732	0.691	0.653	0.616	0.579
26XX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2812	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2819	0.200	0.200	0.200	0.200	0.190	0.180	0.180	0.180	0.176	0.174	0.166	0.158	0.150	0.143
28XX	0.100	0.075	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.049	0.048	0.047	0.046	0.045
3334	1.250	0.783	0.900	0.900	0.850	0.750	0.750	0.800	0.600	0.600	0.600	0.600	0.600	0.600
Subtotal	13.775	9.983	11.100	11.975	11.545	11.890	12.235	11.865	10.910	10.415	10.560	10.678	10.598	10.478

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-low Scenario - Western Montana
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	7.500	6.500	6.400	6.400	6.400	6.700	6.650	6.700	6.812	6.818	7.059	7.330	7.526	7.698
50-51	3.800	3.200	3.250	3.300	3.400	3.325	3.275	3.375	3.386	3.429	3.768	4.152	4.524	4.909
52,53 +	8.000	7.800	7.900	8.000	8.200	8.200	8.650	8.700	8.700	8.700	9.254	9.899	10.471	11.030
54	2.900	2.700	2.800	2.900	3.000	2.725	2.825	2.800	2.700	2.700	2.831	3.028	3.203	3.374
58	7.500	7.400	7.300	7.300	7.500	7.225	7.475	7.500	7.500	7.500	8.650	10.103	11.667	13.422
60-67	3.700	3.500	3.500	3.700	3.400	3.550	3.650	3.650	3.600	3.600	3.837	4.197	4.539	4.889
70	2.500	2.400	2.500	2.700	2.700	2.800	2.900	2.900	2.889	2.935	3.272	3.659	4.045	4.455
72	0.800	0.800	0.800	0.850	0.900	0.900	0.875	0.900	0.911	0.916	0.972	1.035	1.089	1.142
73	1.000	1.000	1.100	1.200	1.700	1.950	2.175	2.200	2.218	2.280	2.695	3.193	3.742	4.366
76	0.300	0.300	0.300	0.300	0.300	0.275	0.350	0.350	0.303	0.304	0.321	0.341	0.357	0.372
80	6.400	6.800	7.100	7.400	7.650	8.100	8.300	8.400	8.495	8.646	9.733	10.991	12.272	13.647
81	0.500	0.500	0.500	0.550	0.600	0.625	0.700	0.700	0.633	0.650	0.764	0.901	1.051	1.220
82,941	8.900	9.300	9.500	9.700	9.775	9.700	9.500	9.400	9.776	9.814	10.312	10.869	11.327	11.756
83	1.400	1.300	1.300	1.300	1.200	1.275	1.525	1.500	1.400	1.300	1.435	1.629	1.828	2.043
89	1.000	1.000	1.000	0.950	0.700	0.700	0.800	0.800	0.724	0.736	0.824	0.926	1.029	1.139
75,78 +	3.300	3.300	3.300	3.325	3.325	3.325	3.450	3.500	3.439	3.359	3.564	3.794	3.994	4.186
90-99	8.300	7.500	7.300	7.300	7.400	7.400	7.400	7.400	7.463	7.444	8.305	8.964	9.342	9.696
Const	4.800	4.000	4.000	4.000	3.800	3.250	2.800	2.700	2.506	2.553	3.240	3.449	3.631	3.806
Agric	7.500	7.400	7.300	7.300	7.300	7.300	7.300	7.300	7.264	7.249	7.028	6.774	6.676	6.575
Mining	3.100	2.675	2.150	1.800	1.875	1.950	2.075	2.100	2.000	2.000	2.100	2.300	2.300	2.300
Fd Gvt	5.600	5.200	5.200	5.100	4.850	4.700	4.900	4.900	4.500	4.500	4.500	4.600	4.800	5.000
Subtotal	88.800	84.575	84.500	85.375	85.975	85.975	87.575	87.775	87.219	87.433	94.464	102.134	109.413	117.025
Total	102.575	94.558	95.600	97.350	97.520	97.865	99.810	99.640	98.129	97.848	105.024	112.812	120.011	127.503

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Medium-low Scenario - Western Montana
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	82.214	83.540	84.263	85.377	84.997	84.954	85.414	85.865	86.117	86.741	93.176	100.413	105.915	110.808
MF[b]	8.895	9.440	9.731	10.132	10.127	10.216	10.444	10.672	10.848	11.127	13.460	16.059	18.225	20.262
MO[c]	15.291	16.220	16.706	17.391	17.276	17.331	17.642	17.936	18.114	18.476	21.833	25.275	27.595	29.626
Total	106.400	109.200	110.700	112.900	112.400	112.500	113.500	114.474	115.078	116.344	128.470	141.747	151.736	160.696

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	294.500	294.300	299.700	300.500	303.900	304.900	304.700	304.500	303.806	304.822	321.174	338.776	355.062	372.815

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	106.400	109.200	110.700	112.900	112.400	112.500	113.500	114.474	115.078	116.344	128.470	141.747	151.736	160.696

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	7,793.00	7,717.00	7,916.00	8,105.00	7,983.00	8,360.00	8,527.20	8,697.80	8,871.70	9,049.10	9,991.00	11,030.90	12,179.00	13,446.70

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Low Scenario - Region
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	73.900	72.700	72.200	72.050	71.965	70.700	72.325	73.500	70.180	67.850	64.425	60.800	57.200	54.600
22	3.000	2.800	2.650	2.650	2.550	2.650	3.000	3.200	2.450	2.150	2.050	1.950	1.850	1.750
23	10.025	8.825	8.725	9.600	8.900	8.710	8.750	9.250	8.350	7.950	7.400	7.025	6.625	6.225
25	6.150	5.300	6.050	6.825	7.240	7.350	6.950	7.100	6.450	6.200	6.000	5.900	5.800	5.700
27	29.650	29.500	30.300	32.375	34.000	35.600	37.775	39.925	37.000	34.850	33.150	32.150	32.150	32.150
29	2.800	2.300	2.300	2.325	2.225	2.425	2.550	2.700	2.200	2.100	1.800	1.600	1.400	1.400
30	6.900	6.675	6.850	7.675	8.575	8.975	9.675	9.825	8.500	8.500	8.600	8.700	8.700	8.600
31	0.700	0.750	0.950	1.050	0.925	1.025	1.180	1.390	0.850	0.750	0.750	0.750	0.750	0.750
32	13.100	10.450	10.200	10.400	10.725	10.600	10.980	11.390	9.850	9.550	9.300	9.100	8.900	8.600
33XX	20.800	15.850	13.750	14.650	15.350	15.450	15.325	17.275	15.150	14.450	13.650	13.350	13.150	13.150
34	26.750	21.400	20.650	22.325	22.850	22.850	22.875	24.250	22.300	21.700	21.700	21.700	21.700	21.700
35	37.750	38.400	35.950	38.200	38.625	37.750	37.325	39.600	36.850	35.350	35.150	36.450	38.150	38.650
36	22.550	22.350	23.150	28.975	28.875	28.375	29.775	32.400	29.500	27.800	28.250	28.775	29.304	29.525
37	109.450	100.800	88.200	91.700	99.825	108.525	118.250	128.450	111.850	100.650	89.150	83.950	79.250	74.750
38	25.950	25.450	24.550	25.000	25.725	23.925	23.220	23.530	20.690	20.000	20.450	21.225	21.753	21.775
39	7.350	6.650	6.925	7.675	7.400	7.600	8.400	9.200	7.750	7.200	6.900	6.600	6.300	6.000
2421	52.427	43.030	46.440	47.725	44.300	44.200	45.850	45.400	29.898	29.521	28.353	27.726	27.514	27.519
2436	26.582	21.430	22.350	22.205	20.900	21.300	22.100	22.000	11.678	11.494	9.609	9.185	9.291	9.077
24XX	61.066	48.840	57.010	59.670	57.100	57.850	60.000	61.375	58.060	56.797	51.656	47.884	44.357	41.060
2611	2.974	2.300	2.050	2.075	2.100	2.100	2.100	2.100	2.000	1.955	1.771	1.634	1.509	1.391
2621	14.143	13.048	12.520	13.295	13.410	13.400	13.350	13.350	12.872	12.706	12.096	11.799	11.434	11.022
2631	5.037	4.999	5.050	4.639	5.000	5.025	4.900	4.800	4.650	4.550	4.141	3.844	3.565	3.302
26XX	7.896	7.453	7.730	7.466	7.815	7.825	7.900	8.000	7.628	7.473	7.213	6.816	6.704	6.551
2812	0.763	0.700	0.650	0.650	0.700	0.700	0.700	0.700	0.686	0.679	0.656	0.660	0.659	0.624
2819	6.567	7.250	7.775	8.200	8.890	8.880	8.780	7.680	5.345	4.830	4.470	3.931	3.893	3.857
28XX	7.470	7.375	7.425	7.400	7.650	8.300	7.650	7.850	7.368	7.272	6.917	6.704	6.494	6.290
3334	10.350	6.883	7.400	8.900	7.250	5.750	5.950	6.500	4.550	3.850	3.650	3.650	3.650	3.650
Subtotal	592.100	533.508	529.800	555.700	560.870	567.840	587.635	612.740	534.654	508.177	479.256	463.858	452.053	439.668

a See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Low Scenario - Region
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	179.500	171.400	168.800	173.500	176.500	178.600	181.250	187.700	180.328	175.624	173.054	172.946	171.462	168.467
50-51	194.000	188.400	187.950	193.800	195.700	198.325	203.575	211.975	205.670	203.507	214.227	229.403	242.590	254.251
52,53 +	275.100	255.000	261.600	276.100	279.300	287.900	297.850	312.630	296.116	295.278	302.749	314.854	324.858	332.196
54	75.100	82.450	84.600	88.100	92.400	96.525	101.125	107.363	100.330	100.046	102.579	106.682	110.074	112.561
58	195.500	197.350	203.000	211.800	218.400	226.125	233.975	243.095	240.733	240.505	262.952	291.585	320.754	349.635
60-67	188.900	181.800	183.300	188.300	193.400	202.150	201.450	205.050	200.948	200.772	207.863	218.278	227.411	234.818
70	40.200	38.900	39.500	41.400	42.600	44.400	46.300	47.575	46.133	46.099	47.761	50.190	52.328	54.072
72	29.600	30.900	31.500	33.350	35.000	36.000	37.575	39.000	37.445	37.368	38.461	40.152	41.586	42.689
73	89.800	81.800	87.400	99.500	109.800	116.050	124.375	133.456	129.627	128.360	141.027	157.147	173.712	190.280
76	9.800	8.700	9.100	10.000	10.500	10.875	11.650	12.244	11.652	11.628	11.968	12.495	12.940	13.284
80	179.800	190.900	196.200	205.100	212.350	221.000	231.500	244.994	239.928	234.975	250.627	271.119	290.984	309.451
81	17.400	19.400	20.300	21.550	22.700	23.925	25.600	27.412	26.666	26.354	28.956	32.266	35.668	39.070
82,941	299.400	284.300	286.750	297.100	303.775	309.700	315.000	321.460	311.771	310.200	314.617	323.338	329.674	333.134
83	31.800	32.000	35.200	38.800	41.800	44.275	47.325	50.050	47.549	47.685	50.606	54.473	58.174	61.559
89	36.400	34.200	33.700	34.750	36.000	37.800	40.300	42.457	40.751	40.458	42.515	45.313	47.916	50.219
75,78 +	122.600	125.900	132.800	136.125	141.125	148.925	158.950	166.313	158.978	158.463	164.026	172.208	179.375	185.177
90-99	230.300	226.100	226.000	229.300	236.100	241.100	248.300	252.950	245.049	243.683	247.326	254.466	259.427	262.123
Const	161.300	122.900	118.400	128.400	132.600	136.650	138.300	152.300	138.964	136.387	144.096	151.456	158.028	163.204
Agric	292.200	286.600	297.200	291.100	286.600	286.900	286.200	285.055	282.201	280.200	270.400	260.700	250.900	241.400
Mining	13.300	11.275	10.550	10.200	9.875	9.150	9.075	10.050	8.500	8.200	8.200	8.200	8.200	8.200
Fd Gvt	117.300	112.600	113.700	115.100	116.350	115.300	117.700	117.400	112.600	110.500	104.000	106.700	109.300	111.900
Subtotal	2,779.300	2,682.875	2,727.550	2,823.375	2,892.875	2,971.675	3,057.375	3,170.529	3,061.939	3,036.292	3,128.010	3,273.971	3,405.361	3,517.690
Total	3,371.400	3,216.383	3,257.350	3,379.075	3,453.746	3,539.515	3,645.010	3,783.269	3,596.594	3,544.469	3,607.266	3,737.829	3,857.414	3,957.358

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Low Scenario - Region
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	2,303.987	2,366.045	2,368.271	2,402.532	2,429.137	2,454.883	2,476.280	2,503.085	2,501.486	2,500.555	2,498.282	2,502.097	2,521.564	2,531.137
MF[b]	427.934	458.244	462.080	478.017	491.921	505.730	527.149	552.422	558.751	565.232	600.172	643.206	700.937	755.480
MO[c]	230.752	254.912	257.349	270.351	280.342	289.888	302.071	316.450	317.931	319.824	328.592	336.822	350.627	362.012
Total	2,962.673	3,079.200	3,087.700	3,150.900	3,201.400	3,250.500	3,305.500	3,371.957	3,378.168	3,385.612	3,427.045	3,482.126	3,573.127	3,648.629

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	8,003.820	8,207.490	8,226.700	8,308.500	8,389.700	8,431.400	8,530.700	8,663.500	8,678.059	8,695.896	8,832.264	8,992.492	9,241.449	9,451.074

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	2,962.673	3,079.200	3,087.700	3,150.900	3,201.400	3,250.500	3,305.500	3,371.956	3,378.168	3,385.611	3,427.045	3,482.125	3,573.127	3,648.629

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	10,347.04	9,914.80	10,132.77	10,303.97	10,478.86	10,839.25	10,973.25	11,106.93	11,238.97	11,370.18	12,039.74	12,753.59	13,518.24	14,328.56

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Low Scenario - Washington
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	31.900	31.800	31.100	30.800	31.100	31.100	31.900	32.500	31.000	29.900	28.400	26.800	25.200	24.100
22	1.000	0.900	0.900	0.900	0.900	1.000	1.100	1.100	0.800	0.800	0.800	0.800	0.800	0.700
23	6.500	5.700	5.900	6.500	6.200	6.100	5.900	6.100	6.000	5.800	5.400	5.100	4.800	4.500
25	3.300	2.900	3.200	3.500	3.800	3.900	3.700	3.700	3.700	3.500	3.400	3.300	3.200	3.100
27	15.800	15.800	16.000	16.900	17.600	18.700	20.100	21.200	20.000	19.000	18.000	17.000	17.000	17.000
29	2.100	1.800	1.800	1.800	1.800	1.900	2.000	2.100	1.800	1.700	1.500	1.400	1.300	1.300
30	3.500	3.525	3.600	4.200	4.500	4.600	4.900	5.100	4.600	4.600	4.600	4.600	4.600	4.600
31	0.400	0.400	0.400	0.400	0.400	0.500	0.500	0.600	0.400	0.400	0.400	0.400	0.400	0.400
32	6.900	6.000	6.000	6.500	6.400	6.200	6.500	6.600	5.900	5.800	5.700	5.500	5.400	5.200
33XX	9.000	8.500	7.200	6.400	6.900	7.200	6.700	7.500	7.000	6.500	6.000	6.000	6.000	6.000
34	11.800	9.900	9.400	9.900	9.700	10.000	10.400	11.000	10.000	9.600	9.600	9.600	9.600	9.600
35	15.000	16.600	15.300	16.400	17.100	17.600	16.300	17.600	16.400	15.400	15.600	16.200	17.500	17.900
36	11.200	10.600	10.300	11.800	12.100	12.700	13.100	13.600	12.000	11.700	11.900	12.200	12.500	12.500
37	98.350	92.100	80.200	82.200	89.600	97.500	106.000	114.300	100.000	90.000	79.000	74.400	70.200	65.700
38	6.400	8.400	9.400	10.200	10.700	10.400	10.700	11.000	10.300	10.000	10.200	10.600	10.900	10.900
39	4.600	4.000	4.200	4.600	4.500	4.600	4.700	5.100	4.500	4.400	4.200	4.000	3.800	3.600
2421	16.027	14.200	14.950	14.700	13.400	13.400	13.900	13.600	9.108	9.083	8.602	8.322	8.225	8.253
2436	4.982	4.100	4.250	4.200	4.200	4.200	4.300	4.100	2.234	2.205	1.853	1.769	1.807	1.783
24XX	25.991	20.700	23.000	22.400	20.700	20.800	21.800	22.300	20.863	20.409	18.561	17.206	15.939	14.754
2611	2.974	2.300	2.050	2.075	2.100	2.100	2.100	2.100	2.000	1.955	1.771	1.634	1.509	1.391
2621	8.818	8.100	7.900	8.900	9.000	9.000	8.900	9.000	8.544	8.432	8.029	7.831	7.589	7.313
2631	1.637	1.600	1.575	1.000	1.200	1.200	1.100	1.100	1.049	1.026	0.934	0.867	0.804	0.745
26XX	4.171	4.100	4.275	4.025	4.400	4.400	4.400	4.500	4.268	4.189	3.983	3.754	3.736	3.707
2812	0.513	0.500	0.450	0.450	0.500	0.500	0.500	0.500	0.490	0.485	0.468	0.475	0.477	0.446
2819	5.300	6.000	6.575	7.000	7.700	7.700	7.700	6.600	4.300	3.800	3.500	3.000	3.000	3.000
28XX	2.887	3.000	3.075	3.050	3.100	3.300	3.300	3.300	3.193	3.152	2.998	2.905	2.814	2.726
3334	7.700	5.200	5.400	7.000	5.800	4.400	4.500	4.800	3.500	3.000	2.800	2.800	2.800	2.800
Subtotal	308.750	288.725	278.400	287.800	295.400	305.000	317.000	331.000	293.948	276.835	258.200	248.463	241.901	234.018

[a] See Standard Industrial Classification codes in Appendix 1-B, Table 1-B-1.

Low Scenario - Washington
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	91.400	89.000	87.900	90.900	93.600	96.200	98.400	103.000	99.047	95.188	93.666	93.478	92.546	90.801
50-51	100.500	100.900	100.500	104.700	105.700	107.300	110.500	114.500	113.020	111.131	116.649	124.185	131.167	137.312
52,53 +	141.000	133.900	137.700	143.900	146.900	153.500	159.700	167.370	158.711	158.219	162.004	168.253	173.362	177.032
54	38.200	43.850	44.700	47.000	49.200	51.400	53.500	56.863	53.169	53.004	54.272	56.365	58.077	59.306
58	101.600	106.750	111.000	116.000	118.900	124.300	129.400	134.545	133.149	133.242	145.501	161.148	177.050	192.751
60-67	91.800	90.700	92.300	95.700	99.600	105.200	107.000	108.300	106.765	106.647	110.290	115.685	120.387	124.165
70	17.800	17.700	18.600	19.600	20.100	21.000	22.500	23.065	22.451	22.426	23.192	24.326	25.315	26.110
72	16.000	17.400	17.800	19.100	19.900	20.800	22.300	23.348	22.198	22.146	22.767	23.739	24.557	25.177
73	52.900	46.500	49.000	55.600	61.000	63.700	68.400	73.206	71.005	70.640	77.519	86.277	95.257	104.215
76	5.500	4.700	5.000	5.300	5.600	5.800	6.200	6.494	6.172	6.157	6.330	6.600	6.828	7.000
80	95.800	102.300	105.800	112.800	117.400	121.900	129.400	138.994	136.071	131.312	139.892	151.148	162.028	172.104
81	9.200	10.500	11.000	11.600	12.400	12.900	13.800	14.812	14.400	14.252	15.640	17.407	19.218	21.026
82,941	154.900	142.200	145.850	152.800	155.600	158.900	162.100	165.730	160.354	159.488	161.395	165.633	168.636	170.159
83	15.600	16.500	18.700	20.800	22.600	23.600	25.300	26.900	25.498	25.597	27.135	29.175	31.121	32.893
89	19.500	19.100	19.200	19.900	21.100	22.000	23.600	24.957	23.690	23.735	24.913	26.523	28.014	29.326
75,78 +	66.800	72.600	77.300	81.000	83.500	87.200	93.600	98.013	93.394	93.291	96.478	101.198	105.311	108.616
90-99	117.400	119.300	120.700	124.100	129.100	132.700	135.900	138.500	134.436	133.710	135.309	138.862	141.380	142.656
Const	92.600	76.200	74.200	79.600	80.600	84.500	87.300	98.000	87.108	87.012	89.984	94.386	98.223	101.305
Agric	119.300	116.300	118.700	117.200	115.100	115.300	114.400	113.300	111.531	110.163	107.332	103.070	99.438	95.625
Mining	3.200	3.000	2.700	2.600	2.700	2.900	3.000	3.300	2.700	2.700	2.700	2.700	2.700	2.700
Fd Gvt	67.900	66.300	67.600	68.900	70.100	69.200	70.500	69.700	68.500	67.400	63.500	65.100	66.700	68.300
Subtotal	1,418.900	1,395.700	1,426.250	1,489.100	1,530.700	1,580.300	1,636.800	1,702.897	1,643.369	1,627.460	1,676.468	1,755.258	1,827.315	1,888.579
Total	1,727.650	1,684.425	1,704.650	1,776.900	1,826.100	1,885.300	1,953.800	2,033.897	1,937.317	1,904.295	1,934.668	2,003.721	2,069.216	2,122.597

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Low Scenario - Washington
Housing, Population, Households and Income

HOUSING

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
SF[a]	1,192.724	1,230.373	1,232.542	1,250.107	1,267.116	1,283.573	1,297.519	1,314.274	1,314.275	1,313.222	1,307.905	1,306.175	1,315.746	1,318.726
MF[b]	250.672	273.185	276.354	287.123	297.674	308.007	323.244	340.763	345.374	349.272	370.288	396.676	434.348	469.279
MO[c]	97.114	111.442	113.105	119.771	126.210	132.420	140.237	149.260	150.793	151.811	156.103	160.729	169.829	176.780
Total	1,540.510	1,615.000	1,622.000	1,657.000	1,691.000	1,724.000	1,761.000	1,804.297	1,810.441	1,814.305	1,834.295	1,863.580	1,919.922	1,964.785

POPULATION

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
	4,132.160	4,279.000	4,304.000	4,349.000	4,406.000	4,463.000	4,538.000	4,619.000	4,634.730	4,644.622	4,695.796	4,770.764	4,915.001	5,029.851

HOUSEHOLDS

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
	1,540.510	1,615.000	1,622.000	1,657.000	1,691.000	1,724.000	1,761.000	1,804.297	1,810.441	1,814.305	1,834.295	1,863.580	1,919.922	1,964.785

INCOME[d]

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
	10,727.00	10,440.00	10,629.00	10,780.00	10,977.00	11,414.00	11,528.10	11,643.40	11,759.90	11,877.50	12,483.30	13,120.10	13,789.40	14,492.80

[a] Single-family homes
[b] Multifamily homes
[c] Manufactured homes
[d] Per-capita income in 1980 dollars

Low Scenario - Oregon
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	24.300	23.700	24.200	24.100	23.800	23.700	23.800	23.200	22.700	22.300	21.200	20.000	18.800	17.900
22	2.000	1.900	1.700	1.700	1.600	1.600	1.800	2.000	1.600	1.300	1.200	1.100	1.000	1.000
23	3.200	2.700	2.600	2.800	2.400	2.300	2.500	2.800	2.200	2.000	1.900	1.800	1.700	1.600
25	2.600	2.200	2.400	2.700	2.700	2.700	2.500	2.600	2.200	2.200	2.200	2.200	2.200	2.200
27	10.000	10.000	10.400	11.000	11.500	12.000	12.700	13.500	12.500	11.500	10.800	10.800	10.800	10.800
29	0.600	0.500	0.500	0.500	0.400	0.500	0.500	0.550	0.400	0.400	0.300	0.200	0.100	0.100
30	2.400	2.300	2.500	2.800	3.200	3.400	3.800	3.900	3.600	3.600	3.700	3.800	3.800	3.700
31	0.300	0.300	0.500	0.500	0.400	0.400	0.500	0.600	0.400	0.300	0.300	0.300	0.300	0.300
32	4.500	3.400	3.000	2.700	3.100	3.300	3.400	3.700	3.100	2.900	2.800	2.800	2.700	2.600
33XX	9.600	7.200	6.400	8.100	8.200	8.000	8.500	9.400	8.000	7.800	7.500	7.200	7.000	7.000
34	12.700	9.700	9.400	10.400	11.000	10.600	10.200	11.000	10.200	10.000	10.000	10.000	10.000	10.000
35	17.700	16.500	15.200	15.900	15.500	15.000	15.500	16.100	15.100	14.700	14.300	15.000	15.400	15.500
36	9.800	10.100	10.700	13.800	13.900	12.900	13.400	14.900	14.000	13.000	13.200	13.400	13.600	13.800
37	10.300	7.900	7.100	8.500	9.200	10.100	11.100	12.800	11.000	10.000	9.500	9.000	8.500	8.500
38	19.300	16.800	14.800	14.400	14.600	13.100	12.100	12.000	10.000	9.600	9.800	10.100	10.300	10.300
39	2.200	2.300	2.300	2.600	2.400	2.500	3.100	3.400	2.800	2.500	2.400	2.300	2.200	2.100
2421	23.800	18.630	20.390	21.925	20.500	20.600	21.600	21.700	13.654	13.600	12.840	12.397	12.245	12.273
2436	20.100	16.230	16.900	16.680	15.500	15.900	16.600	16.700	8.626	8.480	6.852	6.455	6.480	6.275
24XX	25.600	20.740	25.310	28.095	27.600	28.100	29.200	29.500	28.224	27.610	25.111	23.277	21.563	19.960
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	5.100	4.723	4.395	4.145	4.160	4.150	4.200	4.100	4.083	4.032	3.837	3.743	3.628	3.498
2631	2.000	1.949	1.925	1.939	2.100	2.100	2.100	2.000	1.957	1.915	1.743	1.618	1.501	1.389
26XX	3.300	2.928	2.980	2.916	2.840	2.850	2.900	2.900	2.792	2.732	2.662	2.565	2.472	2.384
2812	0.250	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.196	0.194	0.187	0.185	0.182	0.178
2819	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28XX	2.050	1.900	2.000	1.800	1.900	1.800	1.900	1.900	1.838	1.815	1.726	1.673	1.620	1.569
3334	1.400	0.900	1.100	1.000	0.600	0.600	0.700	0.900	0.600	0.400	0.400	0.400	0.400	0.400
Subtotal	215.100	185.700	188.900	201.200	199.300	198.400	204.800	212.350	181.770	174.877	166.458	162.313	158.490	155.327

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Low Scenario - Oregon
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	60.500	56.800	55.400	57.100	57.300	57.200	58.300	59.600	57.024	56.397	55.495	55.384	54.832	53.798
50-51	67.400	62.700	62.600	64.500	65.800	67.400	69.100	74.000	69.363	69.495	72.945	77.658	82.024	85.866
52,53 +	96.200	85.300	87.700	92.900	92.900	95.100	98.100	104.060	97.493	97.191	99.516	103.354	106.492	108.747
54	24.600	26.400	27.200	27.900	29.500	31.700	33.700	36.350	33.491	33.388	34.186	35.505	36.583	37.357
58	67.400	64.300	65.100	67.600	70.400	73.100	75.400	78.400	78.005	77.639	84.782	93.899	103.165	112.314
60-67	70.000	64.900	64.500	65.400	66.800	69.500	71.700	73.700	71.542	71.464	73.904	77.520	80.671	83.202
70	14.800	13.700	13.400	14.000	14.600	14.900	15.200	15.560	15.167	15.150	15.667	16.434	17.102	17.638
72	9.800	9.600	9.600	9.900	10.400	10.600	10.800	10.952	10.750	10.726	11.026	11.497	11.893	12.193
73	24.900	23.200	25.600	31.300	35.000	38.200	40.900	44.150	42.838	42.240	46.353	51.590	56.959	62.316
76	3.000	2.800	2.900	3.400	3.500	3.800	4.100	4.300	4.081	4.072	4.186	4.365	4.515	4.629
80	62.100	65.300	66.400	67.500	69.400	72.500	74.700	77.800	76.034	75.803	80.757	87.254	93.536	99.352
81	5.600	6.300	6.600	7.100	7.300	8.000	8.600	9.200	8.987	8.882	9.747	10.848	11.977	13.103
82,941	100.700	98.700	97.500	99.500	102.200	104.300	105.900	107.530	104.759	104.194	105.439	108.208	110.170	111.165
83	11.400	11.000	11.800	13.000	14.000	15.300	16.400	17.300	16.528	16.593	17.590	18.912	20.173	21.322
89	11.100	9.700	9.300	9.800	10.300	11.200	12.000	12.600	12.326	12.069	12.668	13.486	14.244	14.912
75,78 +	42.200	40.700	42.400	41.500	43.500	47.400	50.800	53.400	51.058	50.633	52.362	54.923	57.156	58.949
90-99	78.200	74.000	72.400	72.200	73.500	74.700	77.300	78.600	76.467	76.054	76.964	78.985	80.417	81.143
Const	46.500	28.900	27.000	30.200	33.100	34.300	34.500	37.400	34.424	32.026	35.561	37.300	38.816	40.035
Agric	96.300	96.800	103.400	100.100	98.800	99.000	99.700	100.300	100.318	100.580	96.647	93.708	90.121	86.728
Mining	2.300	1.800	1.600	1.600	1.500	1.400	1.400	1.400	1.200	1.200	1.200	1.200	1.200	1.200
Fd Gvt	30.800	29.100	29.000	29.300	29.600	29.600	30.200	30.500	28.100	27.500	25.900	26.600	27.200	27.900
Subtotal	925.800	872.000	881.400	905.800	929.400	959.200	988.800	1,027.102	989.955	983.296	1,012.895	1,058.630	1,099.246	1,133.869
Total	1,140.900	1,057.700	1,070.300	1,107.000	1,128.700	1,157.600	1,193.600	1,239.452	1,171.725	1,158.174	1,179.354	1,220.943	1,257.736	1,289.196

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Low Scenario - Oregon
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							HOUSING							
SF[a]	766.660	781.211	778.769	789.367	796.264	804.424	811.360	821.565	820.977	821.177	819.609	820.556	825.313	827.807
MF[b]	143.285	148.654	148.547	152.229	154.855	157.862	163.286	170.477	172.009	173.998	183.209	194.763	209.291	223.508
MO[c]	81.648	87.136	86.684	90.403	92.880	95.714	99.355	104.359	104.649	105.228	106.182	106.975	108.980	110.909
Total	991.593	1,017.000	1,014.000	1,032.000	1,044.000	1,058.000	1,074.000	1,096.400	1,097.635	1,100.402	1,108.999	1,122.294	1,143.583	1,162.223

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							POPULATION							
	2,633.160	2,656.190	2,635.000	2,660.000	2,675.800	2,661.500	2,690.000	2,741.000	2,744.087	2,751.006	2,794.677	2,839.403	2,904.702	2,963.669

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							HOUSEHOLDS							
	991.593	1,017.000	1,014.000	1,032.000	1,044.000	1,058.000	1,074.000	1,096.400	1,097.635	1,100.402	1,108.999	1,122.294	1,143.583	1,162.223

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
							INCOME[d]							
	9,864.00	9,204.00	9,448.00	9,685.00	9,858.00	10,135.00	10,287.00	10,441.30	10,598.00	10,756.90	11,588.30	12,483.80	13,448.60	14,488.00

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Low Scenario - Idaho
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	17.000	16.600	16.300	16.600	16.600	15.400	16.100	17.300	16.000	15.200	14.400	13.600	12.800	12.200
22	0.000	0.000	0.050	0.050	0.050	0.050	0.100	0.100	0.050	0.050	0.050	0.050	0.050	0.050
23	0.300	0.400	0.200	0.250	0.250	0.250	0.300	0.300	0.100	0.100	0.050	0.050	0.050	0.050
25	0.250	0.200	0.400	0.500	0.600	0.600	0.600	0.700	0.450	0.400	0.300	0.300	0.300	0.300
27	3.100	3.200	3.300	3.800	4.200	4.200	4.250	4.525	3.900	3.750	3.750	3.750	3.750	3.750
29	0.100	0.000	0.000	0.000	0.025	0.025	0.050	0.050	0.000	0.000	0.000	0.000	0.000	0.000
30	1.000	0.850	0.750	0.650	0.850	0.950	0.950	0.800	0.300	0.300	0.300	0.300	0.300	0.300
31	0.000	0.050	0.050	0.100	0.100	0.100	0.150	0.150	0.050	0.050	0.050	0.050	0.050	0.050
32	1.300	0.900	1.000	0.900	0.900	0.800	0.800	0.800	0.600	0.600	0.600	0.600	0.600	0.600
33XX	1.200	0.050	0.050	0.050	0.100	0.100	0.000	0.250	0.050	0.050	0.050	0.050	0.050	0.050
34	2.100	1.700	1.700	1.800	1.900	2.000	2.000	2.000	1.900	1.900	1.900	1.900	1.900	1.900
35	5.000	5.200	5.300	5.700	5.800	4.900	5.200	5.600	5.100	5.000	5.000	5.000	5.000	5.000
36	1.500	1.600	2.100	3.300	2.800	2.700	3.200	3.800	3.400	3.000	3.000	3.000	3.000	3.000
37	0.700	0.750	0.850	0.950	0.950	0.850	1.100	1.250	0.800	0.600	0.600	0.500	0.500	0.500
38	0.150	0.200	0.250	0.300	0.300	0.300	0.300	0.400	0.250	0.250	0.250	0.300	0.300	0.300
39	0.400	0.250	0.300	0.350	0.325	0.300	0.300	0.400	0.250	0.200	0.200	0.200	0.200	0.200
2421	8.100	6.500	7.100	7.100	6.400	6.200	6.200	6.300	4.247	4.201	4.246	4.304	4.329	4.297
2436	0.500	0.300	0.400	0.425	0.400	0.400	0.400	0.400	0.288	0.285	0.318	0.339	0.354	0.359
24XX	6.775	5.400	6.400	6.675	6.700	6.500	6.500	7.100	6.581	6.438	5.855	5.428	5.028	4.654
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	0.225	0.225	0.225	0.250	0.250	0.250	0.250	0.250	0.245	0.242	0.230	0.225	0.218	0.210
2631	0.850	0.850	0.900	0.950	0.950	0.950	0.950	0.950	0.919	0.899	0.818	0.759	0.704	0.653
26XX	0.425	0.425	0.475	0.525	0.575	0.575	0.600	0.600	0.568	0.552	0.567	0.497	0.496	0.461
2812	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2819	1.067	1.050	1.000	1.000	1.000	1.000	0.900	0.900	0.871	0.858	0.808	0.776	0.744	0.714
28XX	2.433	2.400	2.300	2.500	2.600	3.150	2.400	2.600	2.288	2.259	2.148	2.082	2.017	1.953
3334	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subtotal	54.475	49.100	51.400	54.725	54.625	52.550	53.600	57.525	49.207	47.184	45.492	44.060	42.739	41.551

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Low Scenario - Idaho
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	20.100	19.100	19.100	19.100	19.200	18.500	17.900	18.400	17.579	17.421	17.315	17.454	17.454	17.297
50-51	22.300	21.600	21.600	21.300	20.800	20.300	20.700	20.100	19.961	19.542	21.094	23.755	25.340	26.783
52,53 +	29.900	28.000	28.300	31.300	31.300	31.100	31.400	32.500	31.431	31.396	32.468	34.057	35.441	36.553
54	9.400	9.500	9.900	10.300	10.700	10.700	11.100	11.350	11.076	11.063	11.441	12.001	12.489	12.881
58	19.000	18.900	19.600	20.900	21.600	21.500	21.700	22.650	22.515	22.477	24.787	27.723	30.759	33.817
60-67	23.400	22.700	23.000	23.500	23.600	23.900	19.100	19.400	19.235	19.252	20.108	21.301	22.388	23.321
70	5.100	5.100	5.000	5.100	5.200	5.700	5.700	6.050	5.710	5.715	5.970	6.324	6.646	6.923
72	3.000	3.100	3.300	3.500	3.800	3.700	3.600	3.800	3.598	3.597	3.734	3.933	4.109	4.255
73	11.000	11.100	11.700	11.400	12.100	12.200	12.900	13.900	13.630	13.298	14.737	16.563	18.466	20.402
76	1.000	0.900	0.900	1.000	1.100	1.000	1.000	1.100	1.099	1.099	1.141	1.202	1.255	1.300
80	15.500	16.500	16.900	17.400	17.900	18.500	19.100	19.800	19.511	19.492	20.974	22.890	24.781	26.583
81	2.100	2.100	2.200	2.300	2.400	2.400	2.500	2.700	2.664	2.597	2.878	3.235	3.607	3.985
82,941	34.900	34.100	33.900	35.100	36.200	36.800	37.500	38.800	37.337	37.207	38.021	39.409	40.525	41.301
83	3.400	3.200	3.400	3.700	4.000	4.100	4.100	4.350	4.309	4.274	4.574	4.967	5.351	5.712
89	4.800	4.400	4.200	4.100	3.900	3.900	3.900	4.100	4.030	3.946	4.183	4.497	4.797	5.071
75,78 +	10.300	9.300	9.800	10.300	10.800	11.000	11.100	11.400	11.220	11.230	11.730	12.426	13.060	13.604
90-99	26.400	25.300	25.600	25.700	26.100	26.300	27.700	28.450	26.811	26.717	27.302	28.299	29.100	29.657
Const	17.400	13.800	13.200	14.600	15.100	14.600	13.700	14.200	15.027	15.041	15.709	16.642	17.491	18.220
Agric	69.100	66.100	67.800	66.500	65.400	65.300	64.800	64.155	63.108	62.245	59.490	57.303	54.884	52.756
Mining	4.700	3.800	4.100	4.200	3.800	2.900	2.600	3.250	2.800	2.500	2.500	2.500	2.500	2.500
Fd Gvt	13.000	12.000	11.900	11.800	11.800	11.800	12.100	12.300	11.600	11.300	10.600	10.900	11.200	11.400
Subtotal	345.800	330.600	335.400	343.100	346.800	346.200	344.200	352.755	344.251	341.409	350.756	367.381	381.643	394.321
Total	400.275	379.700	386.800	397.825	401.425	398.750	397.800	410.280	393.458	388.593	396.248	411.441	424.382	435.872

a See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Low Scenario - Idaho
Housing, Population, Households and Income

HOUSING

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
SF[a]	262.388	270.920	272.697	277.681	280.759	281.932	282.177	281.762	281.400	281.183	284.957	288.033	291.680	294.794
MF[b]	25.082	26.965	27.448	28.533	29.265	29.645	30.080	30.318	30.581	30.897	34.095	37.273	40.816	44.375
MO[c]	36.700	40.114	40.855	42.786	43.976	44.423	44.744	44.705	44.671	44.688	46.868	48.079	49.314	50.608
Total	324.170	338.000	341.000	349.000	354.000	356.000	357.000	356.786	356.652	356.769	365.920	373.385	381.810	389.777

POPULATION

1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
944.000	978.000	988.000	999.000	1,004.000	1,002.000	998.000	999.000	998.624	998.953	1,031.895	1,060.414	1,088.160	1,114.761

HOUSEHOLDS

1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
324.170	338.000	341.000	349.000	354.000	356.000	357.000	356.786	356.652	356.769	365.920	373.385	381.810	389.777

INCOME[d]

1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
8,570.00	8,058.00	8,293.00	8,329.00	8,437.00	8,535.00	8,620.40	8,706.60	8,793.60	8,881.60	9,334.60	9,810.80	10,311.20	10,837.20

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Low Scenario - Western Montana
Manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
20	0.700	0.600	0.600	0.550	0.465	0.500	0.525	0.500	0.480	0.450	0.425	0.400	0.400	0.400
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.025	0.025	0.025	0.050	0.050	0.060	0.050	0.050	0.050	0.050	0.050	0.075	0.075	0.075
25	0.000	0.000	0.050	0.125	0.140	0.150	0.150	0.100	0.100	0.100	0.100	0.100	0.100	0.100
27	0.750	0.500	0.600	0.675	0.700	0.700	0.725	0.700	0.600	0.600	0.600	0.600	0.600	0.600
29	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.025	0.025	0.025	0.025	0.025	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	0.000	0.000	0.050	0.025	0.025	0.030	0.040	0.000	0.000	0.000	0.000	0.000	0.000
32	0.400	0.150	0.200	0.300	0.325	0.300	0.280	0.290	0.250	0.250	0.200	0.200	0.200	0.200
33XX	1.000	0.100	0.100	0.100	0.150	0.150	0.125	0.125	0.100	0.100	0.100	0.100	0.100	0.100
34	0.150	0.100	0.150	0.225	0.250	0.250	0.275	0.250	0.200	0.200	0.200	0.200	0.200	0.200
35	0.050	0.100	0.150	0.200	0.225	0.250	0.325	0.300	0.250	0.250	0.250	0.250	0.250	0.250
36	0.050	0.050	0.050	0.075	0.075	0.075	0.075	0.100	0.100	0.100	0.150	0.175	0.204	0.225
37	0.100	0.050	0.050	0.050	0.075	0.075	0.050	0.100	0.050	0.050	0.050	0.050	0.050	0.050
38	0.100	0.050	0.100	0.100	0.125	0.125	0.120	0.130	0.140	0.150	0.200	0.225	0.253	0.275
39	0.150	0.100	0.125	0.125	0.175	0.200	0.300	0.300	0.200	0.100	0.100	0.100	0.100	0.100
2421	4.500	3.700	4.000	4.000	4.000	4.000	4.150	3.800	2.889	2.637	2.665	2.703	2.716	2.696
2436	1.000	0.800	0.800	0.900	0.800	0.800	0.800	0.800	0.531	0.524	0.585	0.623	0.650	0.660
24XX	2.700	2.000	2.300	2.500	2.100	2.450	2.500	2.475	2.392	2.340	2.128	1.973	1.828	1.692
2611	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2621	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2631	0.550	0.600	0.650	0.750	0.750	0.775	0.750	0.750	0.725	0.710	0.646	0.599	0.556	0.515
26XX	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2812	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2819	0.200	0.200	0.200	0.200	0.190	0.180	0.180	0.180	0.174	0.172	0.162	0.155	0.149	0.143
28XX	0.100	0.075	0.050	0.050	0.050	0.050	0.050	0.050	0.048	0.048	0.045	0.044	0.043	0.041
3334	1.250	0.783	0.900	0.900	0.850	0.750	0.750	0.800	0.450	0.450	0.450	0.450	0.450	0.450
Subtotal	13.775	9.983	11.100	11.975	11.545	11.890	12.235	11.865	9.729	9.281	9.106	9.022	8.923	8.773

a See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Low Scenario - Western Montana
Non-manufacturing Employment (1,000s)

INDUSTRY[a]	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
40-49	7.500	6.500	6.400	6.400	6.400	6.700	6.650	6.700	6.678	6.618	6.578	6.630	6.630	6.571
50-51	3.800	3.200	3.250	3.300	3.400	3.325	3.275	3.375	3.326	3.339	3.539	3.805	4.059	4.290
52,53 +	8.000	7.800	7.900	8.000	8.200	8.200	8.650	8.700	8.481	8.472	8.761	9.190	9.563	9.864
54	2.900	2.700	2.800	2.900	3.000	2.725	2.825	2.800	2.594	2.591	2.680	2.811	2.925	3.017
58	7.500	7.400	7.300	7.300	7.500	7.225	7.475	7.500	7.064	7.147	7.882	8.815	9.780	10.753
60-67	3.700	3.500	3.500	3.700	3.400	3.550	3.650	3.650	3.406	3.409	3.561	3.772	3.965	4.130
70	2.500	2.400	2.500	2.700	2.700	2.800	2.900	2.900	2.805	2.808	2.932	3.106	3.265	3.401
72	0.800	0.800	0.800	0.850	0.900	0.900	0.875	0.900	0.899	0.899	0.934	0.983	1.027	1.064
73	1.000	1.000	1.100	1.200	1.700	1.950	2.175	2.200	2.154	2.182	2.418	2.717	3.030	3.347
76	0.300	0.300	0.300	0.300	0.300	0.275	0.350	0.350	0.300	0.300	0.311	0.328	0.342	0.355
80	6.400	6.800	7.100	7.400	7.650	8.100	8.300	8.400	8.312	8.368	9.004	9.827	10.639	11.412
81	0.500	0.500	0.500	0.550	0.600	0.625	0.700	0.700	0.615	0.623	0.691	0.776	0.866	0.956
82,941	8.900	9.300	9.500	9.700	9.775	9.700	9.500	9.400	9.321	9.311	9.762	10.088	10.343	10.509
83	1.400	1.300	1.300	1.300	1.200	1.275	1.525	1.500	1.214	1.221	1.307	1.419	1.529	1.632
89	1.000	1.000	1.000	0.950	0.700	0.700	0.800	0.800	0.705	0.708	0.751	0.807	0.861	0.910
75,78 +	3.300	3.300	3.300	3.325	3.325	3.325	3.450	3.500	3.306	3.309	3.456	3.661	3.848	4.008
90-99	8.300	7.500	7.300	7.300	7.400	7.400	7.400	7.400	7.335	7.202	7.751	8.320	8.530	8.667
Const	4.800	4.000	4.000	4.000	3.800	3.250	2.800	2.700	2.405	2.308	2.842	3.128	3.498	3.644
Agric	7.500	7.400	7.300	7.300	7.300	7.300	7.300	7.300	7.244	7.212	6.931	6.619	6.457	6.291
Mining	3.100	2.675	2.150	1.800	1.875	1.950	2.075	2.100	1.800	1.800	1.800	1.800	1.800	1.800
Fd Gvt	5.600	5.200	5.200	5.100	4.850	4.700	4.900	4.900	4.400	4.300	4.000	4.100	4.200	4.300
Subtotal	88.800	84.575	84.500	85.375	85.975	85.975	87.575	87.775	84.364	84.127	87.891	92.702	97.157	100.921
Total	102.575	94.558	95.600	97.350	97.520	97.865	99.810	99.640	94.093	93.408	96.997	101.724	106.080	109.694

[a] See Standard Industry Classification codes in Appendix 1-B, Table 1-B-1.

Low Scenario - Western Montana
Housing, Population, Households and Income

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSING														
SF[a]	82.214	83.540	84.263	85.377	84.997	84.954	85.224	85.485	84.835	84.973	85.811	87.332	88.825	89.810
MF[b]	8.895	9.440	9.731	10.132	10.127	10.216	10.540	10.863	10.787	11.065	12.581	14.494	16.481	18.318
MO[c]	15.291	16.220	16.706	17.391	17.276	17.331	17.736	18.126	17.818	18.097	19.439	21.040	22.504	23.715
Total	106.400	109.200	110.700	112.900	112.400	112.500	113.500	114.474	113.441	114.135	117.831	122.867	127.811	131.843

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
POPULATION														
	294.500	294.300	299.700	300.500	303.900	304.900	304.700	304.500	300.617	301.316	309.895	321.910	333.586	342.793

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
HOUSEHOLDS														
	106.400	109.200	110.700	112.900	112.400	112.500	113.500	114.474	113.441	114.135	117.831	122.867	127.811	131.843

	1980	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010
INCOME[d]														
	7,793.00	7,717.00	7,916.00	8,105.00	7,983.00	8,360.00	8,477.00	8,595.70	8,716.10	8,838.10	9,474.30	10,156.30	10,887.50	11,671.20

a Single-family homes
b Multifamily homes
c Manufactured homes
d Per-capita income in 1980 dollars

Chapter 2

Forecast of Electricity Use in the Pacific Northwest

Introduction

The Northwest Power Planning Council (Council) is required by the Northwest Power Planning and Conservation Act to produce 20-year forecasts of the demand for electricity in the Pacific Northwest region. The Bonneville Power Administration needs long-term forecasts of demand for a number of different purposes. In the past, Bonneville and the Council have shared data and research. In November 1988, for the first time, the two organizations published a cooperative long-term forecast of electricity demand. That forecast was included in the Council's draft supplement to the 1986 Power Plan and was adopted by Bonneville for the 1988 Pacific Northwest Loads and Resources study (White Book). The revised forecasts described in this paper have not been officially adopted by Bonneville, however.

The forecasts described in this paper have been modified slightly from the November 1988 draft supplement forecasts. Therefore, these forecasts represent another step in an ongoing monitoring and updating of regional demand forecasts. The earlier draft forecasts were reviewed by the Council's Economic and Demand Forecasting Advisory Committees, were the subject of a Bonneville public review meeting and were disseminated to a wide audience for written comments. The forecasts also have been subjected to intense scrutiny by Council and Bonneville staff.

Demand forecasts play three important roles in the region's power planning process. The first is the traditional role; they are the basis for deciding how much electricity the region will need. The second role is to explore and define the uncertainty surrounding future electrical resource needs. Finally, the demand forecasts are an essential component of conservation assessment. Conservation, identified as the priority resource in the Northwest Power Planning and Conservation Act, is directly related to the demand for electricity. Demand forecasts have a twofold role in conservation planning: they determine the conservation potential associated with various levels of demand, and they aid in determining the reduction in demand attributable to programs undertaken to acquire conservation resources.

Bonneville also needs near-term forecasts for system operations, rate setting, and financial planning purposes. In order to maintain consistency between near-term forecasts and the long-term forecasts used in the resource planning process, Bonneville replaces the near-term loads in the medium forecast with more detailed customer group forecasts that better reflect near-term economic conditions. These forecasts are typically prepared by Bonneville and regional utilities for submission to the Pacific Northwest Utilities Conference Committee. Only the medium case long-term forecast is merged with near-term, customer group-specific forecasts. This merging of forecasts applies only to loads through calendar year 1995.

Besides merging medium-case forecasts, Bonneville also transforms the forecasts into monthly peak and energy loads, accounts for transmission and distribution losses and compiles calendar, fiscal and operating year load (sales plus losses) forecasts to meet various internal and other needs. The discussion and tables of sector sales that follow cover unmerged long-term forecasts.

The Council and Bonneville developed demand forecasting systems to help determine how assumptions about the growth of the region's economy and energy prices affect the demand for electricity. The two sets of forecasting models are similar in many respects and share a great deal of basic data. The Council's demand forecasting system was used to develop the forecast described in this paper. However, some parts of the Council's forecasting system were revised to take into account areas where Bonneville's models are considered to have advantages. During development of these forecasts, Bonneville also used its own forecasting models to help evaluate the forecast results. In future cooperative forecasts, it should be possible to more fully integrate the two demand forecasting systems.

Figure 2-1 illustrates the general structure of the demand forecasting system and its relationship to resource planning. The growth of the regional economy and changes in its composition are the key factors affecting growth in demand for electricity. However, forecast prices of fossil fuels and electricity modify the effects of economic conditions. Future electricity prices are estimated based on the amount of electricity that is needed and the cost of the resources needed to generate that electricity. The demand forecasting system captures these relationships in considerable detail. The role of demand forecasts in resource planning is discussed in more detail in the final section of this paper.

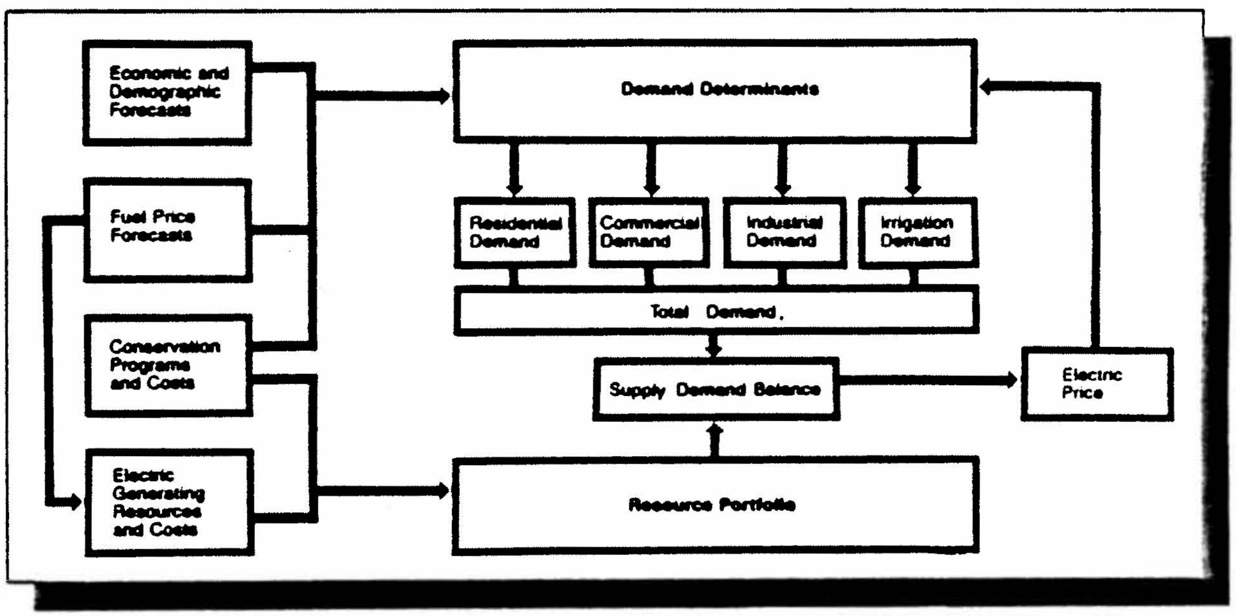

Figure 2-1
Structure of the Demand Forecast System

Overview

The role of these demand forecasts in regional planning is significantly different from the traditional role of demand forecasts. The traditional role of demand forecasts could be characterized as deterministic. That is, a "best-guess" demand forecast determined the amount of new electricity generation needed. Before the early 1970s, it was generally assumed that demand for electricity would continue to grow at close to historical rates. That growth had been rapid and relatively steady. It was assumed that economies of scale in power generation could be relied on to keep prices for electricity from increasing as new generating plants were added. Planners saw little reason for demand growth to slow. In fact, it was widely assumed that there would be little or no response to price changes if they did occur.

The dramatic reduction in electricity demand growth that occurred in the rest of the country as electricity prices increased in the early 1970s caught most planners by surprise. The initial response seems to have been to develop much more sophisticated forecasting tools. The forecasting models adopted by the Council and Bonneville represent the results of those efforts. However, it has also been recognized that, even with the best available forecasting tools, forecasts of future demand remain highly uncertain. In order to deal with this uncertainty in planning, forecast ranges are developed.

The forecast of demand for electricity consists of a range of five forecasts: a low, medium-low, medium, medium-high, and high forecast. The high-demand forecast is designed to ensure that power supplies never constrain the regional economy's growth potential. The high forecast portrays a future in which regional economic growth achieves record high levels, relative to national growth, combined with less competitive prices for alternative fuels. The likelihood that such a rapid regional growth would occur is considered to be very small. The forecast range is bounded on the low side by a forecast that is pessimistic about the regional economy roughly in proportion to the optimism of the high case.

Inside the bounds of the low and high forecasts is a smaller, most probable range of demands bounded by the medium-low and medium-high forecasts. The medium-low, medium, and medium-high forecasts will carry a greater weight in the planning of resources than will the high and low extremes. Nevertheless, the possibilities posed by the high-growth forecast must be addressed by appropriate resource options. Similarly, conditions that are implied by the low-demand forecast will be considered within a flexible planning strategy designed to minimize regional electricity costs and risks.

The demand forecast ranges are constructed by combining economic assumptions, fuel price assumptions, and some modeling assumptions. The combination of assumptions is designed to explore a wide range of possible demands without combining assumptions unrealistically. That is, mutually inconsistent assumptions are not combined just to obtain extreme forecasts. In the high forecast, for example, the high economic assumptions are combined with high fuel price assumptions. In addition, for the high forecast, it was assumed for the industrial sector that large industrial consumers have relatively low price response, and in the residential sector it was assumed that consumers were less likely to invest in energy-efficiency improvements. Electricity prices, which have a significant effect on demand, are determined by an electricity pricing model based on the amount and cost of resources needed to meet demand. Generally, electricity prices will be higher with higher demand growth. The economic and alternative fuel price assumptions that drive these demand forecasts are described in "Economic Forecasts for the Pacific Northwest," dated November 1988.

This paper is primarily concerned with forecasts of electricity sales to final consumers. This concept is normally referred to as electricity demand or sales. Further, the forecasts throughout this paper are average annual energy rather than peak electricity requirements at any particular time. The demand forecast concept presented is a "price effects" forecast. The "price effects" forecast indicates what demand would be if consumers responded to prices but if no new conservation programs were implemented.

The amount of electricity that needs to be generated to satisfy the demand is usually called "electricity load". Electricity load is larger than sales to final consumers because of transmission and distribution losses incurred in delivering the electricity from the generator to the consumer. This loss typically amounts to about 7 percent of generated electricity.

Because electricity loads are the relevant concept for resource planning, electricity demand forecasts are converted to loads for resource planning. A brief description of the load forecast follows, but the rest of the paper discusses demand forecasts. This is because the need for power must be analyzed from the consumer's point of view in order to obtain reliable results and understand the role of conservation in power planning.

Regional firm electricity loads, including transmission and distribution losses, are forecast to grow from 16,641 average megawatts in 1987 to between 16,541 and 31,290 average megawatts by 2010. A more probable range is from 20,482 to 25,719 average megawatts, which are the 2010 forecasts for the medium-low and medium-high cases. The medium forecast is 22,850 average megawatts, which implies an average annual rate of growth of 1.4 percent. The load forecasts are summarized in Table 2-1.

Table 2-1
Pacific Northwest Electricity Load Forecasts
(Average Megawatts)

	ACTUAL 1987	FORECASTS 1990	2005	2010	GROWTH RATE (% PER YEAR) 1987-2010
High	16,641	18,957	27,803	31,290	2.8
Medium-high	16,641	18,085	23,448	25,719	1.9
Medium	16,641	17,575	21,245	22,850	1.4
Medium-low	16,641	16,914	19,162	20,482	0.9
Low	16,641	16,204	15,973	16,541	0.0

In 1987, firm sales of electricity to final consumers in the Pacific Northwest totaled 15,618 average megawatts, or 137 billion kilowatt-hours. The high forecast shows this demand could grow to 29,223 average megawatts by 2010, nearly double current electricity requirements. In more graphic terms, the high implies that energy use equal to more than 12 cities the size of Seattle would be added to the region's demand by 2010. Under the set of assumptions leading to the low forecast, demand decreases slightly to 15,442 average megawatts, an amount little changed from current requirements. Figure 2-2 illustrates the forecast range in the context of historical sales of electricity. This large uncertainty about future needs for electricity resources represents an important challenge for energy planning. The region needs to deal with this uncertainty in a manner that will neither prevent the region from attaining rapid economic growth, nor impose large and unnecessary costs should slower growth occur.

Table 2-2 shows that the rate of growth in demand could be as high as 2.8 percent per year, if the high case materialized, or as low as -0.1 percent if the low case occurred. A more likely outcome, however, is between the medium-low growth rate of 0.9 percent and the medium-high rate of 1.9 percent. The medium forecast is for a 1.4 percent annual growth rate of electricity demand. More detailed tables summarizing the five forecasts appear in Appendix 2-A.

electricity demand increased little. While the low forecast represents a continuation of the 1980s pattern, the high forecast is still well below the growth rate experienced in the 1970s and far below pre-1970 growth.

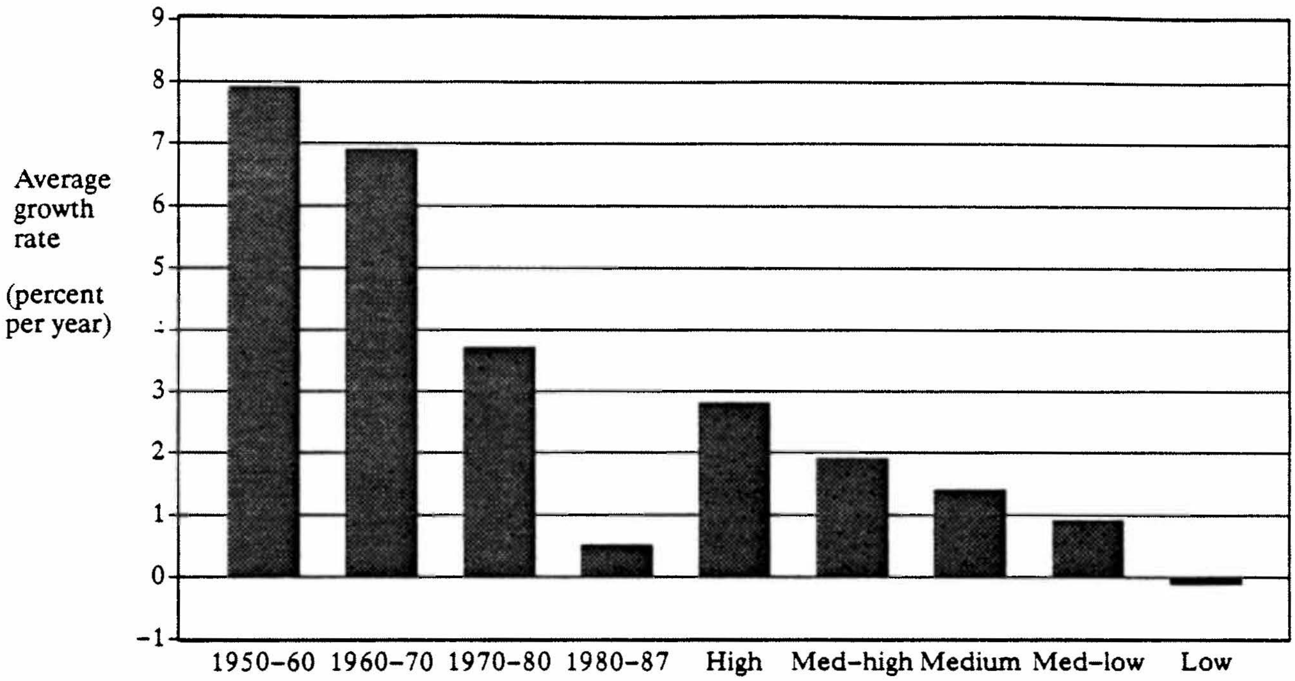

Figure 2-3
Pacific Northwest Electricity Demand
Historical and Forecast 1987-2010 Growth

Decreasing growth rates of demand for electricity, historically and in the forecasts, are a result of many factors. These factors include the rate of growth of the economy, changing standards of living, the price of energy relative to other goods and services, and the changing mix of economic activity, both in the nation and the region. However, the use of electricity is much different in the Pacific Northwest than in the rest of the nation. This difference is illustrated by the patterns of electricity use per capita in Figure 2-4.

Although the historical pattern of increasing per-capita use of electricity is similar in the region and the nation, there is a striking difference in the amount of electricity used. From 1960 through 1980, the Pacific Northwest used about twice as much electricity per person as the nation as a whole. This pattern is due primarily to large supplies of low-cost hydroelectric power in this region. This low-cost power has led to the location of electricity-intensive industry in the region and to heavy use of electricity in other sectors as well. Recent large increases in the Northwest price of electricity, however, have changed the outlook for electricity demand. The forecasts show that, while per capita use will remain well above national levels, growth in use per person will be slower and could actually decline in the lower forecasts.

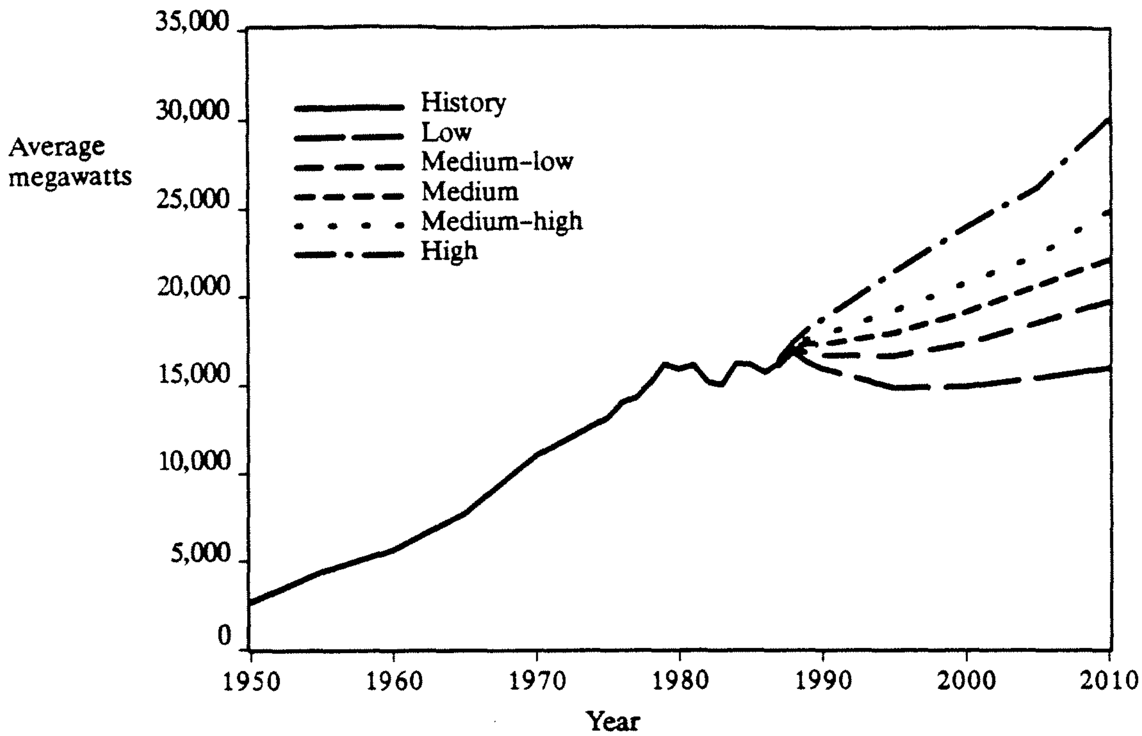

Figure 2-2
Pacific Northwest Sales of Electricity
Historical and Forecast

Table 2-2
Pacific Northwest Firm Sales of Electricity
(Average Megawatts)

	ACTUAL 1987	FORECASTS 1990	FORECASTS 2005	FORECASTS 2010	GROWTH RATE (% PER YEAR) 1987-2010
High	15,618	17,751	25,979	29,223	2.8
Medium-high	15,618	17,934	21,915	24,026	1.9
Medium	15,618	16,456	19,853	21,344	1.4
Medium-low	15,618	15,835	17,897	19,124	0.9
Low	15,618	15,170	14,913	15,442	-0.1

Figure 2-3 compares the projected growth rates of demand to growth rates experienced in the region since 1950. Between 1950 and 1970, demand for electricity grew by an average of 7.4 percent each year. During the 1970s, demand grew much more slowly, at about 3.7 percent per year. Between 1980 and 1987,

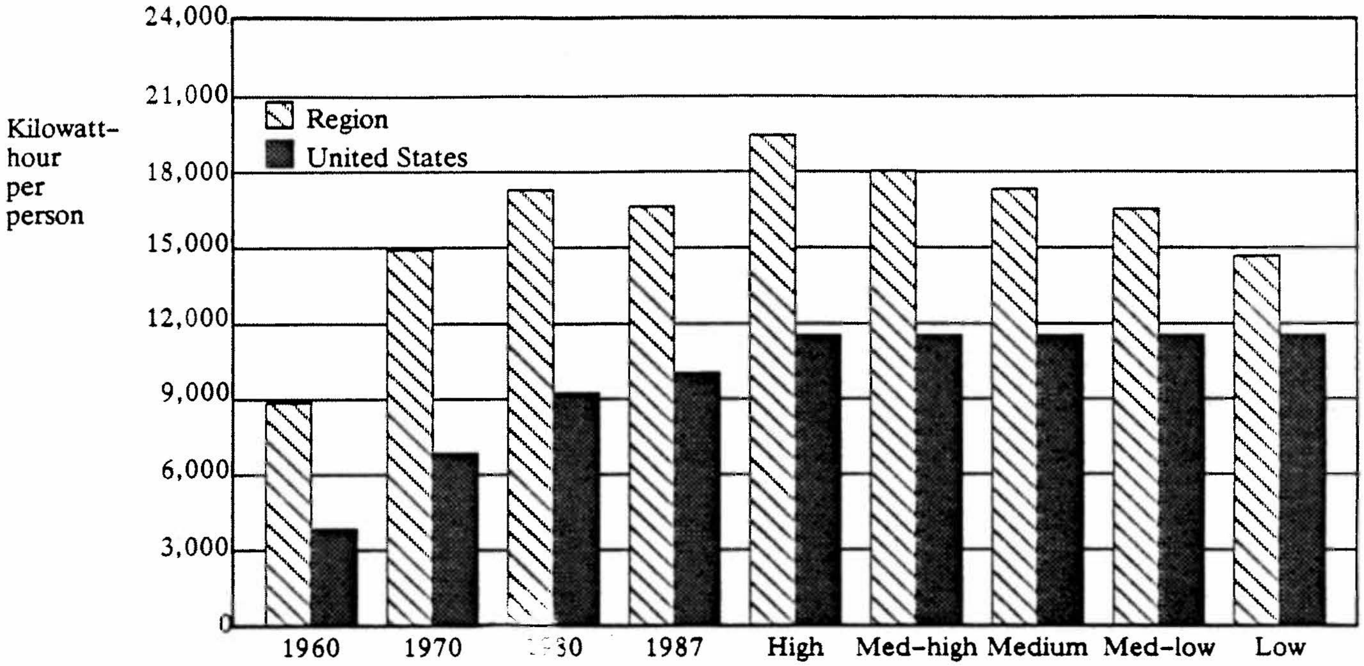

Figure 2-4
Electricity Use per Capita
(Region vs. U.S., History and 2010 Forecast)

Demand Forecasts in Resource Planning

The demand forecasts are not simply a preliminary step to resource planning. Instead, the forecasts interact with resource planning in a number of ways and, as a result, are an integral part of resource planning. Some important dimensions of the use of forecasts in resource planning are described in this section. First, the conceptual roles of forecasts in the planning process are described and then some practical applications of forecasts to resource planning are described.

Demand Forecast Roles

The integral planning role of demand forecasts has three major components. First, forecasts of demand define the extent and nature of uncertainty that planners must face. Second, the level of demand is not independent of resource choices, but responds to the costs of resource choices to meet future demands. Finally, sophisticated demand models are needed to assess the potential impacts of choosing conservation programs as alternatives to building new generating resources. These roles are described below.

Defining the Range of Uncertainty

Future demand for electricity has been the primary uncertainty in developing a risk-minimizing power plan for the region. The demand forecast range measures this uncertainty. The range of demand forecasts is based primarily on variations in the key assumptions. The forecast range has been described above in terms of five forecasts. However, for resource planning, a probability distribution is assumed to describe the likelihood that any given level of future electricity demand within the range will occur.

Bonneville and the Council currently assume different probability distributions about the forecast range. For planning purposes, the Council has adopted the trapezoidal distribution. The implications of the trapezoidal distribution are: 1) that demands outside the high and low forecasts are judged to be of sufficiently low probability that they are not formally considered in resource planning, and 2) that demands between the medium-high and medium-low forecasts are most likely and are considered equally probable. The probability of future demand being between the medium-low and the medium-high forecasts is about 50 percent. The probability of being between the medium-high and high or between the medium-low and low is about 25 percent.

Bonneville assumes a normal probability distribution around the medium forecast. The implications of this assumption are: 1) the medium forecast is described as the most probable future demand, and 2) future demands can fall outside of the low and high forecasts. Bonneville assumes that there is a 50 percent probability that demand will fall between the medium-low and medium- high cases, that the probabilities of being between the medium-low and low or between the medium-high and high are each 20 percent, and that the probabilities of being either below the low or above the high case are each 5 percent.

Resource portfolio analysis is based on the entire probability distribution of future loads. This is a major change from the Council's first power plan in 1983 and is made possible by an enhanced decision model. The decision model analyzes hundreds of possible load paths that are distributed according to the assumed probability distribution defined over the range of demand forecasts.

Effects of Resource Choices on Price

As shown in Figure 2-1, there is an electricity pricing model in the demand forecasting system. The pricing model develops forecasts of retail prices for each sector for investor-owned utilities and public utilities. These rates are forecast through a detailed consideration of power system costs, secondary power sales, and the provisions of the Pacific Northwest Electric Power Planning and Conservation Act. This model translates resource decisions into retail prices. The price model ensures that the implications of future resource decisions, including conservation programs, are consistently reflected in future prices and demands.

Conservation Analysis

In addition to defining uncertainty, the demand forecasting models play an important role in defining and evaluating conservation opportunities. This is particularly true for the residential and commercial sectors, where the demand models are most detailed and conservation opportunities are best defined.

There are two major roles for the demand models in conservation analysis. The first is to help define the size of the potential conservation resource. The second is to predict the effectiveness of programs designed to achieve some portion of the potential conservation available.

Estimates of the number of energy-using buildings and equipment in the region, including their fuel type and efficiency characteristics, are needed to help determine how much additional efficiency can be achieved to offset the need for new electricity generation. The economic forecasts and the building energy demand models provide the detailed building forecasts needed to analyze potential conservation. The demand models evaluate the effects of differing regional growth rates on new building construction and the effects of alternative energy prices on fuel choice in those buildings. This results in different amounts of conservation potential for different forecast scenarios.

The effects of conservation programs can be quite complicated, and the demand models are designed to help assess those effects. For example, an energy-efficient building code can affect all three components of a building owner's energy choice: efficiency, fuel type and intensity of use. While the direct impact is on efficiency choice, there also likely will be unintended effects on fuel choice and intensity of use.

A more stringent code for residential electrical efficiency will tend to increase the construction cost of electrical homes. This relative increase in the initial cost of electrical homes, if borne by home buyers, may cause some increase in the number of homes heated by natural gas or oil, even though the operating cost of the electrically heated homes would be reduced. For cost-effective conservation actions, the cost of providing an end-use service, such as space heating, will decrease. With the decrease in cost, the consumer's intensity of use may increase. Another important complication is that appliances give off waste heat that affects the heating and cooling requirements in buildings. More efficient appliances give off less waste heat and, therefore, more heating and less cooling will be needed than with less efficient appliances. These secondary effects are evaluated in the detailed building models to give a more accurate assessment of the actual impact of conservation on demand for electricity.

Forecast Concepts

Treating conservation as a resource creates interactions among demand forecasts and resource choices that complicate analysis. For example, conservation actions that planners think are available resource choices may also be done by consumers in response to increasing electricity prices. Double counting of this conservation must be avoided in planning. In order to avoid such problems, some innovative analytical methods have been developed.

For example, the Council uses three different demand forecast concepts in its planning. Most presentations and publications, including this paper, describe "price effects" forecasts. Price effects forecasts show what the demand for electricity would be if customers were allowed to respond to price, but no new conservation programs were implemented. Price effects forecasts reflect state building codes as of 1987 and federal appliance efficiency standards beginning in 1990, but do not assume further adoption of the Council's model conservation standards.

An important factor affecting price effects forecasts is what resource mix is assumed in developing the electricity price that is provided to the demand models. The electricity prices that determine the price effects forecast are based on a second concept of demand, a "sales" forecast. A "sales" forecast is a forecast of the demand for electricity after the effects of the model conservation standards and other conservation programs have been taken into account. This is the amount of electricity that would actually be sold by utilities if conservation programs were implemented and savings realized.

The third demand concept, the "frozen efficiency" forecast, attempts to eliminate double counting of conservation actions taken by consumers in response to price, but which also could be achieved through the proposed conservation programs. Frozen efficiency forecasts, as the name implies, hold the technical efficiency of energy use constant at current levels for uses where conservation programs are proposed. This eliminates the part of consumer price response that could potentially be double counted as conservation program savings.

This section summarizes and explains the differences among these three forecast concepts. The three forecasts for the high scenario are shown in Figure 2-5 to help visualize the following discussion.

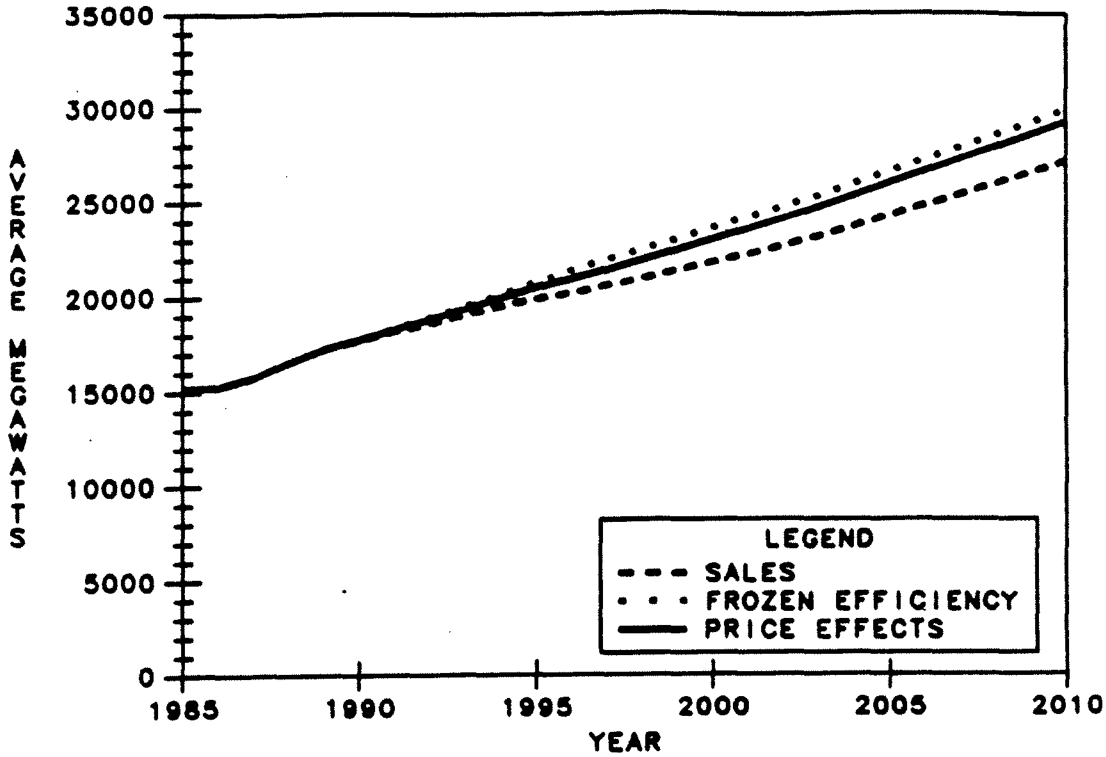

Figure 2-5
Pacific Northwest Electricity Demand
Comparison of High Forecast Concepts

Table 2-3 shows the growth rates for the three forecast concepts for each of the forecast scenarios. The price effects growth rates are the same as those shown in Table 2-2 and Figure 2-3. The frozen efficiency growth rates are slightly higher because part of the demand decreases due to price response have been eliminated. The differences between price effects and frozen efficiency forecasts are relatively small because prices are not forecast to increase much in most forecast scenarios. Demand growth is significantly lower for the sales forecasts than for the other two forecasts, reflecting potential conservation savings from the Council's programs. The differences between the frozen efficiency and sales forecasts are smallest in the low case because only new building standards savings are acquired and relatively few new buildings are constructed.

Table 2-3
Pacific Northwest Electricity Demand
Growth Rates for Different Forecast Concepts
(Average Annual Rate of Change, 1987-2010) (%)

	PRICE EFFECTS	SALES	FROZEN EFFICIENCY
High	2.8	2.4	2.9
Medium-high	1.9	1.5	2.0
Medium	1.4	1.0	1.5
Medium-low	0.9	0.6	0.9
Low	-0.1	0.0	0.0

The difference between the highest forecast (the frozen efficiency forecast) and the lowest (the sales forecast) is the total effect on electricity demand of conservation resources. The price effects forecast divides that total effect into two parts, that which would result from price response and the incremental effect of conservation programs. The difference between the frozen efficiency and price effects forecasts represents the price response portion. The difference between the price effects and the sales forecasts represents the incremental program impacts.

Electrical Loads for Resource Planning

Demand forecasts serve as the basis for resource portfolio analysis. This section describes what forecast concepts are used and how they are modified for resource planning analysis.

For resource portfolio analysis, the decision model uses frozen efficiency forecasts of demand to avoid counting conservation potential twice. However, several adjustments are made to these forecasts before they are used for resource planning.

First, demand forecasts are converted to load forecasts by adding transmission and distribution losses. The demand forecasts are for consumption of electricity at the point of use, while loads are the amount of electricity that needs to be generated. More electricity has to be generated than is actually consumed by utility customers, because some electricity is used or lost in the transmission and distribution of power. The demand forecasts are converted to loads by adding 2.4 percent to direct service industry demand, and 7.5 percent to other demand.

Second, resource analysis is done on an operating year basis. Since the demand forecasts are done on a calendar year basis, the demands must be converted from a year that begins in January to a year that begins the previous September. This is done by calculating a weighted average of the previous and current calendar years. The previous year receives a one-third weight, and the current year a two-thirds weight. In addition, for resource planning, the forecasts were set to actual values for 1987. The forecasts were then interpolated to each scenario's respective 1990 level.

Finally, only non-direct-service-industry loads are provided to the decision model. The assumptions regarding direct service industry demand for electricity are shown in this chapter as a range of operating levels associated with specific forecast scenarios. The direct service industry loads are treated differently, however, in the analysis of electrical loads faced by the region for resource planning. In the resource portfolio analysis, direct service industry load uncertainty is modeled as a random variable that is not correlated to the demand scenarios. Thus, for resource analysis, the risk associated with aluminum loads is not linked to any particular load scenario. This facilitates a better assessment of the uncertainty, since it is not clear that the health of the aluminum industry in this region will be related directly to the general economy. The positive influences of a healthy economy may be offset for aluminum producers by the higher electric rates that would come with a faster growing region.

Federal agency and non-aluminum direct service industry loads are entered into the decision model separately from other loads, and do not vary by scenario. The operating year, frozen efficiency, non-direct-service-industry and non-federal-agency loads that are provided to the decision model are shown for selected years in Table 2-4.

Table 2-4
Pacific Northwest Electricity Demand
Decision Model Loads
(Average Megawatts by Operating Year)

	ESTIMATED	FORECASTS			GROWTH RATE (% PER YEAR)
	1986	2000	2005	2010	1986-2010
High	14,400	22,285	25,474	28,980	3.1
Medium-high	14,400	19,158	21,268	23,632	2.2
Medium	14,400	17,740	19,305	21,024	1.7
Medium-low	14,400	16,351	17,550	18,872	1.2
Low	14,400	14,239	14,726	15,294	0.3

Forecast Detail

The summary of forecast results that are usually presented by the Council and Bonneville tend to hide the fact that the forecasts are done in great detail. A major dimension of the demand forecasting system is the separate treatment of demand by customers of public utilities and customers of investor-owned utilities. A second major dimension is the separate forecasting of residential, commercial, industrial and irrigation uses of electricity. Further, most components of demand, such as residential use of electricity in investor-owned utility service areas, are analyzed for specific end uses as well as other dimensions within the sector forecasting models. The detailed forecast results are described in this section. The forecasts for investor-owned and publicly owned utilities are described first, followed by results for individual consuming sectors.

Utility Type Forecasts

Separate forecasts are done for investor-owned utilities, public utilities and Bonneville direct customers. The economic assumptions driving the forecasts are divided into investor-owned and public utility service areas as described in the March 1989 paper on "Economic Forecasts for the Pacific Northwest" (Chapter 1). These economic assumptions, combined with differences in electric rates and existing conditions, lead to differences in the forecasts for the two customer groups.

Table 2-5 shows the 1987 composition of firm sales and the five forecasts for 2010. In 1987, total regional firm sales of electricity were 15,618 average megawatts. Investor-owned utilities marketed 7,318 average megawatts or 47 percent of the total. Public utilities marketed 39 percent, and Bonneville directly marketed 14 percent of firm sales.

Table 2-5
Pacific Northwest Firm Sales Forecast by Utility Type
(Average Megawatts)

	TOTAL SALES	INVESTOR-OWNED UTILITY SALES	PUBLIC UTILITY SALES	BONNEVILLE DIRECT SALES
Actual 1987	15,618	7,318	6,047	2,253
Forecast 2010				
High	29,223	15,124	11,434	2,664
Medium-high	24,026	12,115	9,536	2,375
Medium	21,344	10,748	8,510	2,085
Medium-low	19,124	9,503	7,887	1,734
Low	15,442	7,632	6,428	1,382
Growth rates (% per year) 1987-2010				
High	2.8	3.2	2.8	0.7
Medium-high	1.9	2.2	2.0	0.2
Medium	1.4	1.7	1.5	-0.3
Medium-low	0.9	1.1	1.2	-1.1
Low	-0.1	0.2	0.3	-2.1

Bonneville's direct sales decrease as a share of future regional electricity demand in all five of the forecast cases. Direct service industries accounted for most of Bonneville's direct sales in 1987, but their energy needs are forecast to increase only moderately from their 1987 levels in the higher cases, and decrease in the other forecasts. Public utility sales are projected to grow slightly more slowly than investor-owned utility sales in the higher forecasts and slightly faster in the lower forecasts.

In addition to providing electricity directly to some customers, Bonneville is the source of much of the electricity sold by public utilities. Although several public utilities generate electricity to serve part of their loads, most public utilities rely entirely on Bonneville. Therefore, the Bonneville Administrator's obligations consist of: 1) direct service industrial customers and various federal agencies that are served directly by Bonneville; 2) all loads of publicly owned utilities that have no, or insignificant, electricity generating resources (non-generating publics); and 3) part of the loads of publicly owned utilities that do have electricity resources (generating publics). In Figure 2-6, Bonneville-supplied electricity is illustrated by the shaded area. Bonneville was the source for about 40 percent of firm electricity sales in the region in 1987.

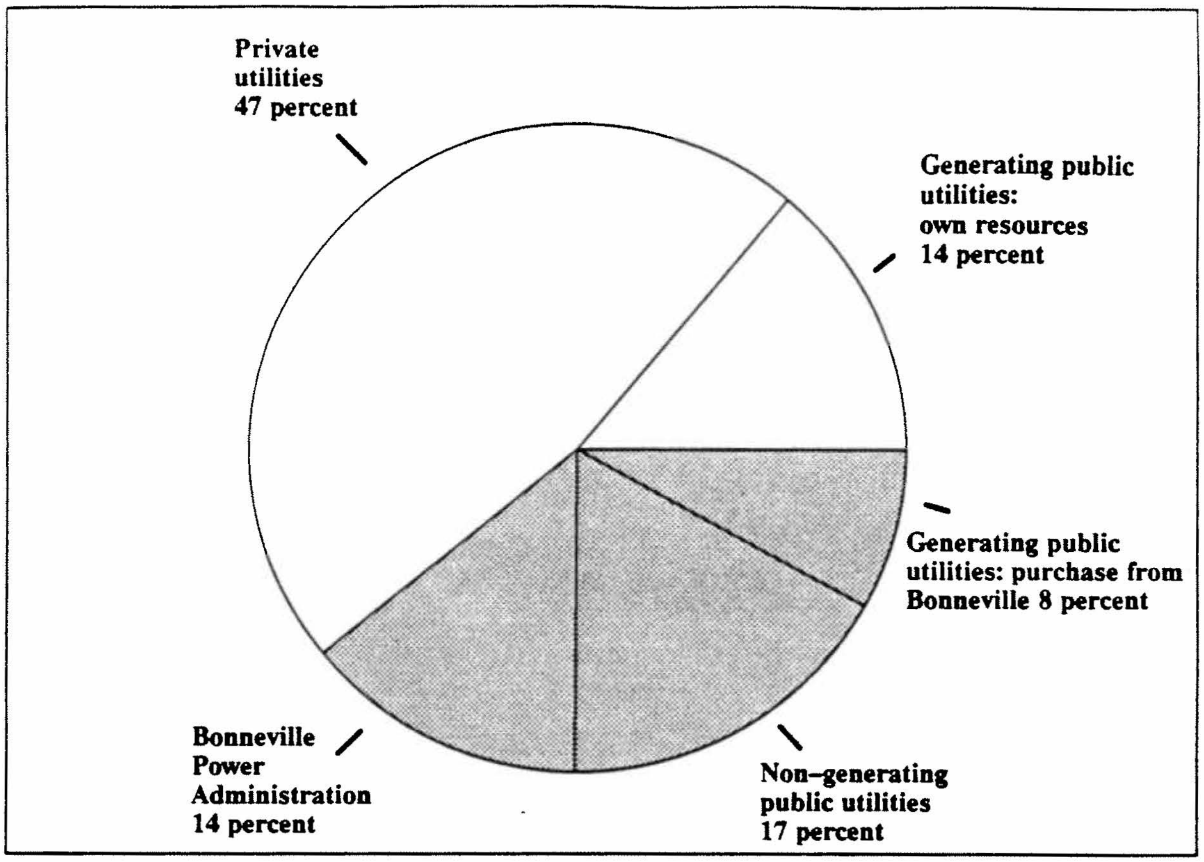

Figure 2-6
Regional Firm Sales by Utility Type
(Bonneville's Current Obligation Shaded)

Forecasting the growth of Bonneville's obligations to provide electricity is complicated by uncertainties well beyond the basic uncertainty embodied in forecasts of regional electricity demand. Figure 2-7 helps illustrate the nature of uncertainty facing the Administrator. The figure shows the forecast range of regional demand as the upper wedge. Below the regional jaws, is an unshaded range of growth forecasts for the current Bonneville customers. Added to the basic Bonneville uncertainty is a shaded area representing the potential additional demands that could be placed on Bonneville with seven years notice. The shaded area is the growth in privately owned utility demands beyond their current resources.

As can be seen from Figure 2-7, Bonneville's uncertainty is essentially the same size as that of the whole region. In relative terms, however, it is much greater. For example, the regional high forecast is 90 percent above the regional low forecast. For Bonneville's current customer base the high is 120 percent higher than the low forecast. Therefore, even without the additional risk of private utility load growth, Bonneville's uncertainty is greater than that facing the region as a whole. This is due to the substantial downside risk associated with the direct service industries. With the potential placement of private utility load growth on Bonneville, the high forecast for the Administrator increases to 260 percent of the low forecast.

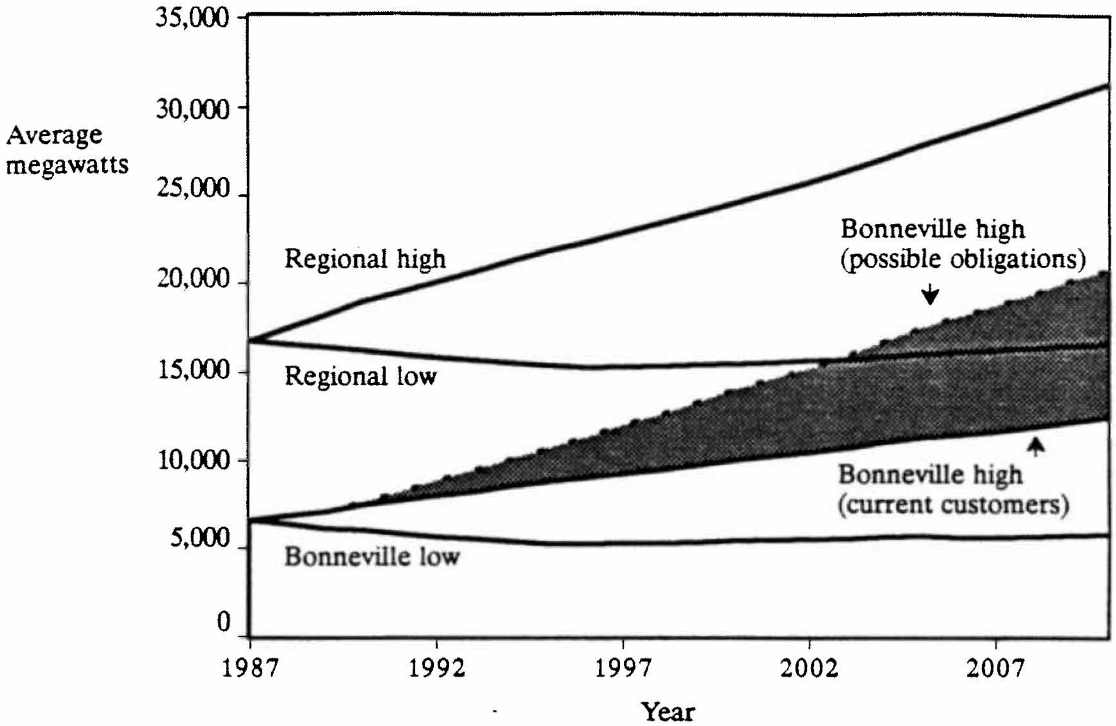

Figure 2-7
Regional and Bonneville Uncertainty

The Administrator also faces additional downside risk that is not reflected in the Bonneville low shown above. That additional risk is that public utilities increasingly will build their own resources in order to gain a measure of independence from Bonneville.

Forecasts by Sector

Figure 2-8 shows the composition by sector of 1987 electricity sales in the region. The industrial sector accounts for the largest share of electricity sales, followed by the residential sector, and then the commercial sector. The industrial, residential and commercial sectors together account for 95 percent of the region's electricity demand. Forecasts for each of the demand sectors are discussed in some detail in the sections that follow.

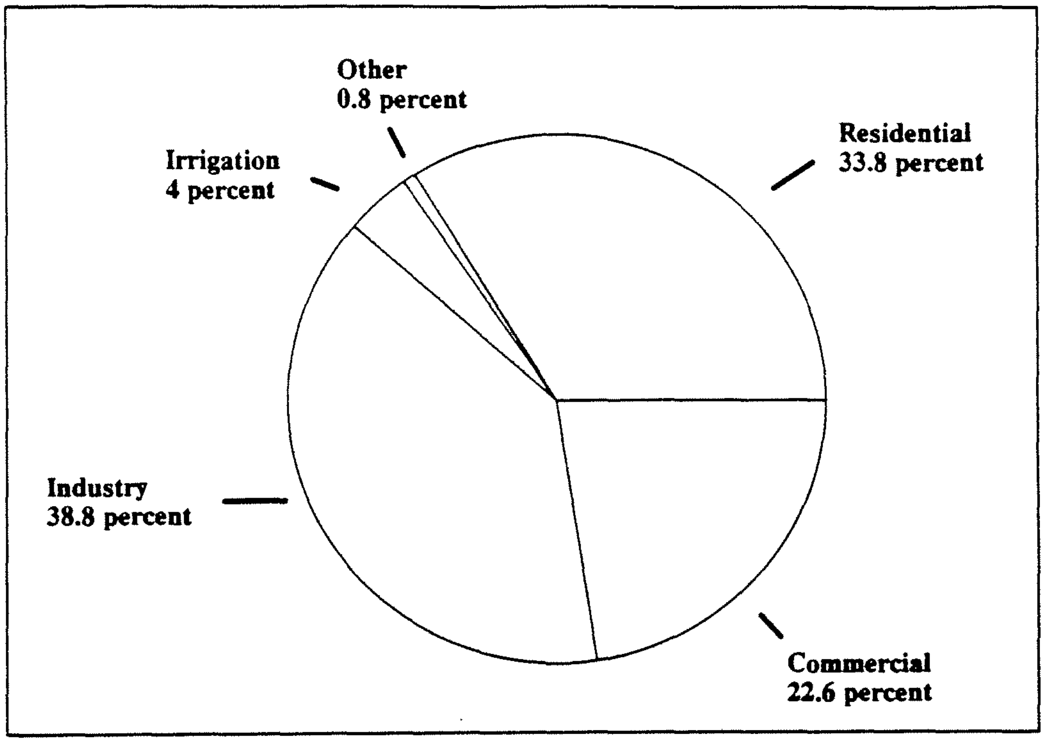

Figure 2-8
Pacific Northwest 1987 Firm Sales Shares

Residential Demand

The residential sector accounted for 34 percent of regional firm sales of electricity in 1987. Residential sector demand is influenced by many social and economic factors, including fuel prices, per capita income, and the choices of efficiency of energy-consuming equipment available to consumers (available technology). The most important factor, however, is the number of households.

The structure of the residential sector demand model reflects this importance by using the individual household as the basic unit. The model simulates future demand for electricity, given future growth in households by housing type, by projecting the amount of electricity-using equipment the average household owns; choices of fuel for space heating, water heating and cooking; the level of energy efficiency chosen; and the energy-using behavior of the household. These choices are influenced in the model by energy prices, equipment costs, per capita incomes and available technology.

The use of electricity is simulated for each of eight use classifications. Figure 2-9 shows estimated historical shares of these uses in total residential use of electricity for 1987. Space heating and water heating are the two most important end-use categories, and account for about half of all residential electricity use. The miscellaneous category, as defined by the Council, also includes some space heating (back-up heating in houses that are primarily heated by wood). It's worth pointing out that Figure 2-9 shows end-use shares averaged over all houses, whether they use electricity for a given end use or not. Houses that use electricity for space and water heating tend to use a larger share for those end uses than is shown in Figure 2-9.

The projections of residential demand for electricity cover a wide range. This range results mostly from variation in projections of the number of households, per capita income and fuel prices in economic and demographic growth assumptions. Projected demand also varies because of different assumptions regarding consumers' efficiency choice behavior.

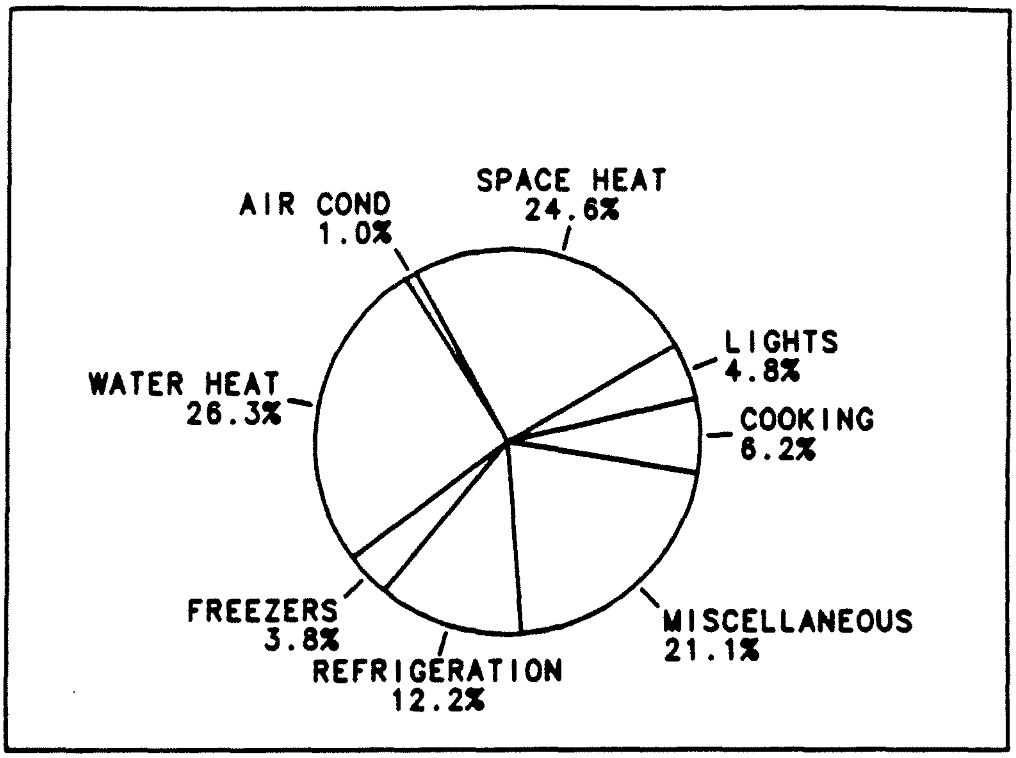

Figure 2-9
Pacific Northwest 1987 Residential Use by Application

In the absence of new conservation programs, projected residential demand increases from 5,280 average megawatts in 1987 to a range that spans from 10,167 average megawatts in the high-growth forecast to 6,088 average megawatts in the low-growth forecast in 2010. As shown in Table 2-6, the average demand growth rate ranges from a low of 0.6 percent per year to a high of 2.9 percent.

Table 2-6
Pacific Northwest
Residential Sector Electricity Demand
(Average Megawatts)

	ACTUAL 1987	FORECASTS 1990	2005	2010	GROWTH RATE (% PER YEAR) 1987-2010
High	5,280	5,887	8,979	10,167	2.9
Medium-high	5,280	5,678	7,772	8,617	2.2
Medium	5,280	5,605	7,323	7,977	1.8
Medium-low	5,280	5,488	6,890	7,464	1.5
Low	5,280	5,287	5,775	6,088	0.6

The residential model of energy demand descends from a computer model originally developed at Oak Ridge National Laboratory in 1978. Since that time, the model has been used in a wide variety of applications for the U.S. Department of Energy, state agencies and utilities. It also has incorporated improvements in logic and data, since the current model is several generations more advanced than the original.

The model is best described as a hybrid of engineering and econometric approaches. It is based on the fundamental idea that residential energy is used by equipment such as furnaces, refrigerators and water heaters to provide amenities to the occupants of residences. Residential energy use, as simulated by the model, is a function of:

1. The total number of residences and the number of new residences constructed. The projections for future years are taken from the economic and demographic projections.

2. The number of energy-using appliances in the average residence. Each year's appliance penetrations, or purchases of appliances per household, are simulated based on econometric analysis of historic sales patterns. Penetrations are influenced by equipment and energy costs and by per capita incomes.

3. The efficiencies of these appliances. Efficiency choice by consumers is simulated based on engineering analysis of costs of appliances of varying efficiencies and on econometric analysis of observed efficiency choices in the past. Efficiency choices are influenced by energy prices, the cost of more efficient appliances and the inclination of consumers to invest in conservation (represented by their implicit discount rates). Efficiency choices can also be constrained (e.g., thermal integrity choices will be no worse than some specified level), which provides the means of representing conservation programs, such as the model conservation standards, that have the objective of modifying consumers' choices of efficiency.

4. The fuels used by these appliances. While some appliances--such as air conditioners--use electricity exclusively, others--such as water heaters--can use any of several fuels. Fuel choice is simulated based on the efficiency choices and econometric analysis of fuel choice behavior that has been observed in the past. Fuel choices are influenced by relative fuel prices, equipment prices and relative efficiencies of the appliances using the various fuels.

5. <u>The intensity of use of these appliances.</u> Intensity of use is varied by such means as thermostat settings, reduced use of hot water for washing clothes and the like. Variation in intensity of use is based on econometric analysis of observed short-run response to fuel prices. Intensity of use is determined in the model by fuel costs, appliance efficiencies and per capita incomes.

The main change in the Council's residential energy demand forecasting model since the 1986 power plan is the adjustment of its fuel choice simulation to more closely match the fuel choice simulation of Bonneville's residential forecasting model. The fuel choice simulation of Bonneville's model is based on data from the Pacific Northwest, collected for the express purpose of this application. The fuel choice simulation of the Council's model originally was based on national data and econometric analysis performed for other purposes and adapted to this application. The fuel choice component of Bonneville's model was judged superior for planning purposes.

The most obvious way to obtain the fuel choice simulation behavior of the Bonneville model would have been to simply adopt the Bonneville model as a whole. However, the Council's model has some advantages in other areas (e.g., computer run time, the ability to make "frozen efficiency" forecasts, the simulation of interaction between appliance use and space conditioning) that are important to the Council's forecasting and conservation assessment work. Therefore, imitating Bonneville's fuel choice mechanism was chosen as a compromise. This imitation is necessarily imperfect, given the different structures of the two models, but the overall impact of these adjustments was to make projected fuel choices in new houses more responsive to energy prices and thermal integrity subsidies.

The adjustment of the Council's fuel choice simulation for existing houses did not follow the Bonneville model's behavior. The data and analysis performed for the Bonneville model applied to new houses, and Bonneville assumed that the fuel choice behavior for existing houses would be about as responsive as fuel choice for new houses. For the Council's model, the assumption was made that existing houses' fuel choice is about half as responsive as that of new houses.

Table 2-7 provides a summary of historical and projected values of some components that determine total demand for electricity in both public and investor-owned utility (IOU) areas. Although total residential use of electricity varies widely across the five growth forecasts, use per household shows much less variation. The table shows use per household for 2010 for the five growth forecasts, as well as historical use in 1987. The fairly narrow range of per household use projections for 2010 means that the variation in total residential demand is primarily due to variation in the projected number of households.

Table 2-7
Residential Sector Summary Indicators for Northwest Utilities

		ESTIMATED 1987	FORECAST 2010 HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Households (millions)	Public	1.324	2.509	2.110	1.946	1.822	1.469
	Private	1.981	3.641	3.072	2.841	2.660	2.180
Electricity Prices (1988 cents/kWh)	Public	3.8	4.2	3.7	3.5	3.2	3.0
	IOU	5.1	5.4	4.8	4.6	4.2	4.1
Efficiency Measures							
Thermal Integrity (New electrically heated single-family,	Public	1.76	1.92	1.90	1.88	1.88	1.91
efficiency relative to regional 1979 stock)	IOU	1.76	1.92	1.91	1.89	1.89	1.92
Refrigerators (New, efficiency relative to 1979 stock)	Public	1.43	1.82	1.82	1.82	1.82	1.82
	IOU	1.46	1.82	1.82	1.82	1.82	1.82
Saturations							
Electric Space Heat (% of homes with electric heat)	Public	58	61	59	57	53	52
	IOU	39	41	39	37	35	34
Electric Hot Water (% of homes with electric hot water)	Public	88	81	84	83	83	84
	IOU	80	76	77	76	75	76
Utilization Intensity (Relative to 1979)	Public	.81	.95	.96	.97	1.01	1.01
(Electrically space-heated homes)	IOU	.91	1.05	1.06	1.07	1.09	1.08
kWh per Household (All homes)		13,995	14,482	14,567	14,598	14,588	14,615
Space Heat kWh per Household (Electrically heated homes)		7,375	7,197	7,405	7,432	7,487	7,357
Non-space-heat kWh per Household (All homes)		10,557	10,944	11,076	11,243	11,420	11,581
Space Heat Sales (MW)		1,297	2,484	2,065	1,833	1,621	1,264
Total Sales (MW)		5,280	10,167	8,617	7,977	7,464	6,088

Electricity use per household is the net result of changes in efficiency, housing type, housing size and fuel choice. The changes in some of these individual components are substantial, but there is a tendency for them to offset one another in their effects on use per household. For example, efficiencies generally improve, tending to reduce use per household, while the sizes of multifamily units and mobile homes are projected to increase, raising per household energy requirements for space conditioning. These patterns are illustrated in Figures 2-10 and 2-11. Figure 2-10 shows the projected increases in the average size of manufactured homes and multifamily housing units, ranging from 7 percent to 32 percent. Figure 2-11 shows that the average thermal efficiency of electrically heated single-family houses improves by between 15 percent and 33 percent in the various growth forecasts.

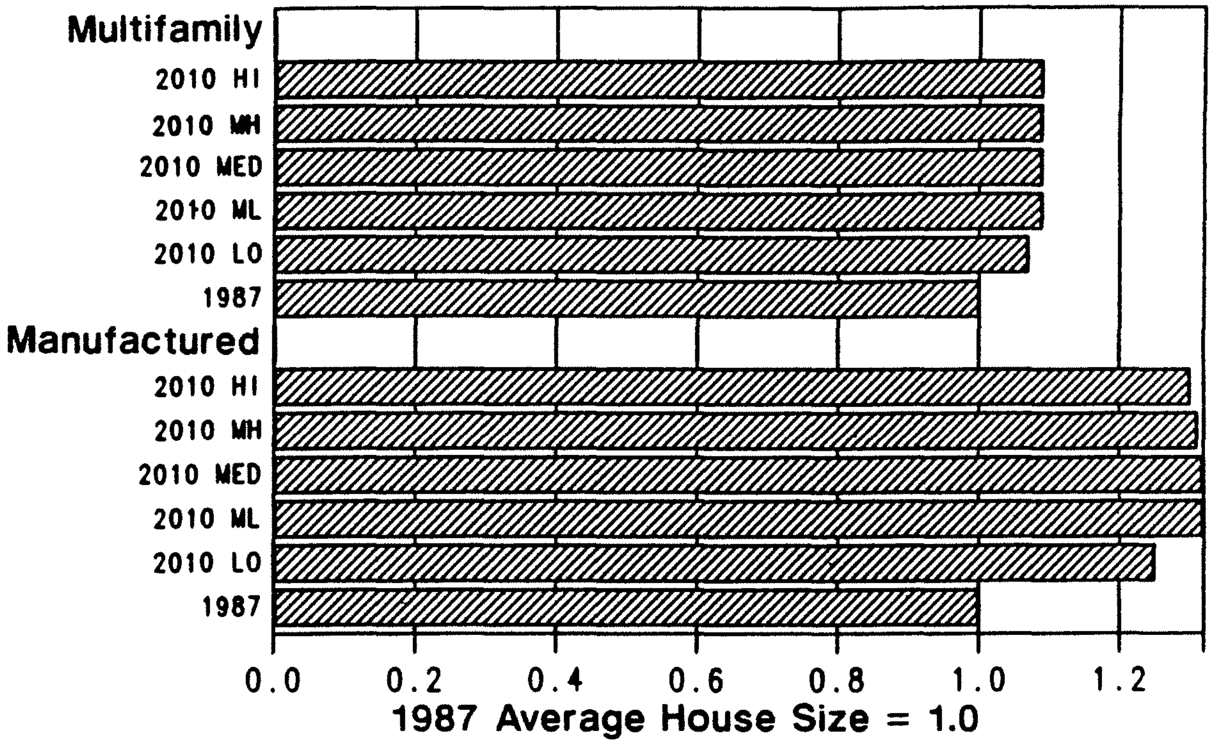

Figure 2-10
Average Size of Electrically Heated Housing Units in the Pacific Northwest

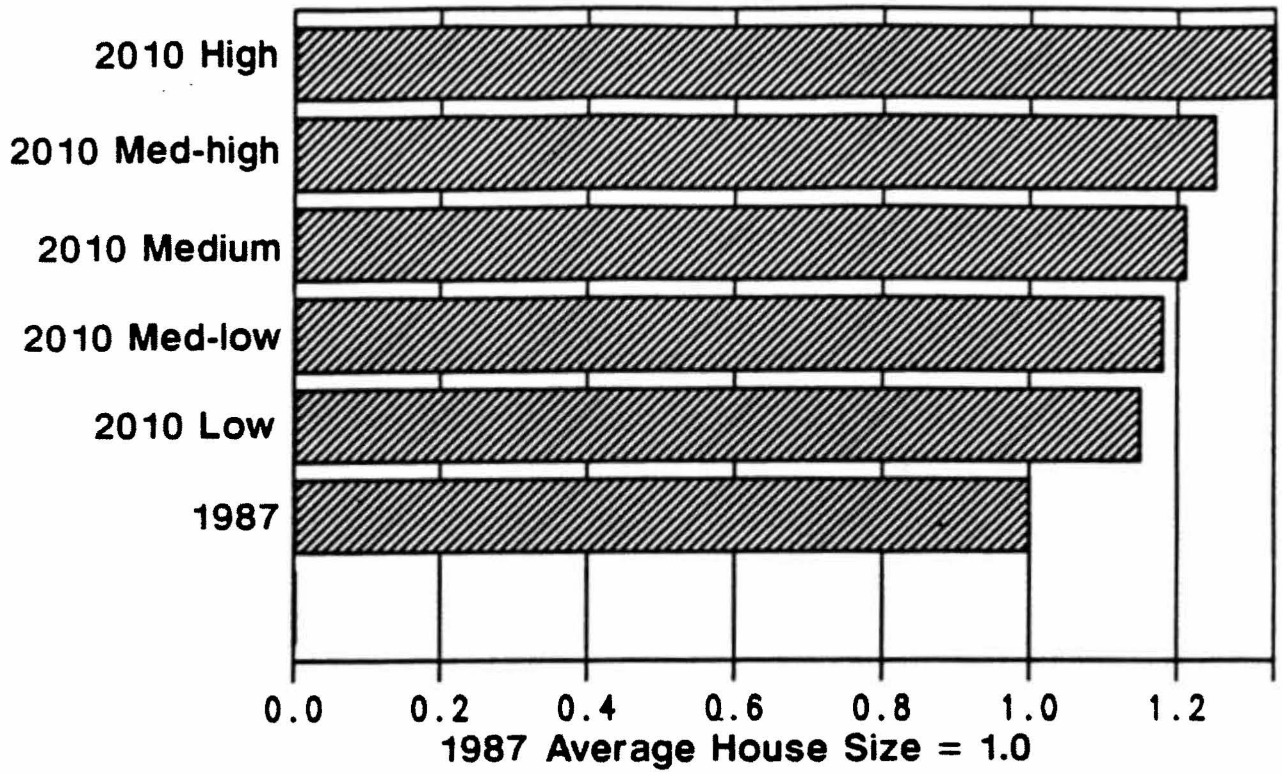

Figure 2-11
Thermal Efficiency of Electrically Heated Single-Family Houses in the Pacific Northwest

The thermal integrity of new houses (shown in Table 2-7) improves significantly from 1980 building practices. This is due mainly to more stringent building codes adopted in Washington and Oregon in 1985 that took effect after 1986. The greater thermal integrity of houses built after 1986 raises the average thermal integrity in 2010; the higher growth scenarios have more new houses, and higher average thermal integrity, as shown in Figure 2-11.

The regionwide adoption of the Council's model conservation standards is not assumed in this forecast. The Council expects that the standards will be adopted throughout the region, but until this has been accomplished, the standards will continue to be treated as a resource rather than included in the demand forecast.

Refrigerator efficiencies (shown in Table 2-7) and freezer efficiencies have improved significantly compared to the stock of appliances existing in 1979. These improvements are the result of a combination of consumers' responses to electricity prices and information programs, and manufacturers' responses to efficiency standards effected by California and other states by the early 1980s. The efficiency of these appliances, along with water heaters, is projected to improve after 1990, when new federal appliance efficiency standards go into effect.

Housing type and fuel choice also influence energy use per household. All the forecasts suggest a drop in the total share of houses that are single-family and a rise in the shares of multifamily units and manufactured homes. Table 2-8 shows the 1980 historical shares of the three building types, along with the projected 2010 shares in each of the forecasts. This trend decreases average use per household, since multifamily units and manufactured homes are smaller and require less energy to heat and cool.

Table 2-8
Pacific Northwest Share of Housing Stock by Building Type
1980-2010 (%)

		2010				
	1980	HIGH	MEDIUM-HIGH	MEDIUM	MEDIUM-LOW	LOW
Single-family Homes	77.8	77.0	71.4	70.9	69.7	69.4
Multifamily Homes	14.4	15.2	16.7	18.3	19.2	20.7
Manufactured Homes	7.8	7.8	11.9	10.7	11.1	9.9

Fuel choice projections have mixed effects on energy use per household. As shown in Table 2-7, the shares of households with electric water heating are projected to decrease in all forecasts. Electric space heating shares are projected to be greater in higher growth forecasts and smaller in lower growth forecasts. Space and water heating saturations are influenced by electricity prices, per capita incomes and the share of recently constructed houses in the stock. In addition, they are influenced heavily by the relationship of electricity prices to those of competing fuels, such as natural gas and oil. As will be described in the section on electricity prices, the higher growth scenarios have higher electricity prices, but relatively lower prices of electricity compared to competing fuels. This pattern helps to explain the higher saturation of electrical space heating in the higher growth scenarios.

When all the sometimes conflicting influences just described are combined, the net effect is the observed pattern of relatively small changes in per household use.

This projection of electrical equipment use is based on demand for electricity before taking into account the Council's proposed conservation programs. The effects of these programs cause sales of electricity to grow at slower rates. In addition, the use of electricity per household would decline because of the increased thermal efficiency of buildings and improved appliance efficiencies. The effects of these efficiency increases would be somewhat diminished, however, by the greater use of energy services due to cost savings from improved efficiency in space and water heating. These effects are reflected in the "sales" forecasts that are the basis of electricity prices used for the "price effects" forecasts described in this paper.

Commercial Demand

Commercial demand accounted for 23 percent of firm regional sales of electricity in 1987. Commercial sector electricity demand, like that of the residential sector, is influenced by many factors, such as fuel prices and available technology. In particular, one fundamentally important factor used as a basis for energy use projections is the total floor space of the buildings in the commercial sector. The commercial sector demand model projects the amount of commercial floor space and predicts fuel choice, efficiency choice and the use of energy-consuming equipment necessary to service this floor space. These choices are based on investment factors, fuel prices and available technology. Energy use projections are made separately for different building types, applications and fuels.

The composition of historical commercial sector demand for electricity shown in Figure 2-12. Space heating and lighting make up the largest shares of commercial electricity use. If space heating, ventilation and air conditioning are combined, as they commonly are, into an HVAC category, HVAC and lighting account for more than 80 percent of electricity use in the commercial sector.

Commercial sector electricity use is forecast separately for 10 different building types. The consumption shares of these building types are shown in Figure 2-13. Offices account for more than one-fourth of electricity use by the sector. Retail buildings are the next largest category, followed by miscellaneous buildings and groceries. More than two-thirds of the sector's electricity use is attributed to these four building types.

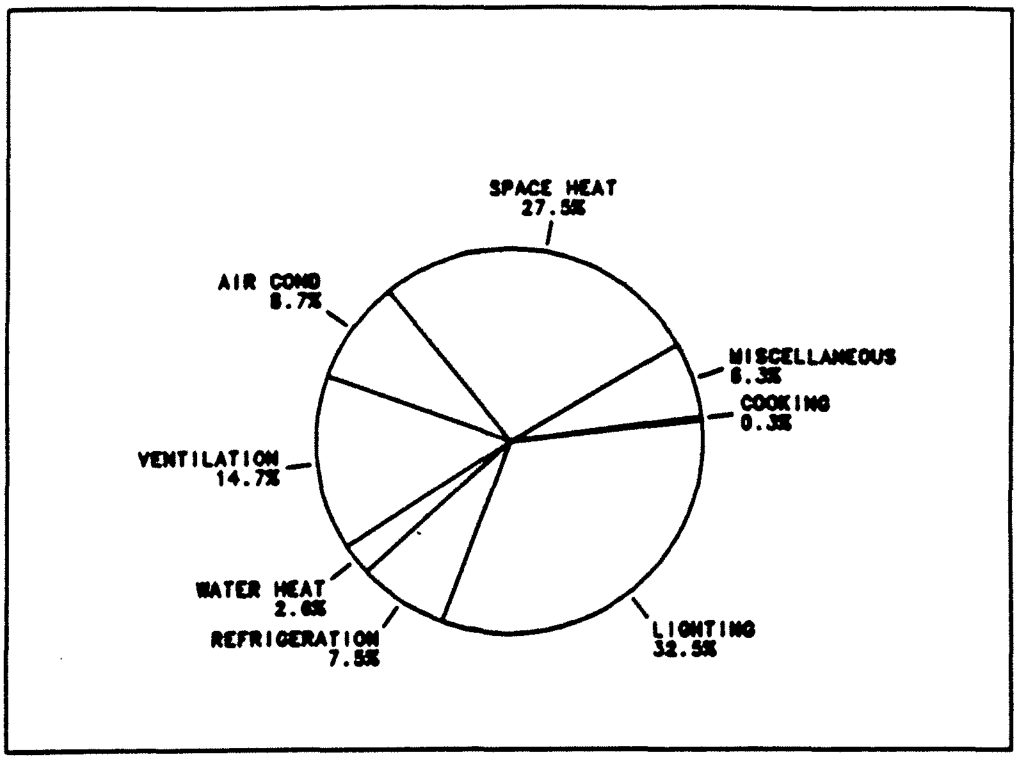

Figure 2-12
1987 Commercial Sector Use by Application
in the Pacific Northwest

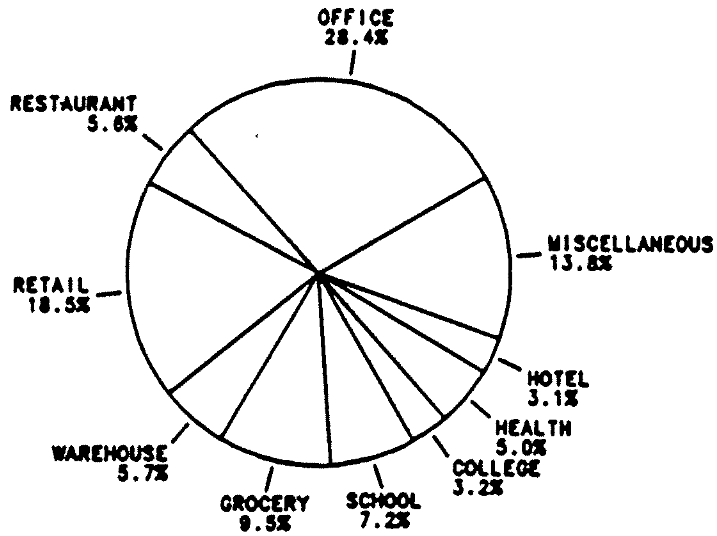

Figure 2-13
1987 Commercial Sector Use by Building Type
in the Pacific Northwest

Since 1986, development of the Council's commercial sector energy demand model has concentrated on incorporating recent data on floor space and energy use. Even before 1986, forecasters of commercial sector energy use in many parts of the United States were discovering that they tended to underforecast energy use in the early 1980s. A number of explanations were proposed, including unexpected growth in use of computers and other office machinery, a cyclical boom in construction of office buildings that exceeded the current requirements for floor space and unexpected resistance to adoption of more efficient space conditioning and lighting equipment. Since 1986, data have become available that, while they do not eliminate all concern about the problem, shed some light on its causes.

First, an estimate of the stock of commercial floor space was developed by Baker, Reiter and Associates under contract to Bonneville. This estimate was the result of a widespread sample of commercial buildings in the region and must be regarded as a significant improvement over the estimate previously used in the forecasting model. The estimated floor space of many building types changed substantially.

The estimation effort also resulted in estimates of 1980-86 construction in the region. The estimated construction is consistent with a boom in office construction. Estimated office space grew faster than employment of office workers. The differential growth of office space and office workers is also consistent with higher-than-normal vacancy rates (around 20 percent) in the metropolitan centers of the region. The Council's forecast assumes that vacancy rates will decline in the long run to around 10 percent, after which office floor space will grow in proportion to employment.

While office floor space appears to have grown faster than office employment, other building types seem to have grown more slowly than relevant employment--health care buildings are one example. In these cases, our forecast assumes that the 1986 relationship of employment to floor space represents the long-term relationship, and that floor space will grow in proportion to employment growth after 1986.

The re-estimated floor space in the commercial sector made it necessary to re-estimate electricity use per square foot in the model's base year (1979). New energy-use data from the End Use Load Conservation Assessment Program (ELCAP), the Commercial Audit Program (CAP) and the Seattle City Light Commercial Data Base (SCLCDB) also contributed to the estimates.

The new energy-use data also allowed the examination of the relationship of energy use in buildings built in the early 1980s to that of buildings built earlier. The data indicate that total electricity use in new offices and retail stores is not much different than use in older ones. Further, this relationship seems to hold even when use for heating, ventilation and air conditioning (HVAC) in new buildings is compared to HVAC use in older ones, and when lighting use is compared between new and older buildings.

These results could be interpreted to imply that the energy efficiency of HVAC and lighting equipment has not improved since 1979. However, there is considerable anecdotal evidence that efficiencies have improved. This evidence suggests that new buildings and equipment are more energy-efficient, but are being used to provide a higher level of service or amenity to the occupants of the buildings. This higher amenity can take a number of forms (more hours of operation, greater control of temperature or humidity, more attractive display lighting, etc.), but the final effect is that energy use per square foot apparently has not necessarily declined with improved energy efficiency of buildings or equipment.

Information about changing amenity levels in commercial buildings is mainly anecdotal--new schools tend to be air conditioned, new groceries tend to have delis, and the like. Amenity levels may not increase in all new buildings, but they may increase in some existing buildings as well. The assumption in our commercial forecast is that for five building types (offices, retail, schools, colleges, and miscellaneous) buildings built after 1980 provide increased amenities. These increased amenities, together with improved efficiencies, make HVAC and lighting electricity use about the same as these buildings types' 1979 stock. It is also assumed that the pre-1980 stock of these same building types will provide gradually increasing levels of amenities until they reach 75 percent of the level provided by new buildings.

These assumptions had the effect of raising the forecast and brought the projected electricity use from 1979 to 1987 into much closer agreement with actual commercial sales during that period. This historical agreement is not conclusive proof that the assumptions are accurate, or that the assumptions lead to accurate long-run forecasts--historical agreement could have been obtained with other assumptions, leading to different long-run forecasts. Given that these assumptions are based on the available data, the performance of the model in matching historical experience is some confirmation that the assumptions are reasonable.

Finally, the high-scenario assumptions include modifications that bring fuel choices in the investor-owned utilities closer to fuel choices in the public utilities. The intent is to include in the high scenario the possibility that fuel choice is strongly influenced by factors not included in the forecasting model's simulation, and that the net effect of these factors is that electricity is preferred as a heating fuel even when electricity's apparent life-cycle costs are not particularly attractive.

The resulting projections of commercial demand for electricity vary widely. In the low-growth forecast, commercial demand for electricity decreases from 3,479 megawatts in 1987 to 3,471 megawatts by 2010. In the high-growth forecast, it reaches 7,465 megawatts. As shown in Table 2-9, the average rate of growth of demand ranges from 0 percent to 3.4 percent per year.

Table 2-9
Pacific Northwest Commercial Sector Electricity Demand
(Average Megawatts)

	ACTUAL	FORECASTS			GROWTH RATE (% PER YEAR)
	1987	1990	2005	2010	1987-2010
High	3,479	3,915	6,465	7,465	3.4
Medium-high	3,479	3,722	5,328	6,055	2.4
Medium	3,479	3,626	4,708	5,220	1.8
Medium-low	3,479	3,524	3,974	4,317	0.9
Low	3,479	3,458	3,330	3,471	-0.0

Table 2-10 shows some of the components underlying these totals. Floor space--the major driver of growth in electricity demand--increases in all forecasts, as a result of increased employment in the commercial sector. Use of electricity per square foot of floor space of all buildings increases in the higher growth forecasts and decreases in lower growth forecasts. The change in use per square foot from 1987 to 2010 is modest for all forecasts, ranging from an increase of 4 percent in the high-growth forecast to a decrease of 14 percent in the low-growth forecast.

Use of electricity per square foot of office floor space, however, is projected to move in different directions depending on utility type. It decreases in investor-owned utilities for all forecasts. In public utilities, it increases for all forecasts. These changes are modest in either direction. The largest projected increase is about 8 percent and the largest projected decrease is about 9 percent.

Saturation of electric space heating is projected to increase most in the higher growth scenarios, and to decrease in the lower scenarios. This pattern holds for offices and for commercial buildings as a whole.

The pattern of projected electric space heat saturations is due partly to the pattern of projected electricity prices. Table 2-10 shows that prices increase in the higher growth scenarios and decrease (in constant dollars) in the lower growth scenarios. In addition, projected 2010 prices for investor-owned utilities are at least 63 percent higher than those for public utilities.

Projected prices of competing fuels also influence space heat saturations. Figure 2-17, in the section on prices, demonstrates that while projected residential electricity prices are lowest in the low scenario, natural gas prices are projected to decline even more, so that electricity prices relative to natural gas prices are highest in the low scenario. Fuel prices projected for the commercial sector follow a similar pattern and lead to higher electric space heat saturations in the higher growth scenarios and lower electric space heat saturations in the lower growth scenarios.

Table 2-10
Commercial Sector Summary Indicators for Northwest Utilities

		1987	2010 HIGH	2010 MEDIUM-HIGH	2010 MEDIUM	2010 MEDIUM-LOW	2010 LOW
Floor Space (million sq. ft.)	Public	640.5	1,219.7	1,005.4	889.2	795.9	680.5
	IOU	1,213.7	2,600.4	2,182.1	1,927.1	1,719.1	1,481.0
Electricity Prices (1988 cents/kWh)	Public	3.4	3.8	3.2	3.0	2.7	2.5
	IOU	5.4	6.2	5.8	5.6	5.2	5.4
Sales - kWh per Square Foot Floor Space							
Offices							
Space Heat (offices heated by electricity)	Public	6.6	5.9	6.4	6.5	6.8	6.5
	IOU	6.1	4.9	5.2	5.2	3.9	3.8
Lighting	Public	8.3	8.0	8.2	8.3	8.5	8.6
	IOU	8.2	8.1	8.0	8.0	8.1	8.2
Total	Public	25.6	25.7	27.0	27.5	27.7	27.2
	IOU	23.9	23.5	23.6	23.3	21.9	21.7
All Commercial Buildings							
Space Heat (buildings heated by electricity)		9.0	6.6	7.7	8.2	8.9	9.9
Lighting		5.3	5.2	5.2	5.2	5.3	5.2
Total		16.4	17.1	16.6	16.2	15.0	14.1
Saturation of Electric Space Heat (%)							
Offices	Public	72	97	93	89	76	58
	IOU	69	96	83	74	50	39
All Commercial Buildings	Public	58	92	85	79	64	47
	IOU	46	83	56	44	23	12
Total Sales (AMW)							
Space Heat		957	2,462	1,829	1,449	924	564
Lighting		1,132	2,269	1,881	1,675	1,511	1,294
Total		3,479	7,465	6,055	5,220	4,317	3,471

The mixed pattern of projected energy use is due in part to projected electricity prices and in part to conflicting trends in efficiency and amenity levels. As described earlier, new buildings are assumed to provide a higher level of service or amenity to their occupants, which tends to use more electricity. At the same time, new buildings and equipment are projected to be more energy-efficient in providing any specified level of amenity. The net result of these conflicting trends is the observed pattern of small increases and decreases in overall electricity use per square foot.

These projections do not take into account the conservation programs included in the power plan, but are based on existing building codes and market response to increased energy prices. The Council's programs will reduce overall demand for electricity, reduce demand per square foot and improve equipment efficiency.

In general, the new information that has become available in the last two years has raised more questions than it has answered. A number of underlying assumptions of the 1986 forecast have been called into question by this new information. Among these are the assumptions of a stable relationship between employment and floor space and a stable level of HVAC and lighting amenity in new and existing buildings. The forecasts reported here assume that the relationships between employment and floor space have changed for some building types between 1979 and 1986, and that the new relationships will continue for the period of the forecasts. The level of HVAC and lighting amenity are assumed to be stable for new buildings, but to increase in existing buildings to levels 75 percent of those of new buildings. These seem to be reasonable assumptions, but further adjustments may well be justified as more information becomes available. The commercial sector will be the subject of continuing research and analysis.

Industrial Demand

The industrial sector is the largest of the four consuming sectors. In 1987, the industrial sector consumed 6,062 average megawatts of firm power, accounting for 39 percent of total firm demand in the region. In addition, the direct service industrial customers of Bonneville consume varying amounts of nonfirm electrical energy, depending on economic and hydroelectric conditions.

Unlike the residential and commercial sectors, in which the general uses of electricity are similar in different houses or buildings, the industrial uses of electricity are extremely diverse. It is difficult to generalize about the end uses of energy or the amounts of energy used in a "typical" industrial plant. For example, the primary metals industry uses about 80 times as much electricity per dollar of output as the apparel industry.

The industrial use of electricity in the Northwest is highly concentrated in a few industrial subsectors. Figure 2-14 illustrates the composition of total industrial demand for electricity. The data for Figure 2-14 are based on 1981, the most recent year for which a comprehensive accounting of industrial energy use by detailed industry sector in the Northwest was possible. Five industries--food, chemicals, paper, lumber and metals--accounted for more than 90 percent of industrial use of electricity. Metals production, alone, accounted for nearly half of total industrial electricity use. More than 90 percent of electricity use in metals is by direct service industry customers, primarily the region's 10 aluminum smelters. These aluminum smelters also dominate all direct service industry sales, accounting for about 90 percent of that total. Bonneville's direct service industrial customers accounted for 46 percent of total industrial demand for electricity in 1981, or about 18 percent of total regional sales to all sectors. One-fourth of the direct service industry demand is considered nonfirm demand, or interruptible demand. If Bonneville were to have a shortage of energy, for example, due to poor water conditions, it has the right to not serve one-fourth of the direct service industry demand. Only the firm portion of direct service industry demands are included in the Council's forecasts of energy requirements. However, the interruptible portion of direct service industry demand is considered in system operation and electricity pricing analyses.

Forecasts of industrial demand for electricity reflect production forecasts for the various industrial sectors, the amount of energy used per unit of output and the effects of electricity and other fuel prices on their use of energy. Table 2-11 shows industrial sector firm demand forecasts for selected years for all five forecasts. In the high forecast, consumption of electricity by the industrial sector grows to 10,749 average megawatts by 2010--an average annual growth rate of 2.5 percent per year. In the low forecast, industrial demand decreases due to significant reductions in direct service industry sales offsetting modest growth in other industries. The more likely range of industrial demand growth is from 0.4 percent to 1.5 percent per year, with the medium case growth at 0.8 percent per year.

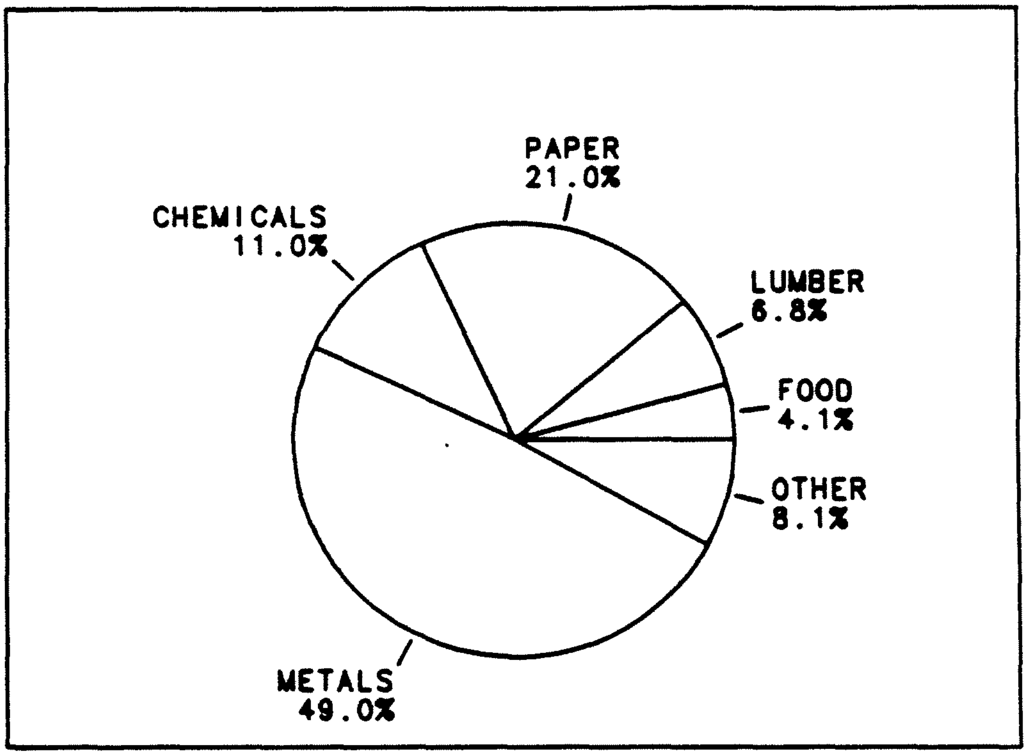

Figure 2-14
Composition of Industry Demand
in the Pacific Northwest

Table 2-11
Industrial Sector Firm Sales
in the Pacific Northwest
(Average Megawatts)

	ACTUAL 1987	FORECASTS 1990	2005	2010	GROWTH RATE (% PER YEAR) 1987-2010
High	6,062	7,153	9,703	10,749	2.5
Medium-high	6,062	6,770	7,982	8,509	1.5
Medium	6,062	6,488	7,023	7,363	0.8
Medium-low	6,062	6,112	6,287	6,599	0.4
Low	6,062	5,735	5,110	5,211	-0.7

Methods of forecasting industrial demand for electricity vary substantially among different industrial subsectors. In general, forecasting methods are most detailed for activities that consume the greatest amounts of electricity. It is necessary to forecast industrial activity and demand for electricity individually for up to 40 industry components in order to obtain reliable forecasts of total industry demands.

The composition of the industrial forecasting system is shown in Table 2-12. The components of the industrial sector are defined using the Standard Industrial Classification (SIC) code. Table 2-12 shows the share of total industrial consumption of electricity estimated to have been consumed by each subsector in 1981. The concentration of demand for electricity illustrated in Figure 2-14 also is apparent in Table 2-12.

There are four different forecasting methods used for the industrial sector. The methods are referred to as: 1) key industry model, 2) econometric model, 3) simple relationships, and 4) assumptions. The method applied to each industry component is abbreviated in Table 2-12. All of the forecasting methods, except assumptions, are driven primarily by forecasts of industrial production for each industrial sector. In addition, each of those methods modifies the relationship between production and electricity use to reflect the effects of changing energy prices and other factors.

Direct service industrial customers of Bonneville are treated separately from other industrial components. Aluminum demands were forecast by Bonneville using industry forecasting models supplemented by judgment, results of various aluminum studies, external consultants and specific knowledge gained through years of dealing with the industry. The load forecasts are done primarily on the basis of the relationship between aluminum prices and costs of production. The aluminum price projections take into consideration forecasts from independent consultants who follow the aluminum industry. Production costs for each smelter are Bonneville estimates. Two models used in the load forecasting process are the Aluminum Smelter Model, used for the short-term portion, and the joint decision analysis model, used for the long-term portion. These models assume that the smelters will operate when the market price of aluminum exceeds short-run variable costs and close when they do not. The model results are evaluated with staff judgment to produce the final load forecast.

Electric loads of the non-aluminum direct service industries also were forecasted by Bonneville using econometric models, with load determined by general macroeconomic conditions, industry-specific production indices and the region's relative price of electricity. Variables reflecting national trends were taken from Data Resources, Inc.

The three largest non-direct-service industries are forecast using the Council's key industry models. The key industry models are detailed approaches to forecasting demand for electricity. The three so-called key industries are lumber and wood products, pulp and paper, and chemicals. First, the industry is further divided into the most energy intensive activities. For those activities, the uses of electricity are divided into several types of uses, such as motors for specific processes, electrolysis or lighting. The fraction of electricity use attributable to each of these end uses is estimated for an average plant. In the case of chemical production of phosphorous and chlorine, the model is specified separately for each of the relatively few plants in the region.

The forecast requires a specification of how the types of end uses may change their shares over time. In addition, the degree to which electricity for each type of end use could be conserved in response to price changes must be specified. The degree of price response varied across forecast scenarios, being largest in the low forecast and smallest in the high forecast. Given these specifications, the demand for electricity per unit of production will change from its base year value as production and electricity prices change.

The key industry models require a great deal of data and judgment. This information goes beyond readily available sources of data. For this reason, specification of the key industry models relied heavily on the judgment and advice of industry representatives and trade organizations.

The industrial forecasting system includes a variety of econometric forecasting equations for the remaining non-key and non-direct-service industry demands for electricity. Econometric models consist of equations estimated from historical data. The equations attempt to measure the effect of industry production and energy prices on the demands for different types of energy, including electricity. Because historical data are generally of poor quality at the industrial subsector level, it is often difficult to obtain plausible relationships for econometric equations. Where econometric results appeared implausible, simple relationships between output and electricity use were used as a basis for the forecasts.

Alternative econometric estimates are available in the demand forecasting system for most industry components. In Table 2-12, the alternative equation used is specified in the column labeled "model version." Equations obtained from the Oregon Department of Energy are noted as "ODOE." Equations obtained from Bonneville are labeled "AEA" for the consulting firm that estimated the equations, Applied Economic Associates.[1]

1./ Applied Economic Associates, Inc., Update and Re-estimation of the Northwest Energy Policy Project Energy Demand Forecasting Model, report to Bonneville Power Administration, December 1981.

Table 2-12
Industrial Forecasting Methods

SIC CODE	TITLE	1981 PERCENT OF MFG. ELECTRICITY		FORECASTING METHOD	MODEL VERSION
Manufacturing					
20	Food and Kindred Products	4.1		Simple	
22	Textiles	.1		Econometric Model	AEA
23	Apparel	.1		Simple	
24	Lumber and Wood Products	6.8		Summed	
2421	Sawmills and Planing Mills		2.8	Key Industry Model	
2436	Softwood Veneer and Plywood		1.5	Key Industry Model	
24xx	Rest of SIC 24		2.5	Simple	
25	Furniture	.1		Simple	
26	Pulp and Paper	21.0		Summed	
2611	Pulp Mills		1.6	Key Industry Model	
2621	Paper Mills		12.1	Key Industry Model	
2621	Paper Mills - DSI		.2	Assumption	
	Crown Zellerback				
2631	Paperboard Mills		4.4	Key Industry Model	
26xx	Rest of SIC 26		2.7	Simple	
27	Printing and Publishing	.5		Econometric Model	ODOE
28	Chemicals	11.0		Summed	
2812	Chlorine and Alkalies		1.9	Key Industry Model	
2812	Chlorine and Alkalies - DSI		1.1	Assumption	
	Georgia Pacific				
	Pennwalt				
2819	Elemental Phosphorous		5.6	Key Industry Model	
2819	Elemental Phosphorous - DSI		.8	Assumption	
	Pacific Carbide				
	Doe Richland			(Included in Federal Agencies)	
28xx	Rest of SIC 28		2.2	Econometric Model	ODOE
29	Petroleum Refining	1.4		Simple	
30	Rubber and Plastics	.5		Econometric Model	AEA
31	Leather and Leather Goods	0.0		Not Forecast	
32	Stone, Clay, Glass and Concrete	1.2		Summed	
3291	Abrasive Products - DSI		.3	Assumption	
	Carborundum				
32xx	Rest of SIC 32		.9	Econometric Model	ODOE
33	Primary Metals	49.0		Summed	
3334	Aluminum - DSI		43.2	Assumption	
3313	Electrometallurgical - DSI		1.3	Assumption	
	Hanna				
	Gilmore				
3339	Non-ferrous N.E.C. - DSI		.1	Assumption	
	Oremet				
33xx	Rest of SIC 33		4.4	Econometric Model	ODOE
34	Fabricated Metals	.8		Simple	
35	Machinery Except Electrical	.8		Simple	
36	Electrical Machinery	.4		Econometric Model	ODOE
37	Transportation Equipment	1.9		Simple	
38	Professional Instruments	.4		Simple	
39	Miscellaneous Manufacturing	.1		Simple	
xx	Residual Categories	.4		Simple	
Mining				Grows with Employment	

The sectors whose forecasting methods are listed as "simple" are those for which econometric results were unsatisfactory. The econometric models that were used in the Council's 1983 plan analysis for these industries were abandoned in response to public comment criticizing the behavior of those equations. In these simple forecasts, demand for electricity is assumed to grow at the same rate as production, but is modified by an assumed trend in electricity use per unit of production. There is substantial agreement in econometric models and other research on industrial energy demand that, in the absence of other influences, energy demand will grow with production.

There is much less agreement about the degree of influence price changes will have on demand. To reflect this uncertainty, assumptions about changes in demand per unit of production were varied across forecast scenarios. Electricity use per unit of production was assumed constant in the high forecast for industry components that were forecast using the simple method. In the medium-high forecast, the electric intensity was assumed to decrease by 0.5 percent per year; in the medium-low forecast, by 1.5 percent per year; and in the low forecast by 2.0 percent per year. The medium case assumes a reduction of electricity use per unit output of 1.0 percent per year. These assumptions are similar to the range of results from econometric equations that were more acceptable theoretically and behaviorally.

The forecast growth rates of industrial demand for electricity are considerably smaller than the projected rates of growth in total industrial production. Production by Northwest manufacturing industries is expected to grow by 4.9 percent per year in the high forecast, 3.5 percent and 2.3 percent per year in the medium-high and medium-low forecasts, respectively, and by 1.1 percent per year in the low forecast. The medium forecast is 2.9 percent per year. The relative growth rates of electricity demand and output imply an overall reduction in the electricity intensity of the Northwest industrial sector. The ratios of electricity use to production decline over the forecast period in all five forecasts. The rates of decline vary from 2.3 percent per year in the high case to 1.6 percent per year in the low case. Although these rates of decrease are significant, they are lower than recent regional history. Between 1977 and 1986, regional industrial electricity intensity is estimated to have declined by about 4.5 percent per year. Such decreases in energy intensity are not unprecedented. At the national level, for example, total energy use per unit of production in the industrial sector has been estimated to have decreased by 4.5 percent per year between 1970 and 1986.

Several factors reduce industrial rates of electricity growth relative to production growth. The most important is a change in the mix of industry. Many of the large users of electricity are not expected to grow as fast as industry does on average. This is most notable in the case of the direct service industries, which represent a very large portion of the industrial demand, whose energy use is not expected to increase and may even decline.

Historically, direct service industrial demands for electricity have exhibited enormous volatility, primarily reflecting swings in aluminum industry market conditions. This volatility is expected to continue, with the uncertainty for the regional industry compounded by the potential outcomes of major issues. Such issues include the impact of resource strategies taken by the region on availability of power to aluminum smelters, terms and conditions of future direct service industry power sales contracts, the nature and extent of direct service industry contract assignments, and the level of industrial power rates. In general, future direct service industry demand for electricity will be a function of the perceptions of industrial producers about the attractiveness of the region as a place to invest and operate, as well as their ability to maintain competitiveness in product markets. While regional smelters have reduced their costs considerably, and have benefitted from recent market strength, there is some evidence that the long-term problems facing the aluminum industry have not gone away.

The uncertainty of future direct service industry power sales is reflected in the five forecast scenarios for purposes of defining the full range of electrical resource needs. Figure 2-15 shows the percent of aluminum plant capacity that is expected to be operating in the region by the end of the forecast period for each of the five forecasts. Capacity, as used here, is the power demand the aluminum smelters are expected to draw after efficiency improvements made under Bonneville's conservation/modernization program. Since Bonneville currently has contractual obligations to serve all direct service industry capacity, 100 percent of current direct service industrial capacity is included in the high forecast. It is projected that 91 percent of direct service industrial capacity will operate in the medium-high forecast. In the medium forecast, 82 percent of the capacity would operate. The operating rates in the medium-low and low forecast are 66 and 50 percent, respectively.

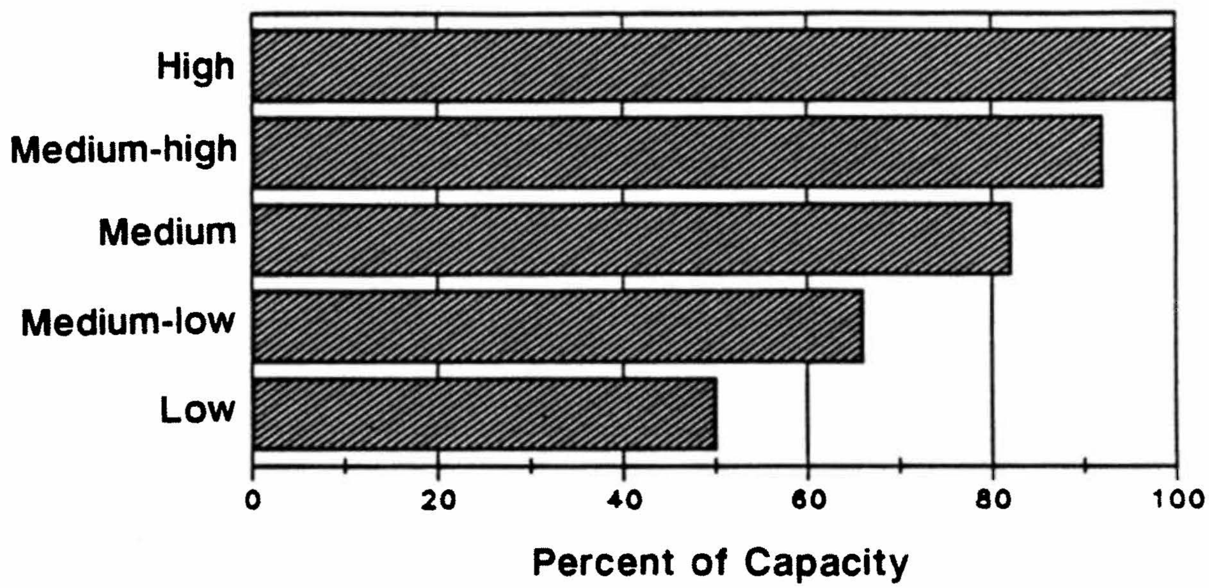

Figure 2-15
Projected Aluminum Operating Rates
in the Pacific Northwest

The forecasts of direct service industry demand for electricity are shown as a range of demand levels associated with specific forecast scenarios. The direct service industry loads are treated differently, however, for resource planning purposes. In the Council's 1986 plan resource portfolio analysis, for example, direct service industry load uncertainty was modeled by including 50 percent of aluminum direct service industry load in all load cases and randomly adding portions of the remaining 50 percent of aluminum direct service industry loads. This was based on the conclusion that half of the aluminum production capacity in the region appeared to be economically viable in the long run, while more uncertainty existed about the remaining capacity.

The forecast of industrial electricity use is further dampened by the fact that some of the large non-direct-service industrial users such as lumber and wood products, food processing, and pulp and paper are not projected to grow as fast as less energy-intensive industries. As shown in Table 2-13, output growth for the key non-direct-service industries combined is expected to be 1.3 percent per year in the medium forecast, compared with 2.9 percent per year for all industrial production. Thus, the two components of the industrial sector that accounted for more than 90 percent of the sector's electricity demand historically will show relatively weak growth over the next 20 years.

Table 2-13
Composition of Pacific Northwest Industry Growth
1987-2010 (Medium Forecast)

	HISTORICAL SHARE OF CONSUMPTION (%)	PRODUCTION GROWTH RATE (% per year)	DEMAND GROWTH RATE (% per year)
Direct Service Industries	46	n.a.	-0.5
Key Non-direct Service Industries	45	1.3	1.0
Minor Industries	9	3.8	2.8
TOTAL	100	2.9	0.8

The second major reason for lower electricity growth relative to production is the effect of the large change in the relative price of electricity in the region over the last several years. The effects of price on industrial demand cannot be separated into components as they can for the residential and commercial sectors, but conceptually they include efficiency improvements, fuel switching and product mix changes within individual industrial sectors.

Irrigation Demand

Irrigation use of electricity is less than 5 percent of total regional firm electricity sales. In 1987, irrigation used 619 average megawatts of electricity. For several decades, Pacific Northwest irrigation sales climbed rapidly and steadily. Since 1977, they have become more erratic. They began to level off and then decreased slowly. The average annual rate of growth of on-farm and Bureau of Reclamation irrigation electricity use from 1970 to 1977 was a robust 10 percent. From 1977 to 1987 the growth rate was -0.3 percent, reflecting increased electricity and water conservation and a slower pace of development on new irrigated land.

There are about 8.2 million acres of irrigated land in the region. Nearly half of that is in Idaho. Oregon and Washington each have a little over one-fifth of the total irrigated acres. Most electricity use in irrigation is associated with sprinkler irrigation. Currently, about 55 percent of the irrigated land in the region is irrigated with sprinkler systems. The distribution of irrigation by state is different for electricity used than for irrigated acres. Washington and Idaho accounted for over 80 percent of irrigation electricity use in 1987, but only 67 percent of sprinkled acres. This difference is due to the high electricity intensity of Washington's irrigated agriculture.

Table 2-14 shows the forecasts of use of electricity for irrigation. The forecast range is quite flat. The high and medium-high forecasts show little growth in electricity used for irrigation from its 1987 level. The medium, medium-low and low forecasts all show declining amounts of electricity used for irrigation compared to 1987. The irrigation forecast excludes about 100 megawatts of Bureau of Reclamation pumping loads at Grand Coulee and Roza dams, which were included in the Council's 1986 plan irrigation sales forecasts. The forecasts shown in Table 2-14 include U.S. Bureau of Reclamation irrigation sales, which Bonneville included in federal agency loads, rather than in irrigation sales, in its 1986 forecast.

The forecasts reflect the expectation that major additions to Northwest irrigated agriculture are unlikely and that additions that occur are likely to be offset by increased efficiency in the use of electricity and water. Other factors reducing future irrigation growth include agricultural production surpluses, slow improvements in farm costs, prices and exports, and environmental concerns.

Table 2-14
Electricity Demand in the Pacific Northwest's
Irrigation Sector
(Average Megawatts)

	ACTUAL 1987	FORECASTS 1990	2005	2010	GROWTH RATE (% PER YEAR) 1986-2010
High	619	611	617	624	0.0
Medium-high	619	578	619	627	0.1
Medium	619	551	584	565	-0.4
Medium-low	619	524	531	525	-0.7
Low	619	504	484	454	-1.3

The irrigation forecast was based on a combination of Bonneville and Council forecasting models. The Bonneville model of Pacific Northwest agriculture is a comprehensive programming model of all Northwest agricultural activities. The model allocates production of Pacific Northwest farm products to several areas of the region depending on the costs of production, including electricity, and on the availability of land and water.

The Council irrigation model is a simpler method that uses specified rates of growth in irrigation sales for five-year increments to forecast loads and then adjusts loads, based on price increases and on price elasticities for these time periods. The load growth rates for the 1988 Council model were taken from the Bonneville model, and the electricity price elasticities were jointly specified by the Council and Bonneville. The prices are from the Council electricity pricing model.

The Bonneville and Council irrigation models were combined by first forecasting irrigation loads using the Bonneville model, including water and electricity use efficiency changes. They did not include changes in irrigation electricity prices. The resulting loads were then adjusted for price effects using the Council irrigation model. This two-step procedure ensured consistency between electricity demands and prices in the integrated forecasting system.

Retail Electricity Prices

The forecasts of electricity prices in the Pacific Northwest show relatively stable prices over the next several years. The exact price outlook varies substantially in the different forecasts, however, due to differences in the amount of new resources to be acquired. Because nearly all new resources are more costly than the existing resource base, adding new resources will raise electricity prices.

These demand forecasts use retail electricity price forecasts produced by an electricity pricing model that is part of the Council's demand forecasting system. Bonneville's Supply Pricing Model was also used to produce retail price forecasts. Both models develop forecasts of retail prices by sector for investor-owned and for public utilities. In both models, the prices are forecast through detailed (but somewhat different) considerations of power system costs, secondary power sales, forecast assumptions and the provisions of the Pacific Northwest Electric Power Planning and Conservation Act (the Act). Due to differences in approach and forecast assumptions (described later), the wholesale price forecasts of the two pricing models differed. Bonneville will continue to use its Supply Pricing Model for wholesale rate setting purposes. However, the difference between the retail price forecasts of the two models was deemed to be small enough to not significantly affect this demand forecast.

The electricity pricing model used in this forecast contains capacity and cost information on both generating and conservation resources. Cost and capacity of the federal base hydroelectric resources are included as a total. However, most other resources are treated on an individual basis. Capability of each resource is specified for critical water conditions and for peak capacity. Capital costs and operating costs are specified for each generation resource. 'For conservation resources, only those costs that are to be paid through electric rates are included. The effects of conservation programs are generally predicted directly in the various demand models, although in some cases the savings are included as a resource within the pricing model and subtracted from demand there.

The costs of generation and conservation are added up and allocated to the various owners (Bonneville, investor-owned utilities and public utilities). The costs of resources used to provide power to customers of Bonneville, public utilities and investor-owned utilities are combined to reflect contractual agreements among utilities and the exchange and other provisions of the Act. The model develops forecasts of wholesale power costs for three Bonneville rate pools--priority firm, direct service industries and new resources. Similarly, costs are developed for investor-owned and public utilities. Retail markups are added to these costs to obtain estimates of retail rates for each consuming sector of each type of utility.

As demands grow, resources are added to meet demand, and the new resource costs are melded with existing resource costs. The pricing model balances resources and demand based on critical water capacities. However, the effects of different water conditions on secondary energy and electric rates are simulated by the pricing model. The operation of the hydroelectric system on a monthly basis over 40 historical water years is the basis of this simulation. When there is surplus hydroelectric power in any month for a specific water year, the model allocates that secondary power to various uses according to a set of priorities specified in the model assumptions. These uses, in the assumed order of priority, are: 1) serve the top quartile of direct service industry demand; 2) shut down combustion turbines; 3) sell outside the region; and 4) shut down other thermal generation.

For purposes of the pricing model, firm surpluses are added to secondary power and allocated using the same priorities. If the region is in a deficit situation, instead of surplus, the model will import power at a prespecified price until additional resources are added to meet demand.

The revenues from sales of secondary power and firm surplus power, or the costs of importing to cover deficits, are averaged over months and water years to obtain estimates of expected prices of power, given uncertain water conditions.

Several differences in assumptions between Bonneville and the Council remain for long-term forecasting purposes. These differences include: 1) Washington Public Power Supply System Units (WNP) 1 and 3 availability; 2) assumed water conditions; 3) investor-owned utility load placement on Bonneville; and 4) prices for secondary and surplus firm power.

The forecast prices described here used the Council assumptions that WNP 1 and 3 would not be available to meet regional load growth. It also assumed the expected water conditions described above. In addition, it assumed that investor-owned utilities do not place loads on Bonneville except to the extent that combustion turbines are built to firm secondary power, resources are not built before regional need, and that a constant real price is received for secondary and firm surplus power sales except during times of excess water conditions (spill).

Figure 2-16 shows real average retail rates in 1988 dollars for the five forecasts. As can be seen from Figure 2-16, retail rates were projected to stabilize in real terms after 1990.

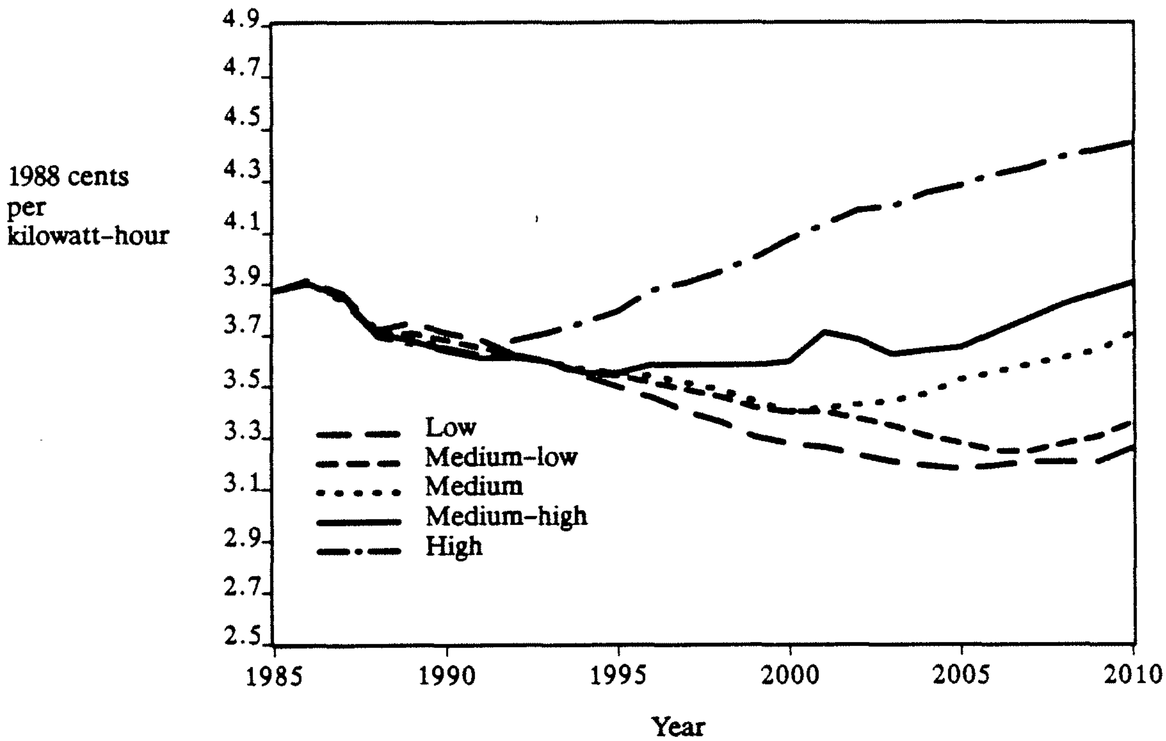

Figure 2-16
Average Retail Electric Rates
in the Pacific Northwest

Table 2-15 shows 1987 estimated average electricity prices, forecasts for 2010 and average annual rates of change for three different kinds of rates. The rates shown include average retail rates paid by all consumers combined, average retail rates paid by customers of public utilities and average retail rates paid by customers of investor-owned utilities.

Table 2-15
Pacific Northwest Electricity Price Forecasts
(1988 Cents per Kilowatt-Hour)

	AVERAGE RETAIL ALL CONSUMERS	AVERAGE RETAIL PUBLIC UTILITIES	AVERAGE RETAIL PRIVATE UTILITIES
Estimated 1987 (1988 cents per kWh)	3.9	3.4	4.7
Forecast 2010 (1988 cents per kWh)			
High	4.4	3.7	5.3
Medium-high	3.9	3.1	4.8
Medium	3.7	3.0	4.6
Medium-low	3.4	2.6	4.2
Low	3.3	2.4	4.3
Growth rates (1987-2010) (% per year)			
High	0.5	0.5	0.5
Medium-high	0.0	-0.3	0.1
Medium	-0.2	-0.5	-0.1
Medium-low	-0.7	-1.0	-0.5
Low	-1.3	-1.7	-0.4

Average retail prices in the region are predicted to increase faster than inflation between 1987 and 2010 in the high forecast. In the medium-high and medium cases, real prices are about the same in 2010 as in 1987, and in the low and medium-low forecasts, real prices decline. Private utility prices are projected to increase faster or decrease less, in most cases, than are the prices for publicly owned utilities. This is because private utilities need to add new resources sooner than public utilities.

These results depend on the pricing model assumptions discussed above. In addition, they depend on an assumption about the resource portfolio that will be used to meet future demand growth. The portfolio will be modified following a more detailed regional discussion and analysis of resource alternatives over the next year. Another important assumption is that no dramatically revised repayment requirement will be imposed for the federal debt on the region's hydroelectric system. Some of the more extreme versions of the revised repayment costs would have a significant effect on electricity prices.

For most of the demand sectors, the relative price of electricity compared to oil or natural gas is important. It is the relative price that most affects consumers' choice of fuel type. Figure 2-17 shows forecast prices of electricity relative to natural gas for residential customers. Natural gas prices have been divided by 0.75 to adjust for differences in the end-use efficiency of gas and electricity. Thus, the relative prices shown in Figure 2-17 are more appropriate comparisons of the cost of heating than of the cost of buying fuel. Although electric rates are highest in the high forecast, it is in the high forecast that relative electric rates are lowest. This stimulates the demand for electricity in the high forecast. The relative fuel price pattern results because the range of uncertainty in future fuel prices is much wider than the range of uncertainty in the electricity prices.

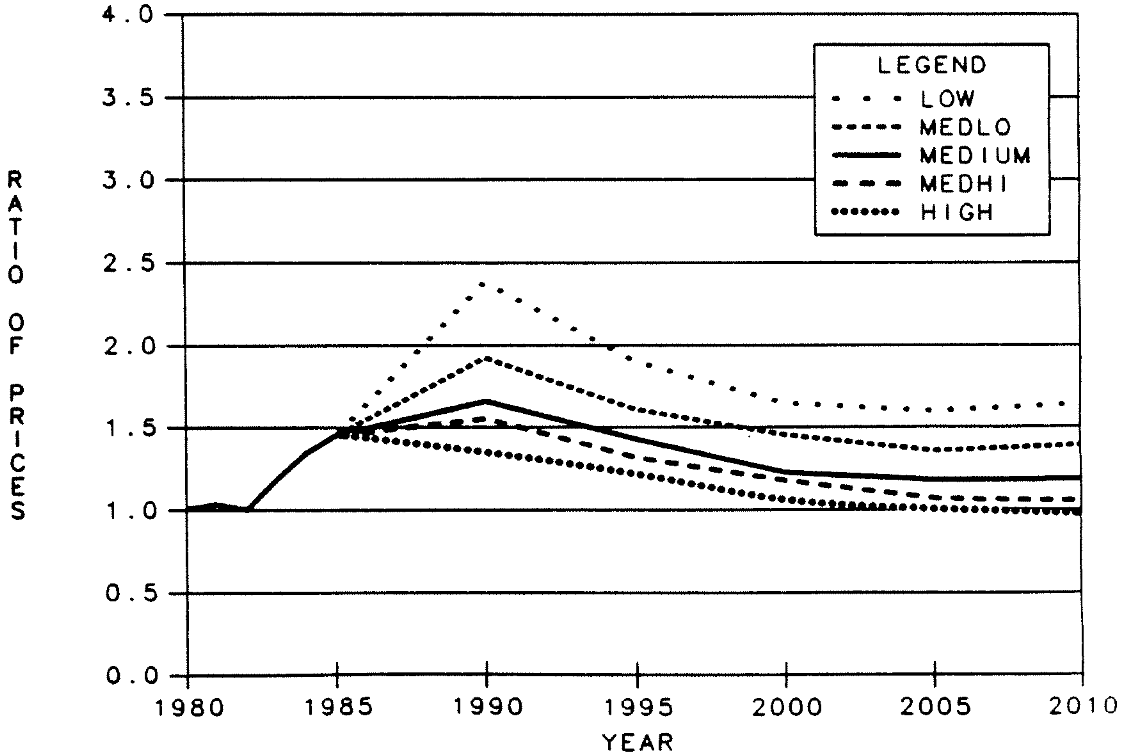

Figure 2-17
Relative Residential Energy Prices in the Pacific Northwest
(Ratio of Electricity to Natural Gas)

When the ratio in Figure 2-17 is above 1.0, it means electricity is relatively more expensive than natural gas. During most of the 1970s, electricity in the Pacific Northwest was inexpensive relative to natural gas, its main competitor. However, recent large increases in electric rates combined with decreases in natural gas prices have increased the competitiveness of natural gas. This result is only a general tendency, because the relative prices of electricity vary significantly for different utility areas. Further, the attractiveness of electricity or natural gas also can depend on consumer tastes and the relative cost of equipment used to convert energy to a useful service, such as heat. The general conclusion to be drawn from Figure 2-17 is that natural gas and electricity prices could remain competitive within a fairly broad range. However, natural gas prices have clearly become more attractive relative to electricity in the early 1980s, and could continue to gain advantage through 1990, particularly in the low and medium-low scenarios.

Change from Previous Forecasts

This section discusses the changes made to the forecasts since the November 1988 draft supplement, and compares the forecasts to the previous official forecasts of Bonneville and the Council, both done in 1986. The November draft supplement forecast was adopted by Bonneville for use in the 1988 Pacific Northwest Loads and Resources study.

Several changes were made to the forecasts since the November draft. These changes were made in response to public comment and further analysis by Council and Bonneville staff. The overall effect of the changes on the medium range of forecasts for 2010 was negligible. The low forecast was decreased by 117 average megawatts and the high forecast was increased by 381 average megawatts. That increased the range of the forecast by 498 average megawatts.

In general, the commercial sector forecasts were increased, especially for the investor-owned utilities, and the residential sector forecasts were decreased. Overall, public utility demands decreased from the November forecast while investor-owned utility forecasts increased. Specific changes that were made are listed below:

- Changed housing retirement methods - The methods of retiring housing from the stock were changed. As a result, fewer single-family and multifamily units were retired, and substantially more manufactured homes were retired. More single- and multifamily homes are available for weatherization as a result of the change.

- Most recent economic information incorporated - The data for 1987 and 1988 were updated to reflect the most recent employment, population and households information available. In addition, the three higher forecasts were increased in the 1989-1995 period to reflect the most recent forecasts made by the Northwest states.

- Effectiveness of current commercial energy codes - Improved estimates of the savings that are expected from Washington and Oregon commercial building codes have decreased those savings. This change increases the price effects forecast, and leaves more conservation to be achieved through future programs.

- Conservation in recently constructed buildings - In the previous forecasts, it was assumed that buildings built between 1980 and 1987 could not be cost-effectively retrofit. Now the assumption is that they can. This has little impact on the price effects forecast, but could decrease the sales forecast because of increased potential conservation program savings.

- Changes in historical weatherization -

  - The November forecasts reflected the assumption that weatherization data applied only to homes heated primarily by electricity. However, we now know that some weatherization was done on primarily wood-heated homes. The updated forecasts reflect an assumption that 15 percent of historical weatherizations occurred in houses that are primarily wood heated. Therefore, the average electricity saving per house in past programs is lower, and the number of electrically heated homes left to weatherize is higher. This increases the price effects forecasts and the future conservation program savings potential.

  - The estimate of average savings achieved in historically weatherized houses has been increased. This, by itself, lowers the forecasts.

- In the November forecasts, it was assumed that homes that already have been partially weatherized cannot be revisited cost-effectively. We now assume that some of these homes can be revisited and additional savings captured. This will not affect the price effects forecasts, but will increase potential conservation program savings and lower the "sales" forecast.

- New data on the number of historical weatherizations for single-family and multifamily homes has been incorporated into the forecast.

- Change in public/private multifamily space heating shares - The allocation of space heating electricity use by multifamily units between rate pools was recalibrated.

- Cogeneration treatment - The treatment of cogeneration in the pricing model was changed to leave cogenerated electricity on the supply side instead of subtracting it from the "sales" forecast. This increased the industrial "sales" forecast, but had small effects on the "price effects" and "frozen efficiency" forecasts.

- Consistent accounting for public and private conservation - The accounting for separate estimates of public and private supply side conservation was not carried through to the summary reports in the November forecasts. This inconsistency has been corrected.

- Irrigation sector price elasticity - Bonneville recently completed a contract to estimate irrigation price elasticities. The irrigation model elasticities were increased to reflect the findings of the new study.

- Price model changes -

  - The existing resource capabilities and costs were updated for recent changes, including removal of Hanford Generating Project, which was not taken out until 1993 in the November forecast. The overall effect of the changes was to increase average megawatts of capability and increase costs.

  - The assumed availability of both combustion turbines and cogeneration were substantially reduced from the assumptions used in the November forecasts.

  - Secondary ownership shares among Bonneville, public and investor-owned utilities were changed to be consistent with information used in the decision model.

The differences between the range of forecasts discussed in this paper and the 1986 forecasts by Bonneville and the Council are generally small. The changes are discussed separately for Bonneville and the Council's previous forecasts using 2005 as the year for specific comparisons. The Council's previous forecast appeared in the 1986 "Northwest Conservation and Electric Power Plan." Bonneville's previous long-term forecast, dated October 1986, is described in "Bonneville Power Administration Forecasts of Electric Consumption in the Pacific Northwest."

The revised forecasts could be generally characterized as slightly lower than the Council's 1986 plan forecast, with a wider range between the medium-low and medium-high forecasts. However, the picture is really more complicated than that. In the context of the overall forecast range, the changes are not extremely significant. Not all scenarios decreased, and not all consuming sectors changed in the same direction.

Figure 2-18 compares the high and low forecasts to the corresponding forecasts from the Council's 1986 plan. The high forecast is 122 average megawatts, or 0.5 percent, lower in 2005. The low is 208 average megawatts, or 1.4 percent, lower. As a result, the range between the low and high forecasts changed little.

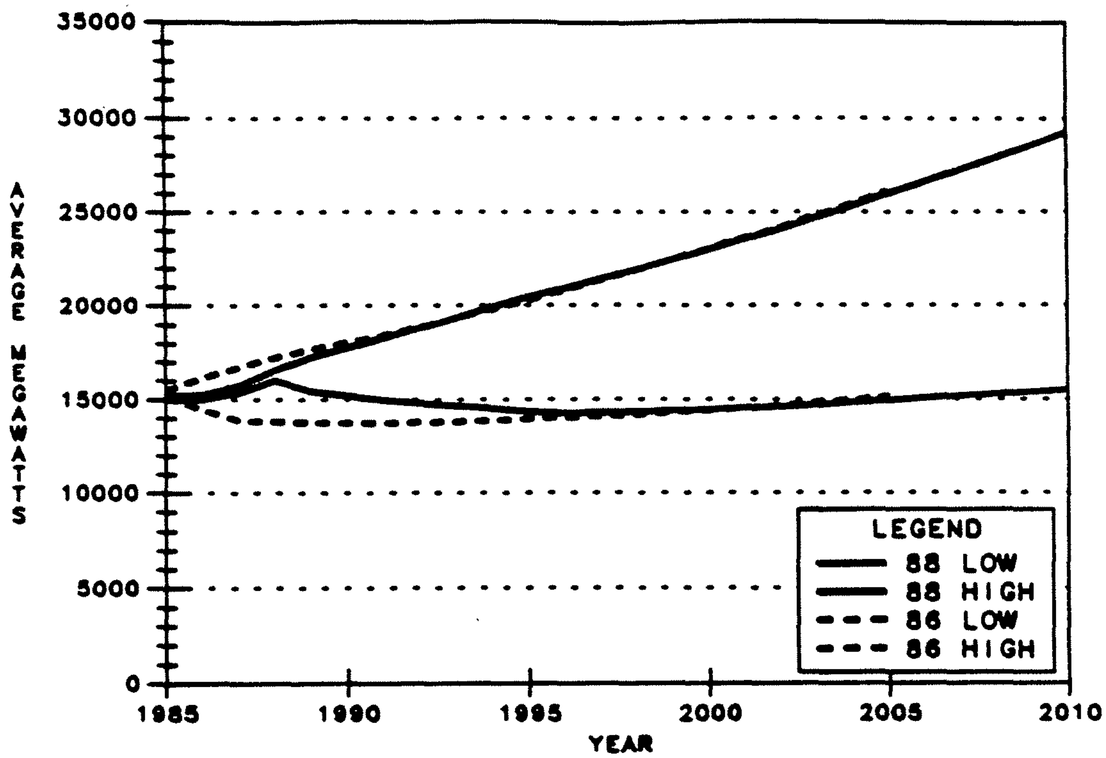

Figure 2-18
Change in High and Low Forecasts from Council's 1986 Power Plan of Pacific Northwest Electricity Demand

In contrast, the range between the medium-low and medium-high forecasts is wider. This is illustrated in Figure 2-19. The wider most likely range is a result of a substantial decrease in the medium-low forecast (5.6 percent) combined with a small increase in the medium-high forecast (1.1 percent). Table 2-16 summarizes the changes from the Council's 1986 forecast.

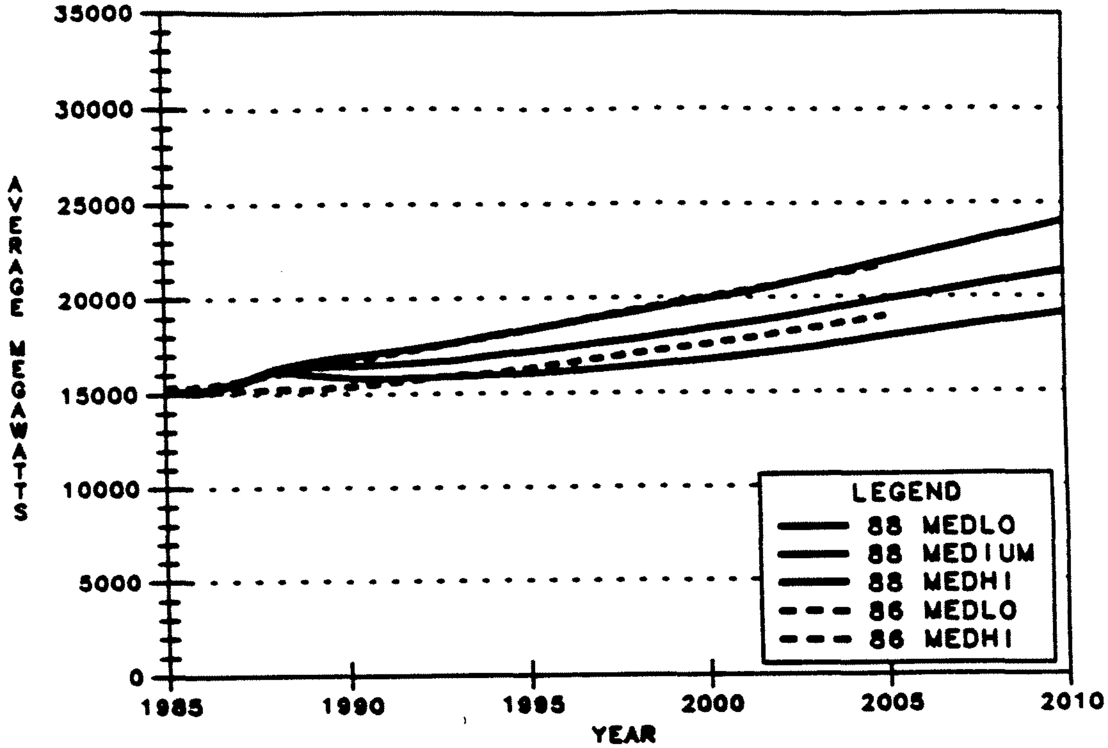

Figure 2-19
Change in Medium Range Forecasts from Council's 1986 Power Plan of Pacific Northwest Electricity Demand

Table 2-16
Forecast Changes from Council's 1986 Power Plan in Pacific Northwest Electricity Demand (Average Megawatts)

	1986 FORECAST 2005	REVISED FORECAST	CHANGE	PERCENT CHANGE
High	26,101	25,979	-122	-0.5
Medium-high	21,687	21,915	+228	+1.1
Medium	n.a.	19,853		
Medium-low	18,950	17,897	-1053	-5.6
Low	15,121	14,913	-208	-1.4

Some of the forecast changes follow from changes in economic and energy price assumptions, but others are a result of definition changes. These distinctions are best made by discussing the changes for the major consuming sectors.

Forecasts of residential electricity demand are lower in all cases. A major factor reducing the residential forecast was an increase in the amount of conservation subtracted from the price effects forecast. This was due to two changes. First, new information significantly increased the estimate of how much conservation has already been achieved in the region by utility programs. Second, because federal appliance efficiency standards have been enacted since the 1986 plan, some appliance efficiency gains that were included in future conservation supply curves have been subtracted from the price effects forecast. The second major factor that lowered the residential forecasts was lower fuel prices, which make electricity less attractive as a heating energy source.

Commercial sector forecasts are higher than the Council's 1986 forecast throughout the forecast range. This results from improved historical data on commercial floor space and from energy use and model refinements made to correct the commercial model's tendency to underestimate demand for 1984 through 1987. The commercial forecasts would have been even higher but they were reduced in most scenarios by economic and fuel price assumptions and by including commercial sector energy codes for Washington and Oregon in the price effects forecast.

The industrial forecast range is wider than in the Council's 1986 plan. The low and medium-low forecasts were decreased, while the high forecast was increased. The effects of lower fuel prices and model changes were offset in the high case by higher productivity growth assumptions. Higher productivity results in increased forecasts of industrial output, which--in turn--increases energy use. Throughout the forecast range, industrial demand was reduced by excluding a substantial private utility interruptible load that was included in the Council's 1986 forecast.

Irrigation demands are significantly lower in all of the forecast cases. Much of the decrease is due to removing about 110 average megawatts of pumping loads from demand. These loads also have been taken out of the energy available from hydroelectric generation on the supply side. The forecasts have been further reduced because the probability of further large-scale irrigation development has become smaller. The revised forecasts implicitly assume that little additional development of the Columbia Basin Project will take place.

Comparing the revised forecast with to Bonneville's 1986 forecast for 2005 shows modest increases in the low and medium forecasts, and a slight decrease in the high. Figure 2-20 shows Bonneville's 1986 forecast range as dashed lines and the three corresponding revised forecasts as solid lines. The medium forecast of firm electricity demand in 2005 is roughly 530 average megawatts, or 2.8 percent, higher than Bonneville's 1986 medium forecast.

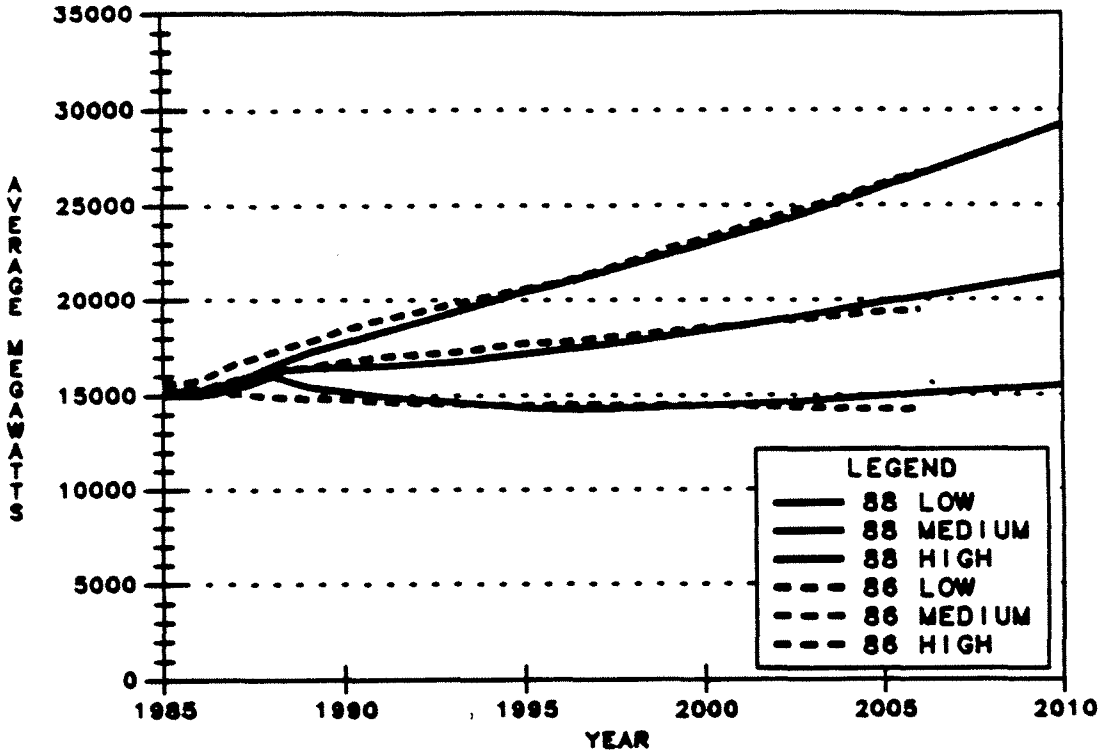

Figure 2-20
Change from Bonneville's 1986 Forecast Range

The medium forecasts are higher than Bonneville's 1986 forecast in the industrial and commercial sectors. Industrial demand is about 250 megawatts higher and commercial demand is 230 megawatts higher. Residential demand is about 30 megawatts lower. The remaining categories of demand are little changed.

The high forecast for 2005 is 140 megawatts, or 0.5 percent, lower than Bonneville's 1986 forecast. The major differences are in the residential (940 megawatts lower), commercial (120 megawatts higher) and utility industrial (800 megawatts higher) sectors. The revised draft low case forecast for 2005 is about 700 megawatts, or 5 percent higher than Bonneville's 1986 forecast. Major changes are in the residential (170 megawatts lower), utility industrial (340 megawatts higher) and direct service industrial (590 megawatts higher) sectors.

Appendix 2-A

Pacific Northwest Electricity Load Forecasting System
Summary of Regional Demand and Growth Rates

Table 2-A-1
Pacific Northwest Electricity Load Forecasting System
Summary of Regional Demand and Growth Rates (High)

	DEMAND IN AVERAGE MEGAWATTS								DEMAND GROWTH RATES		
	1986 ACTUAL	1987 ACTUAL	1990	1995	2000	2005	2008	2010	1987-1990	1987-2008	1987-2010
					TOTAL						
Commercial	3,365	3,479	3,915	4,863	5,596	6,465	7,069	7,465	4.01	3.43	3.37
Residential	5,372	5,280	5,887	6,869	7,850	8,979	9,672	10,167	3.69	2.92	2.89
Industrial Firm[a]	5,703	6,062	7,153	7,868	8,694	9,703	10,305	10,749	5.67	2.56	2.52
DSI[b] Firm	1,885	2,060	2,449	2,436	2,436	2,436	2,436	2,436	5.93	0.80	0.73
Non-DSI[b] Firm	3,818	4,002	4,704	5,433	6,258	7,268	7,870	8,314	5.54	3.27	3.23
Irrigation[c]	585	619	611	632	625	617	620	624	-0.44	0.01	0.03
Other[d]	177	181	186	206	211	215	217	219	0.91	0.87	0.82
Total Firm Sales	15,202	15,621	17,751	20,439	22,975	25,979	27,884	29,223	4.35	2.80	2.76
Total Non-DSI[b] Sales	13,317	13,561	15,302	18,003	20,540	23,543	25,448	26,787	4.11	3.04	3.00
					PUBLIC CUSTOMER POOL						
Commercial	1,383	1,413	1,611	2,036	2,340	2,630	2,823	2,946	4.47	3.35	3.25
Residential	2,382	2,336	2,571	2,981	3,390	3,854	4,135	4,333	3.24	2.76	2.72
Industrial Firm[a]	3,829	4,082	4,772	5,081	5,456	5,898	6,154	6,340	5.34	1.97	1.93
DSI[b] Firm	1,885	2,060	2,449	2,436	2,436	2,436	2,436	2,436	5.93	0.80	0.73
Non-DSI[b] Firm	1,944	2,022	2,323	2,646	3,020	3,463	3,718	3,905	4.73	2.94	2.90
Irrigation[c]	304	320	295	302	298	294	295	296	-2.73	-0.39	-0.33
Other[d]	148	152	157	176	179	181	183	183	1.08	0.87	0.81
Total Firm Sales	8,046	8,303	9,405	10,576	11,663	12,858	13,590	14,099	4.24	2.37	2.33
Total Non-DSI[b] Sales	6,161	6,243	6,956	8,140	9,228	10,422	11,154	11,663	3.67	2.80	2.75
					PRIVATE CUSTOMER POOL						
Commercial	1,982	2,066	2,304	2,828	3,256	3,835	4,246	4,519	3.70	3.49	3.46
Residential	2,990	2,944	3,316	3,888	4,460	5,124	5,537	5,834	4.05	3.05	3.02
Industrial Firm	1,874	1,980	2,382	2,787	3,238	3,805	4,151	4,409	6.35	3.59	3.54
Irrigation	281	299	316	330	326	323	325	328	1.89	0.40	0.40
Other[d]	29	29	29	31	32	34	35	35	0.00	0.86	0.87
Total Firm Sales	7,156	7,318	8,347	9,863	11,312	13,121	14,294	15,124	4.48	3.24	3.21

[a] Includes Colockum and mining.
[b] DSI - Direct Service Industries.
[c] Includes U.S. Bureau of Reclamation, excludes Grand Coulee and Roza Pumping.
[d] Federal agencies and street lighting.

Table 2-A-2
Pacific Northwest Electricity Load Forecasting System
Summary of Regional Demand and Growth Rates (Medium-high)

	DEMAND IN AVERAGE MEGAWATTS								DEMAND GROWTH RATES		
	1986 ACTUAL	1987 ACTUAL	1990	1995	2000	2005	2008	2010	1987-1990	1987-2008	1987-2010
TOTAL											
Commercial	3,365	3,479	3,722	4,265	4,702	5,328	5,761	6,055	2.28	2.43	2.44
Residential	5,372	5,280	5,678	6,295	6,974	7,772	8,268	8,617	2.45	2.16	2.15
Industrial Firm[a]	5,703	6,062	6,770	6,963	7,426	7,982	8,285	8,509	3.75	1.50	1.49
DSI[b] Firm	1,885	2,060	2,349	2,172	2,155	2,158	2,146	2,146	4.47	0.20	0.18
Non-DSI[b] Firm	3,818	4,002	4,421	4,790	5,271	5,823	6,139	6,363	3.38	2.06	2.04
Irrigation[c]	585	619	578	605	620	619	627	627	-2.29	0.06	0.05
Other[d]	177	181	186	206	211	215	217	219	0.91	0.87	0.82
Total Firm Sales	15,202	15,621	16,934	18,333	19,933	21,915	23,159	24,026	2.73	1.89	1.89
Total Non-DSI[b] Sales	13,317	13,561	14,585	16,161	17,778	19,756	21,013	21,880	2.46	2.11	2.10
PUBLIC CUSTOMER POOL											
Commercial	1,383	1,413	1,548	1,820	2,033	2,248	2,391	2,488	3.10	2.54	2.49
Residential	2,382	2,336	2,483	2,756	3,039	3,364	3,564	3,702	2.06	2.03	2.02
Industrial Firm[a]	3,829	4,082	4,538	4,537	4,749	5,004	5,137	5,238	3.59	1.10	1.09
DSI[b] Firm	1,885	2,060	2,349	2,172	2,155	2,158	2,146	2,146	4.47	0.20	0.18
Non-DSI[b] Firm	1,944	2,022	2,189	2,365	2,594	2,846	2,991	3,092	2.68	1.88	1.86
Irrigation[c]	304	320	281	292	298	296	300	300	-4.23	-0.31	-0.29
Other[d]	148	152	157	176	179	181	183	183	1.08	0.87	0.81
Total Firm Sales	8,046	8,303	9,008	9,581	10,298	11,093	11,574	11,911	2.75	1.59	1.58
Total Non-DSI[b] Sales	6,161	6,243	6,659	7,409	8,143	8,935	9,428	9,765	2.17	1.98	1.96
PRIVATE CUSTOMER POOL											
Commercial	1,982	2,066	2,174	2,445	2,669	3,080	3,370	3,567	1.71	2.36	2.40
Residential	2,990	2,944	3,195	3,538	3,935	4,408	4,704	4,915	2.77	2.26	2.25
Industrial Firm	1,874	1,980	2,232	2,426	2,677	2,978	3,148	3,271	4.08	2.23	2.21
Irrigation	281	299	296	313	323	322	327	327	-0.29	0.43	0.39
Other[d]	29	29	29	31	32	34	35	35	0.00	0.86	0.87
Total Firm Sales	7,156	7,318	7,927	8,752	9,635	10,822	11,585	12,115	2.70	2.21	2.22

[a] Includes Colockum and mining.
[b] DSI - Direct Service Industries.
[c] Includes U.S. Bureau of Reclamation, excludes Grand Coulee and Roza Pumping.
[d] Federal agencies and street lighting.

Table 2-A-3
Pacific Northwest Electricity Load Forecasting System
Summary of Regional Demand and Growth Rates (Medium)

	DEMAND IN AVERAGE MEGAWATTS								DEMAND GROWTH RATES		
	1986 ACTUAL	1987 ACTUAL	1990	1995	2000	2005	2008	2010	1987-1990	1987-2008	1987-2010
TOTAL											
Commercial	3,365	3,479	3,626	3,954	4,250	4,708	5,021	5,220	1.38	1.76	1.78
Residential	5,372	5,280	5,605	6,078	6,686	7,323	7,707	7,977	2.01	1.82	1.81
Industrial Firm[a]	5,703	6,062	6,488	6,355	6,646	7,023	7,215	7,363	2.29	0.83	0.85
DSI[b] Firm	1,885	2,060	2,248	1,908	1,875	1,881	1,857	1,857	2.96	-0.49	-0.45
Non-DSI[b] Firm	3,818	4,002	4,239	4,447	4,771	5,142	5,358	5,507	1.94	1.40	1.40
Irrigation[c]	585	619	551	568	580	584	571	565	-3.78	-0.38	-0.40
Other[d]	177	181	186	206	211	215	217	219	0.91	0.87	0.82
Total Firm Sales	15,202	15,621	16,456	17,162	18,372	19,853	20,731	21,344	1.75	1.36	1.37
Total Non-DSI[b] Sales	13,317	13,561	14,208	15,254	16,498	17,972	18,875	19,487	1.56	1.59	1.59
PUBLIC CUSTOMER POOL											
Commercial	1,383	1,413	1,512	1,698	1,869	2,028	2,131	2,194	2.28	1.98	1.93
Residential	2,382	2,336	2,450	2,655	2,909	3,161	3,313	3,417	1.60	1.68	1.67
Industrial Firm[a]	3,829	4,082	4,341	4,096	4,217	4,389	4,461	4,527	2.07	0.42	0.45
DSI[b] Firm	1,885	2,060	2,248	1,908	1,875	1,881	1,857	1,857	2.96	-0.49	-0.45
Non-DSI[b] Firm	1,944	2,022	2,093	2,188	2,342	2,508	2,604	2,670	1.16	1.21	1.22
Irrigation[c]	304	320	271	277	282	283	278	275	-5.45	-0.67	-0.66
Other[d]	148	152	157	176	179	181	183	183	1.08	0.87	0.81
Total Firm Sales	8,046	8,303	8,731	8,901	9,455	10,042	10,365	10,595	1.69	1.06	1.07
Total Non-DSI[b] Sales	6,161	6,243	6,482	6,993	7,581	8,161	8,508	8,739	1.26	1.49	1.47
PRIVATE CUSTOMER POOL											
Commercial	1,982	2,066	2,114	2,256	2,381	2,681	2,890	3,026	0.77	1.61	1.67
Residential	2,990	2,944	3,155	3,423	3,777	4,161	4,395	4,561	2.34	1.93	1.92
Industrial Firm	1,874	1,980	2,146	2,259	2,429	2,634	2,754	2,837	2.72	1.58	1.58
Irrigation	[illegible]	[illegible]	[illegible]								

Table 2-A-4
Pacific Northwest Electricity Load Forecasting System
Summary of Regional Demand and Growth Rates (Medium-low)

	DEMAND IN AVERAGE MEGAWATTS								DEMAND GROWTH RATES		
	1986 ACTUAL	1987 ACTUAL	1990	1995	2000	2005	2008	2010	1987-1990	1987-2008	1987-2010
TOTAL											
Commercial	3,365	3,479	3,524	3,673	3,711	3,974	4,185	4,317	0.43	0.88	0.94
Residential	5,372	5,280	5,488	5,852	6,303	6,890	7,245	7,464	1.29	1.52	1.52
Industrial Firm[a]	5,703	6,062	6,112	5,736	5,965	6,287	6,472	6,599	0.28	0.31	0.37
DSI[b] Firm	1,885	2,060	2,136	1,541	1,514	1,517	1,505	1,505	1.21	-1.48	-1.35
Non-DSI[b] Firm	3,818	4,002	3,977	4,196	4,451	4,769	4,967	5,094	-0.21	1.03	1.05
Irrigation[c]	585	619	524	531	533	531	532	525	-5.38	-0.72	-0.71
Other[d]	177	181	186	206	211	215	217	219	0.91	0.87	0.82
Total Firm Sales	15,202	15,621	15,835	15,998	16,721	17,897	18,651	19,124	0.45	0.85	0.88
Total Non-DSI[b] Sales	13,317	13,561	13,699	14,458	15,207	16,379	17,145	17,619	0.34	1.12	1.14
PUBLIC CUSTOMER POOL											
Commercial	1,383	1,413	1,467	1,569	1,656	1,773	1,856	1,904	1.26	1.31	1.31
Residential	2,382	2,336	2,402	2,563	2,755	3,003	3,149	3,237	0.93	1.43	1.43
Industrial firm[a]	3,829	4,082	4,113	3,626	3,731	3,891	3,977	4,038	0.25	-0.12	-0.05
DSI[b] Firm	1,885	2,060	2,136	1,541	1,514	1,517	1,505	1,505	1.21	-1.48	-1.35
Non-DSI Firm[b]	1,944	2,022	1,978	2,086	2,217	2,373	2,471	2,533	-0.74	0.96	0.98
Irrigation[c]	304	320	260	262	263	262	262	260	-6.75	-0.94	-0.91
Other[d]	148	152	157	176	179	181	183	183	1.08	0.87	0.81
Total Firm Sales	8,046	8,303	8,399	8,196	8,583	9,109	9,426	9,621	0.38	0.61	0.64
Total Non-DSI[b] Sales	6,161	6,243	6,263	6,656	7,069	7,592	7,921	8,116	0.11	1.14	1.15
PRIVATE CUSTOMER POOL											
Commercial	1,982	2,066	2,057	2,104	2,055	2,202	2,329	2,413	-0.14	0.57	0.68
Residential	2,990	2,944	3,086	3,290	3,548	3,887	4,095	4,228	1.58	1.58	1.59
Industrial Firm	1,874	1,980	1,999	2,110	2,234	2,396	2,495	2,561	0.32	1.11	1.13
Irrigation	281	299	265	269	270	269	270	266	-3.97	-0.49	-0.51
Other[d]	29	29	29	31	32	34	35	35	0.00	0.86	0.87
Total Firm Sales	7,156	7,318	7,436	7,802	8,138	8,788	9,224	9,503	0.53	1.11	1.14

[a] Includes Colockum and mining.

[b] DSI - Direct Service Industries.

[c] Includes U.S. Bureau of Reclamation, excludes Grand Coulee and Roza Pumping.

[d] Federal agencies and street lighting.

Table 2-A-5
Pacific Northwest Electricity Load Forecasting System
Summary of Regional Demand and Growth Rates (Low)

	DEMAND IN AVERAGE MEGAWATTS								DEMAND GROWTH RATES		
	1986 ACTUAL	1987 ACTUAL	1990	1995	2000	2005	2008	2010	1987-1990	1987-2008	1987-2010
TOTAL											
Commercial	3,365	3,479	3,458	3,395	3,248	3,330	3,416	3,471	-0.21	-0.09	-0.01
Residential	5,372	5,280	5,287	5,331	5,494	5,775	5,963	6,088	0.05	0.58	0.62
Industrial Firm[a]	5,703	6,062	5,735	4,888	4,962	5,110	5,172	5,211	-1.83	-0.75	-0.66
DSI[b] Firm	1,885	2,060	2,024	1,172	1,153	1,153	1,153	1,153	-0.58	-2.73	-2.49
Non-DSI[b] Firm	3,818	4,002	3,711	3,716	3,810	3,957	4,019	4,058	-2.49	0.02	0.06
Irrigation[c]	585	619	504	501	499	484	468	454	-6.62	-1.33	-1.34
Other[d]	177	181	186	206	211	215	217	219	0.91	0.87	0.82
Total Firm Sales	15,202	15,621	15,170	14,322	14,414	14,913	15,236	15,442	-0.97	-0.12	-0.05
Total Non-DSI[b] Sales	13,317	13,561	13,146	13,151	13,261	13,760	14,084	14,289	-1.03	0.18	0.23
PUBLIC CUSTOMER POOL											
Commercial	1,383	1,413	1,439	1,440	1,427	1,470	1,512	1,537	0.60	0.32	0.37
Residential	2,382	2,336	2,309	2,325	2,389	2,504	2,580	2,627	-0.39	0.47	0.51
Industrial Firm[a]	3,829	4,082	3,872	3,028	3,077	3,170	3,208	3,230	-1.75	-1.14	-1.01
DSI[b] firm	1,885	2,060	2,024	1,172	1,153	1,153	1,153	1,153	-0.58	-2.73	-2.49
Non-DSI[b] firm	1,944	2,022	1,848	1,856	1,924	2,018	2,055	2,078	-2.96	0.08	0.12
Irrigation[c]	304	320	252	251	251	244	238	232	-7.72	-1.41	-1.39
Other[d]	148	152	157	176	179	181	183	183	1.08	0.87	0.81
Total Firm Sales	8,046	8,303	8,028	7,220	7,322	7,569	7,720	7,809	-1.12	-0.35	-0.27
Total Non-DSI[b] Sales	6,161	6,243	6,003	6,048	6,170	6,416	6,567	6,657	-1.30	0.24	0.28
PRIVATE CUSTOMER POOL											
Commercial	1,982	2,066	2,019	1,955	1,821	1,860	1,904	1,933	-0.76	-0.39	-0.29
Residential	2,990	2,944	2,978	3,006	3,104	3,271	3,384	3,461	0.39	0.67	0.71
Industrial Firm	1,874	1,980	1,863	1,861	1,886	1,940	1,964	1,980	-2.00	-0.04	0.00
Irrigation	281	299	253	250	248	240	230	222	-5.47	-1.24	-1.29
Other[d]	29	29	29	31	32	34	35	35	0.00	0.86	0.87
Total Firm Sales	7,156	7,318	7,142	7,102	7,092	7,344	7,516	7,632	-0.81	0.13	0.18

[a] Includes Colockum and mining.
[b] DSI - Direct Service Industries.
[c] Includes U.S. Bureau of Reclamation, excludes Grand Coulee and Roza Pumping.
[d] Federal agencies and street lighting.

Chapter 3

The Derivation of Conservation Resources for the 1989 Power Plan Supplement

Overview and Comparison to 1986 Power Plan Estimates

Conservation is a key ingredient in the Council's resource portfolio for meeting future electrical energy needs. Each megawatt of electricity conserved is one less megawatt that needs to be generated. The Council has identified close to 2,540 average megawatts of achievable conservation in the high demand forecast, available at an average cost of 2.4 cents per kilowatt-hour.[1] This is enough energy to replace the output of almost six large coal plants, at less than half the cost. While much has been accomplished in the conservation arena since the 1986 Power Plan (described below), the remaining conservation is still an extraordinarily cost-effective resource for the region to acquire. This chapter provides an overview of the procedures and major assumptions used to derive the Council's estimates of conservation resources in both the public and private utility service territories.

In the Council's plan, conservation is defined as the more efficient use of electricity. This means that less electricity is used to produce a given service at a given amenity level. Conservation resources are measures[2] that ensure the efficient use of electricity for new and existing residential buildings, household appliances, new and existing commercial buildings, and industrial and irrigation processes. For example, buildings with heat loss reduced through insulating and tightening require less electricity for heating. These savings of electricity mean that fewer power plants must be built to meet growing demand. Conservation also includes measures to reduce electrical losses in the region's generation, transmission and distribution system. These latter conservation resources are discussed in the Generating Resources chapter.

Comparison of Conservation Estimates from the 1986 Plan

The 1986 Power Plan estimated that about 4,300 average megawatts of technical conservation potential were available to the region to reduce loads by the year 2005. Using a similar basis for conservation as was used in the 1986 plan, but extending the forecast to 2010 and updating estimates of economic growth in the region, the technical conservation potential would be 5,200 average megawatts in the year 2010. Most of this change is due to new estimates of conservation available from commercial buildings.

However, significant actions taken over the last few years by various jurisdictions in the region, and in some cases by the federal government, have already set in motion a number of mechanisms that will acquire a large portion of this conservation resource over the next 20 years. For example, the states of

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1./ This average cost includes administration costs and transmission and distribution adjustments. The savings shown have been adjusted to reflect market penetration and line loss reductions.

2./ A "measure" means either an individual measure, action or combination of actions.

Oregon and Washington passed building codes that will, as construction occurs over time, capture part of the conservation resource identified in the 1986 plan. While the Council believes that more aggressive code enforcement is needed to secure these savings, the conservation potential captured by these new codes has been incorporated as lower electricity use in new buildings in the forecast. A similar situation occurs with residential appliances since the federal government passed minimum appliance efficiency standards that will make many residential appliances more efficient than assumed in prior estimates. Primarily as a direct result of these codes, partially as a consequence of updated forecasting models and estimates, and partially as a result of retrofitting that has occurred in the last two years, the total technically potential conservation in this section is about 2,890 average megawatts.[3]

Table 3-1 presents the average megawatts of conservation and average levelized[4] costs for all the conservation resources estimated in the 1986 Power Plan and the current supplement. Table 3-1 also shows the average megawatts of savings that would have been included in the 1989 supplement if the pre-conservation consumption estimates remained the same as those used in the 1986 plan. These resource estimates are based on the high demand forecast. In lower demand forecasts, less conservation is available from many sectors because the economy is not growing as rapidly and there are fewer new houses, businesses and appliances that can supply conservation.

Since the last plan was adopted, the region has taken action to help secure the conservation resources identified in that plan. About two-thirds of the difference between the current supplement estimates and those that would have been estimated using pre-conservation consumption from the 1986 plan, or over 1,540 average megawatts of technical potential, are due to estimates of retrofitting activity that have occurred during that period, as well as to the significant changes in residential and commercial building codes and in new minimum appliance efficiency standards. All of these standards were adopted since 1985. The remaining one-third is due to modeling changes and better information. The estimate of the conservation resource in this 1989 supplement assumes that the new building codes and appliance standards will continue to be implemented over the planning period. Each of these codes means that there is less of the conservation resource left to acquire, because it will be secured through fairly stable mechanisms: building and appliance codes. The energy reductions secured through codes already adopted now appear as lower use in the load forecasts.

Legislation that mandates implementation of conservation reduces the forecast of electric loads, which--in turn--automatically reduces the amount of conservation potential remaining to be secured. Figure 3-1 depicts the effect on forecast loads and conservation resources of adopting conservation codes and standards. Forecast loads without building and appliance codes result in the highest electricity consumption over the 20-year horizon, along "Pathway A." "Pathway C" represents electricity loads if all new houses and appliances purchased were to install all cost-effective conservation. Once building codes and appliance standards are adopted, each new building or appliance is mandated to be more efficient. This results in an intermediate load forecast, because each new unit will consume less electricity than in Pathway A. But there are still cost-effective conservation measures not included in all of the codes and standards and many end uses for which there are no codes or standards. This intermediate step is depicted as Pathway B in Figure 3-1. The difference between Pathway A and B is the conservation secured through the codes and standards. The difference between B and C is the remaining conservation potential identified in this plan that still needs to be secured to fill electricity needs. This conservation resource remains a significant and cost-effective resource for the region to acquire.

3./ This value is technical potential and has not been increased to reflect conservation's benefits of avoiding line losses when compared to generating resources, nor decreased to reflect expected market penetration rates.

4./ Levelized costs are total lifetime resource costs (capital, financing and operating costs) converted into a stream of equal annual payments.

Table 3-1
Comparison of Conservation Savings and Costs[5]
High Demand Forecast Technical Potential

	1989 SUPPLEMENT AVERAGE MEGAWATTS (in 2010)	1989 SUPPLEMENT LEVELIZED COST (1988 $) (cents/kWh)	1989 SUPPLEMENT WITH 1986 PLAN PRE-CONSERVATION USE AVERAGE MEGAWATTS (in 2010)	1986 POWER PLAN AVERAGE MEGAWATTS (in 2010)	1986 POWER PLAN LEVELIZED COST (1988 $) (cents/kWh)
Commercial Sector					
Existing buildings	625	2.5	815	780	2.7
New buildings	555	2.2	1,050	515	2.4
Waste Water Treatment	15	2.5	15	15	2.5
Residential Sector					
Space Heating:					
Existing single-family	150	3.9	180	385	3.5 (avg.)
Existing multifamily	50	4.1	110	115	3.5 (avg.)
New single-family	355	3.1	960	770	3.6 (avg.)
New multifamily	40	2.4	145	90	3.6 (avg.)
New manufactured houses	210	2.2	255	90	3.6 (avg.)
Water Heating	385	2.0	530	515	2.2
Refrigerators	100	1.2	335	300	1.0 (avg.)
Freezers	35	1.3	160	110	1.0 (avg.)
Industrial Sector	280	2.1	500	500	3.7
Irrigation Sector	90	1.9	145	145	2.2
TOTAL	2,890	2.4	5,200	4,330	

5./ Average megawatt savings need to be increased to reflect line loss savings before comparing to generating resources. Average levelized costs have been increased for administrative costs and adjusted downward for transmission and distribution cost and energy savings.

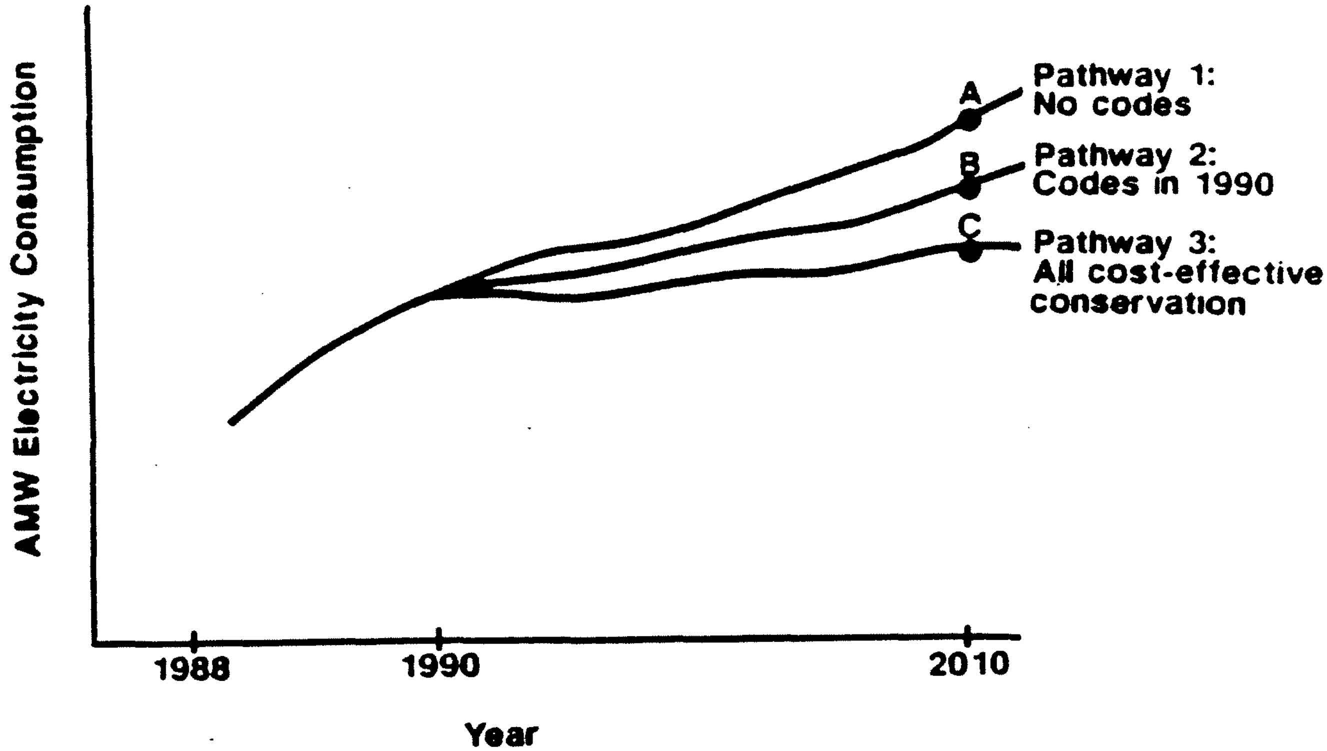

Figure 3-1
The Effect on Loads and Conservation of Building and Appliance Codes

This section summarizes the Council's estimates of conservation resources available to the region. The narrative is based on calculations from the Council's high demand forecast, but similar calculations were done for the low, medium-low, medium, and medium-high forecasts.

Estimating the Conservation Resource

The evaluation of conservation resources involves three major steps. The first step is to develop conservation supply curves based on engineering analysis. This step entails evaluating the levelized life-cycle cost[6] of all conservation measures and ranking them with the least-cost measure first.

The second step is to group into programs all measures with levelized costs less than a given avoided cost and evaluate savings from these programs in the context of the Council's forecasting model. The avoided cost is the cost of the resource or resources that would be used in the electrical system should conservation not be developed. Avoided cost varies somewhat, depending on the specific characteristics of the conservation program, such as whether the savings from the program can be developed as need occurs or whether they must be developed today, during the current surplus. The avoided costs used in this plan are described briefly in the section below called "conservation programs for portfolio analysis."

6./ Levelized life-cycle cost is the present value of a resource's cost (including capital, financing and operating costs) converted into a stream of equal annual payments; unit levelized life-cycle costs (cents per kilowatt-hour) are obtained by dividing this payment by the annual kilowatt-hours saved or produced. Unlike installed cost, levelized costs that have been corrected for inflation permit comparisons of resources with different lifetimes and generating capabilities. The term "levelized cost" as generally used in this chapter refers to unit levelized life-cycle cost.

The third step involves using the cost and savings characteristics of each program to evaluate the conservation resource's cost-effectiveness and compatibility with the existing power system. Cost-effectiveness of each conservation program is determined by comparing the program against other resources to determine which resource provides electric service at the lowest cost.

The bulk of this chapter deals with steps one and two, which are preliminary cost-effectiveness screens to size the conservation resource that is used in the resource portfolio.

Supply Curves

Conservation supply curves are used to evaluate the amount of conservation available at given costs. A supply curve is an economic tool used to depict the amount of a product available across a range of prices. In the case of conservation, this translates into the number of average megawatts that can be conserved (and made available for others to use) at various costs. For example, an industrial customer may be able to recover waste heat from a process and conserve 3 average megawatts at a cost of 2 cents per kilowatt-hour. This same customer may conserve 5, 7 and 8 average megawatts of electricity for the respective costs of 3, 4 and 5 cents per kilowatt-hour. These figures represent the conservation supply curve for this particular customer. Individual conservation estimates for end uses in each sector are merged to arrive at the regional supply curve for that sector.

The supply curves used in this plan do not distinguish between conservation resulting from specific programs and conservation motivated by rising prices of electricity. This is a regional perspective; whether the consumer or the utility invests in a conservation measure, the region is purchasing those savings at a particular price, and the money is not available for investment in other resources and goods. However, if a customer contributes to the purchase of conservation resources, then the cost to the electricity system will be less than the costs developed in this chapter.

Conservation supply curves are primarily a function of the conservation measure's savings and cost. Each measure's savings and cost are used to derive a levelized cost, in terms of cents per kilowatt-hour, for that measure. The absolute value (In terms of kilowatt-hours per year) of the savings produced by adding a conservation measure is a function of the existing level of efficiency. The less efficient the existing structure or equipment, the greater the savings obtained from installing the measure. Consequently, the amount of conservation available is directly related to the amount of energy currently used. In order to minimize the costs of efficiency improvements, conservation measures are applied with the least costly measure first,[7] until all measures are evaluated.

The levelized costs used to generate the supply curves are based on the capital, operation and maintenance expenditures incurred over the lifetime of the conservation measure. To ensure consistency between the conservation supply curves and the system models,[8] capital recovery factors used in the levelized cost calculation are the same ones used in the system models. This means that the tax benefits, rate requirements and other financial considerations specific to the developer of the resource are accounted for in the levelized cost of the conservation resource.

7./ Least costly is defined in terms of a measure's levelized life-cycle cost, stated in terms of mills or cents per kilowatt-hour.

8./ The system models are the Integrated System for Analysis of Acquisitions and the System Analysis Model.

Conservation was assumed to be financed for 20 years by Bonneville and for the average lifetime of the program by the investor-owned utilities. It was assumed that Bonneville would sponsor 40 percent of the conservation acquisition costs, and the investor-owned utilities would sponsor 60 percent, based on their share of total loads. Twenty-five percent of the investor-owned utilities' share is financed equally between debt and equity, while 75 percent of the investor-owned utilities' share is financed by Bonneville.

Conservation Programs for Portfolio Analysis

After the supply curves are generated for each end use or sector, the amount of conservation to be used in the resource portfolio analysis is first sized by cutting off the supply curve at the point where the levelized cost of the last measure included is equal to or just slightly less than the avoided cost. This is called the "technical" conservation potential. The technical potential is then reduced to reflect the portion of the conservation resource that is considered not achievable. Achievable conservation is the net savings the Council anticipates after taking into account factors such as consumer resistance, quality control and unforeseen technical problems. The Council believes that the wide assortment of incentives and regulatory measures the Northwest Power Act makes available can persuade the region's electric consumers to install a large percentage of the technically available conservation. As a consequence, the proportion of technical potential considered achievable in this plan varies from 50 percent to 90 percent depending on the sector and the conservation measures.

High penetration rates, on the order of 85 percent to 90 percent, are fully supported in the residential sector, where direct purchase of the conservation measures has proved to be a significant motivating factor in capturing conservation. In the existing commercial sector, there may be more significant barriers to overcome, but no one has tried an all-out effort to secure full penetration in even a subgroup in this sector. The Council currently thinks that the strong tools given the region under the Act, such as the ability to set model conservation standards and assess a surcharge if not adopted, will secure similar penetration rates in the commercial sector. For these reasons, the Council continues to pursue aggressive penetration rates.

As described in Volume II, Chapter 4 of the 1986 Power Plan, the avoided cost is 5.5 cents per kilowatt-hour[9] for conservation resources that can be scheduled to meet load. These are called "discretionary resources," because they can be scheduled. They don't need to be developed during the current surplus. Conservation resources that fit into this category are primarily existing end uses--for example, commercial retrofit programs and residential weatherization. Residential weatherization is a special case within the discretionary resource category, because this resource is being secured today, even though a surplus exists. The avoided cost for residential weatherization measures purchased in 1986 was approximately 3.8 cents per kilowatt-hour. This increases over time up to 5.5 cents per kilowatt-hour as the surplus nears an end. The residential weatherization program has been reduced to a minimum viable level in the near term, and the majority of savings should not be developed until near the end of the surplus. In addition, any weatherization that does occur should be aimed at developing the capability to deliver the full amount of savings when the program is required to accelerate. Over the next few years, the weatherization program should be aimed primarily at the low income and rental subsectors, because further capability needs to be developed here. As a consequence of these factors, the Council used the 5.5 cents per kilowatt-hour cutoff to size the weatherization resource in the portfolio. Even so, the vast majority of measures included in the residential weatherization program cost less than 3.8 cents per kilowatt-hour.

The 5.5 cents per kilowatt-hour avoided cost also applies to conservation resources that grow automatically with economic development, but are not expected to be developed until the later years of the forecast, when the region is no longer in a surplus condition. Savings from refrigerators and freezers, not

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9./ The avoided costs from the 1986 Power Plan have been escalated to reflect real 1988 dollars.

anticipated to be developed until 1995, fall into this category. Resources that fall into this category have lifetimes that are shorter than expected building lifetimes.

The avoided cost is between 4.4 and 4.9 cents per kilowatt-hour for conservation resources that grow with loads, have lifetimes longer than the duration of the surplus and must be acquired today or their savings are lost forever. The derivation of this value is discussed further in the resource portfolio chapter of the 1986 plan. However, the avoided costs for these resources will increase over time. Savings from the model conservation standards in new residential and commercial buildings epitomize this type of conservation resource.

Each conservation program consists of the package of measures that cost less than the avoided cost. Costs and savings for this package are taken from the supply curves described in this chapter. The present-value costs of the achievable savings for each program are adjusted in the following manner before they are used in the system models to determine compatibility with the existing power system and to derive a least-cost resource portfolio.

First, since the system models use conservation programs instead of measures in the resource portfolio, capital replacement costs have to be added to those measures with lifetimes shorter than the lifetime of the major measure in the program. For example, caulking and weatherstripping have shorter lifetimes than insulation; therefore, replacement costs are incurred over the expected lifetime of the insulation to maintain the benefits of caulking and weatherstripping. Consistent with generating resources, these capital replacement costs were escalated at 0.4 percent per year for the first 20 years after calculating out the effects of inflation.

Second, in addition to the direct capital and replacement costs of the conservation measures, administrative costs to run the program must be included in the overall cost. Administrative costs can vary significantly among programs, and are usually ongoing annual costs. In the 1983 and 1986 power plans, the Council used 20 percent of the capital costs of a conservation program to represent administration costs. This figure is an oversimplification of a complex situation.

Several factors can affect the level of administrative costs needed to run a program. First, programs with different desired rates of acquisition will require different levels of administrative costs, especially for such things as marketing, advertising and contract management. Programs that can acquire conservation slowly will probably need smaller amounts of administration; whereas, those that need to act quickly will have higher costs.

Furthermore, it is likely that the administrative costs will increase as the megawatts from a discretionary resource become fewer. The first few megawatts likely will be acquired from willing homeowners or businesses most interested in energy conservation. Alternatively, the last few megawatts may be very hard to identify and secure.

Finally, administrative costs likely will decrease as the portion of the total cost of conservation that a utility pays increases. Higher payments to individuals and businesses probably will result in lower administrative costs because customers will require less of a "sales-pitch" to participate.

The Council believes that the administrative cost of a given program is largely independent from the number of measures installed in a house or building. For example, the administrative expense of requiring an insulation contractor to install full levels of cost-effective ceiling insulation is no more than if the contractor were only required to install half the cost-effective amount. Processing of contracts, quality checks and other administrative actions still need to be taken, regardless of the number of measures installed.

Some evidence suggests that administrative costs in the commercial sector might exceed those in the residential sector, for several reasons. First, the commercial sector is far more diverse than the residential sector and therefore much more difficult to target and work with. Furthermore, more barriers probably exist to adopting energy conservation measures in the commercial sector. These barriers could be such things as absentee landlords. In the existing commercial sector in particular, where daily business activities could be interrupted in order to install all cost-effective energy conservation measures, administrative costs of convincing owners to participate in a program could be large. The cost of lost productivity or business perceived by business or building owners may prevent them from taking cost-effective energy actions.

Countering some of these barriers is the fact that the Northwest Power Act provided significant mechanisms and incentives for this region to promote conservation. This includes the Council's authority to develop model conservation standards for multiple end uses and to recommend that Bonneville assess a surcharge if those standards are not adopted. The Bonneville Administrator can acquire the electrical output of conservation measures through direct purchase, through authorizing loans and grants to consumers, by providing technical and financial assistance, by aiding in the implementation of the model conservation standards, and by funding demonstration projects to determine the cost-effectiveness of conservation measures. In terms of administrative costs, the region still has little experience with programs that fall within the range of options that are authorized by the Act.

The data concerning administrative costs, even for currently operated programs, are still scarce. Puget Sound Power and Light provided the Council with two estimates of administrative costs: 5 percent of capital costs for its commercial lighting program[10] and 30 percent for its Audit Incentive Program. The Oregon Department of Energy found about a 25-percent administrative cost for its business energy tax credits program. Bonneville has found 25-percent administrative costs in its commercial Purchase of Energy Savings (PES) program and Commercial Incentive Pilot Program (CIPP). The Energy Edge program, which has a significant research component, incurred 33-percent administrative costs. Other programs with some data on administrative costs were reviewed in the Council's report on progress with conservation after five years with the Northwest Power Act.[11] These were primarily residential sector programs, and their administrative costs ranged from 15 percent to 28 percent. The Council's current choice of 20 percent falls within the range of costs experienced in the region to date. At this time, there is no evidence that strongly argues for an estimate of administrative costs different from the 20 percent assumed in the 1986 plan. Therefore, the average cost of the conservation programs is increased 20 percent before the conservation is compared to other generating resources to determine which is more cost-effective. The Council is committed to continued monitoring of the administrative costs of regional conservation programs to see if this estimate can be refined for future information.

A third factor that must be accounted for when comparing conservation programs with other generating resources is the 10-percent credit given to conservation in the Northwest Power Act and continued by Bonneville in response to the Council's five-year review of conservation. This credit means that conservation can cost 10 percent more than the next lowest cost resource and still be considered cost-effective under the Act.

Finally, to ensure that conservation and generating resources are being compared fairly, the costs and savings of both types of resources must be evaluated at the same point of distribution in the electrical grid. Conservation savings and costs are evaluated at the point of use--in the house, for example. In contrast, the costs and generation from a power plant are evaluated at the generator (busbar) itself. Thus,

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10./ In this program, which was operated through contractors, there was some suspicion that a portion of the administrative costs were hidden in the seemingly high costs of the measures.

11./ The report is called "A Review of Conservation Costs and Benefits--Five Years of Experience under the Northwest Power Act." (Order publication number 87-6.)

to make conservation and the traditional forms of generation comparable, the costs of the generation plant must be adjusted to include transmission system losses (7.5 percent) and transmission costs (2.5 percent).

The net effect of all these adjustments is different for the marginal conservation measure than for the average program, because administrative costs are assessed to the average program and not the marginal measure. As mentioned above, the Council determined that the administrative cost of a given program is largely independent from the number or amount of measures installed. The cost threshold for investment in the marginal conservation measure is the busbar cost of coal plants, the resource that generally establishes the avoided cost, plus 20 percent. The 20 percent consists of 10 percent for the Act's credit, 7.5 percent for transmission system losses and 2.5 percent for transmission costs.

The effect on the average cost of conservation programs that are compared to generating resources is to increase the average cost of the conservation programs by 7.5 percent--20 percent added for administrative costs minus 10 percent for the Act's conservation credit and 2.5 percent saved in transmission and distribution costs--and to increase the average savings from the program by 7.5 percent to account for line-loss credits.

The adjustments to the average costs and savings from conservation programs were made for purposes of comparing conservation resources with generating resources, as is done in the models used by the Council to simulate system responses. However, in this chapter, the 10-percent benefit from the Act is not included in the average cost calculations, in order to portray the true cost of conservation programs. As a consequence, the levelized program costs in this chapter are 10 percent higher than those used in the system models. In addition, this chapter is based on conservation savings at the end use, so the savings presented are 7.5 percent lower than those used in the resource portfolio.

Compatibility with the Power System

After these adjustments are made, each conservation program is evaluated in terms of its compatibility with the existing power system and is compared to the cost and savings characteristics of other electricity resources. To assess compatibility, and ultimately the cost-effectiveness of the conservation programs, the Council used two complex computer programs, called the Integrated Systems for Analysis of Acquisitions (ISAAC) and the System Analysis Model (SAM). These models served as a final screen for judging whether a conservation program was regionally cost-effective.

Like the previous Decision Model, the Integrated Systems for Analysis of Acquisitions model determines how many resources are needed to serve the loads described by each of the Council's forecasts. The Integrated Systems for Analysis of Acquisitions model includes several variables that describe the characteristics of different resources, both generating and conservation resources. The key conservation variables are program ramp rates, program type, conservation ownership assumptions, seasonal distribution of savings and percent payments for conservation acquisition. These are described next.

Ramp Rates: The discretionary conservation resources that the model secures in any one year to meet energy needs depends on how fast a program can become operational and on the ultimate amount of cost-effective conservation available. The rate at which a program can be brought online is sometimes known as the program ramp rate. If the region is surplus for a long time, but a conservation program is already operating, the rate at which the program can slow down and the minimum viable level of that program are also important. The minimum viable level of the program, if above zero, determines the amount of savings that would accrue even though the region would prefer to delay purchase of the resource during the surplus period. The ramp rate assumed in the portfolio analysis is displayed in Chapter 5 of the supplement.

Program Type: The Integrated Systems for Analysis of Acquisitions models four types of conservation programs. The first one, called non-discretionary programs, is modeled as savings that are secured automatically, regardless of the status of the power system. This is exemplified by conservation that is secured through codes. The second program type is very similar to the first, because the conservation is secured as new end uses of electricity are purchased, but the savings may not be the result of codes, but programs. This second program type is known as voluntary programs that operate on newly purchased appliances, houses and businesses. The third program type is a discretionary program that secures savings from existing end uses, such as residential weatherization. The fourth program type is a mixture of two programs, where the conservation is initially secured without a program or code by homeowners or business managers on their own, and where the end use is later transitioned into a particular program to secure the remaining conservation.

Resource Ownership: In addition to program types, the model needs to know the distribution of the ownership of the conservation savings among various parties in the region, particularly the investor-owned utilities, generating public utilities and non-generating public utilities. Ownership splits are based on the estimated number of customers in each electricity-consuming sector in each of these utilities' service territories.

Seasonal Distribution of Savings: The model also uses the seasonal distribution of the savings over the months of the year when assessing compatibility. In general, end-use monitored data from the End-Use Load and Conservation Assessment Program is used to model the seasonal distribution of savings from residential space heating and appliances. For lack of data, commercial and industrial savings will be assumed to be evenly distributed throughout the year. Finally, agricultural savings will be modeled as large in April, May and June, with a smaller peak in September, but are non-existent at other times of the year.

Payments: Finally, the model can accommodate different levels of incentive payments for the acquisition of different types of conservation programs. These vary depending on the types of studies being conducted, and are primarily used to model rate impacts.

The technical discussion that follows describes the evaluation of conservation resources conducted by the Council. The narrative is illustrated with calculations from the high demand forecast, but similar calculations were conducted for all of the Council's forecasts. All costs are in 1988 dollars. This discussion, and the technical exhibits listed at the end of each sector, provide the capital costs, energy savings and measure life used by the Council. Bonneville is expected to use comparable assumptions and procedures in any calculation of cost-effectiveness.

RESIDENTIAL SECTOR

In 1987, the region's residential sector consumed 5,280 average megawatts of electricity, which is about 33 percent of the region's total electrical consumption. Space heating is the largest single category of consumption in the residential sector; water heating is second.

Space Heating Conservation in Existing Residential Buildings

Figure 3-2 shows the estimated space heating savings available from existing residences at various electricity prices. The technical conservation potential available with no single measure exceeding 5.5 cents per kilowatt-hour is approximately 200 average megawatts. The Council's plan calls for developing up to 85 percent of the technical potential, or about 170 average megawatts. The estimated average cost of insulating and weatherizing existing residences is about 3.6 cents per kilowatt-hour for single-family houses and 3.8 cents per kilowatt-hour for multifamily. These values escalate to 3.9 and 4.1 cents per kilowatt-hour, respectively, if administration costs and transmission and distribution adjustments are incorporated.

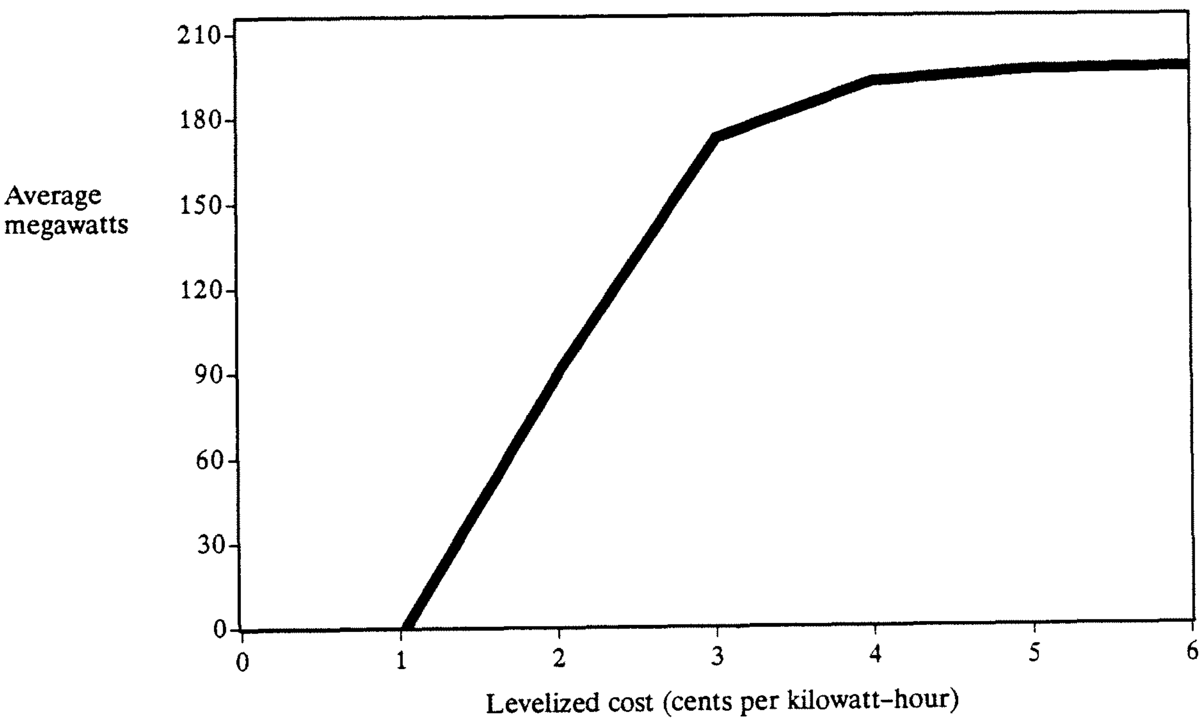

Figure 3-2
Technical Conservation Potential from Space Heating Measures in Existing Residences

The Council's assessment of the conservation potential for existing space heating involved four steps. These steps were to:

1. Estimate cost-effective thermal integrity changes that are available from insulating existing electrically heated dwellings.

2. Develop savings estimates and conservation supply functions that are consistent with the Council's forecasting model, and incorporate the forecasting model's estimates of the effect of consumer behavior on savings from the thermal integrity changes identified in Step 1.

3. Compare projected cost and savings estimates with historically observed cost and savings data.

4. Estimate realizable conservation potential.

Step 1. <u>Estimate Cost-effective Thermal Integrity Improvements From Conservation Measures</u>

The costs and savings of conservation measures are the primary determinants of the amount of conservation that is available from the supply curves. The Council's estimates of single-family home weatherization costs are based on information provided by Bonneville and utilities on the costs they have incurred in recent years to weatherize single-family residences. The actual costs of measures installed by the programs are shown in Table 3-2. Final costs from the Hood River Project were not received in time to incorporate into this supplement, although some information was used from the Hood River Project on the costs of insulating floors to R-30 if additional joist space had to be added to accommodate the depth of the insulation, and for triple glazed windows. As can be seen from the table, the region currently has a large data base of costs for common weatherization measures.

The manner in which the information was collected from the weatherization projects is not completely compatible with the prototype analysis that is required here. Consequently, the data was put in a format that reflected incremental steps from, for example, R-0 to R-19 ceiling insulation and then from R-19 to R-30 and R-30 to R-38, instead of from R-0 to R-38 in one step. This required making an estimate of the cost that is incurred to initially set up an insulation job, compared to the cost of adding additional insulation once the contractor is already incurring the labor to get to the house and set up. The costs from Puget Power and Bonneville are averaged together using the estimated proportion of houses in private and public service territories still eligible for a weatherization program. These costs are then allocated between job set-up costs and add-on costs for each measure. The results are displayed in Table 3-3 for those measures where costs had to be constructed from the actual measure data.

The costs of weatherizing multifamily units are based on costs reported by Bonneville and Puget Power to weatherize multifamily buildings in their service territories. While the data base for the multifamily weatherization measures is not as large as that for single-family weatherization, it is still quite large. The costs as reported by Bonneville and Puget are shown in Table 3-4. As with single-family costs, this information had to be summarized in a manner that was compatible with the prototype analysis. This information, after Bonneville and Puget costs were weighted together, is displayed in Table 3-5 for ceiling insulation. The costs for insulating floors from R-19 to R-30 are taken from information on single-family buildings.

Consistent with the 1986 plan, no savings or costs were estimated for weatherizing or insulating existing manufactured homes.

Table 3-2
Cost to Weatherize Single-family Houses:
Actual Program Data[a]

	PUGET POWER		BONNEVILLE DATA GATHERING PROJECT		OTHER SOURCE	
	($/sq ft)	(N)	($/sq ft)	(N)	($/sq ft)	(N)
Ceiling Insulation						
R-0 to R-38	0.65	1,761	0.76	778		
R-11 to R-38	0.51	6,513	0.52	1,951		
R-19 to R-38	0.44	2,379	0.46	881		
R-30 to R-38	0.44	79	0.67	149		
Wall Insulation						
R-0 to R-11	0.48	3,075	0.79	1,296		
R-0 to R-19			0.79	184		
Floor Insulation						
R-0 to R-11	0.71	9,117	0.78	2,081		
R-0 to R-30	--	--	0.88	9		
Doors					14.05[b]	
Caulking and Weatherstripping			100/house	1,600[c]		
Glass						
Single to double	7.38	10,763	8.20	2,624		
Single to triple	9.78	55			13.42	768[d]

[a] These costs were incurred over a three- to five-year period. However, they are estimated to be approximately 1985 dollars. For use in this update they are escalated to 1988 dollars.

[b] Taken from 1983 Power Plan, escalated to 1988 dollars.

[c] Approximate sample size.

[d] Approximate sample size. These costs are from the Hood River Conservation Project.

Table 3-3
Costs to Weatherize Single-family Houses
Individual Measure Costs Constructed
from Actual Program Data

	SET-UP[a] COSTS	ADD-ON[b] COSTS
Ceiling Insulation		
R-0 to R-19	0.48	--
R-19 to R-30	0.35	0.16
R-30 to R-38	0.31	0.12
R-38 to R-49	--	0.16[d]
Floor Insulation		
R-0 to R-19	0.81	--
R-19 to R-30	--	0.15
R-19 to R-30 w/added joist	0.70[c]	--

[a] Set-up costs are the costs of adding insulation, assuming the contractor is not installing any other insulation in that building component.

[b] Add-on costs represent the incremental cost of adding insulation assuming the contractor is already installing insulation for that building component.

[c] Estimated cost for the measure if additional joist space must be added to accommodate the R-30 insulation.

[d] Costs taken from 1986 Power Plan, escalated to 1988 dollars.

Table 3-4
Costs to Weatherize Multifamily Dwellings:
Actual Program Data[a]
(N = sample size)

	PUGET POWER		BONNEVILLE DATA GATHERING PROJECT		OTHER SOURCE	
	($/sq ft)	(N)	($/sq ft)	(N)	($/sq ft)	(N)
Ceiling Insulation						
R-0 to R-38	0.49	933	0.83	62		
R-11 to R-38	0.49	2,079	0.46	159		
R-19 to R-38	0.40	1,199	0.52	50		
R-30 to R-38	0.47	23	0.28	10		
Wall Insulation						
R-0 to R-11	0.61	184	0.77	42		
R-0 to R-19			0.59	12		
Floor Insulation						
R-0 to R-19	0.69	2,717	0.75	145		
Doors					14.04[b]	
Caulking and Weatherstripping			129/dwelling unit	115[c]		
Glass						
Single to double	6.90	4,395	6.56	217		
Single to triple	6.96	50	14.81	32		

[a] These costs were incurred over a three- to five-year period. However, they are estimatec : be approximately 1985 dollars. For use in this supplement they are escalated to 1988 dollars.

[b] Taken from 1983 Power Plan, escalated to 1988 dollars.

[c] Approximate sample size.

Table 3-5
Costs to Weatherize Multifamily Dwellings
Individual Measure Costs Constructed
from Actual Program Data

	SET-UP[a] COSTS	ADD-ON[b] COSTS
Ceiling Insulation		
R-0 to R-19	0.50	--
R-19 to R-30	0.46	0.08
R-30 to R-38	0.44	0.05

[a] Set-up costs are the costs of adding insulation, assuming the contractor is not installing any other insulation in that building component.

[b] Add-on costs represent the incremental cost of adding insulation assuming the contractor is already installing insulation for that building component.

It is useful to distinguish between set-up and add-on costs to answer two different questions. Set-up costs are included when determining whether any insulation should be added to a building component, given that a certain level already exists. For example, if a ceiling is already insulated to R-30, it turns out that it is not cost-effective to the region to pay for a contractor to come to the house and increase the ceiling insulation level to R-38. Add-on costs determine how far a building component should be insulated, assuming the contractor is already set up and has installed some base insulation. It turns out, for example, that it is cost-effective to set up a contractor to increase ceiling insulation to R-38 from a base of R-19 and it is also cost-effective to continue adding insulation to R-49 (based on costs from the 1986 Power Plan), if the contractor is already there. Thus the regional cost-effectiveness limit is R-49 in the ceiling if anything less than about R-30 exists before weatherization.

In an ideal situation, where all measures can be installed in the building and no lost-opportunity measure has already been created, the following measures would be recommended for installation in single-family houses: R-49 ceiling insulation if the house has less than R-30; R-11 wall insulation if no insulation currently exists; R-30 under floor insulation if less than R-19 currently exists; and triple pane windows if single panes are present, but not if the windows are already double paned. The current analysis indicates that if the house is already at R-30 in the ceiling, has some wall insulation, has R-19 or more in the floor and double pane windows, it is not cost-effective to weatherize further.

These results have important implications for the design of weatherization programs. For example, if a utility runs a weatherization program that takes the ceiling insulation to R-30 only, the savings from going beyond R-30 are lost to the region, even though it would have been cost-effective to go further at the time the house was weatherized. Additionally, these results lead to a weatherization program design that could be modeled after the oil dipstick in a car. If an audit shows that the house already has R-30 in the ceiling, it is only half a quart low and no oil--that is, insulation--should be added. On the other hand, if the audit shows that the ceiling is only at R-19, it is a full quart low, and insulation should be added to the full cost-effectiveness level (R-49), or as close as structural barriers permit.

Three typical building designs were used to estimate the retrofit potential for single-family houses in the region. The first is an 850-square-foot single-story house built over an unheated basement. The second is a 1,350-square-foot house over a vented crawl space, and is similar to the design used in the 1983 and 1986 power plans. The third is a 2,100-square-foot two-story house with a heated basement. The multifamily design is a three-story apartment house with four 840-square-foot units on each floor.

There are limitations on the number of houses that can reach full cost-effective weatherization levels. For example, if the house does not have room in the joist system to accommodate R-30 insulation, then given current data, it does not appear cost-effective to add the increased joist space to accommodate the thicker insulation. Similarly, while an effective triple glazed window appears cost-effective if single glazing is the base, it is very difficult to find double storm windows on the market today. As a consequence of these limitations, the current analysis of single-family residential weatherization savings only uses R-30 floors and triple glazing on one of the three prototypes. Less information is known about multifamily buildings. As a consequence, the multifamily prototypes were modeled with only double glazing, but with floors that could go to R-30 insulation without the increased joist cost. In addition, recent draft information on air change rates in multifamily units indicates that these dwellings have less air exchange with the outside air than single-family houses. The base case single-family air-change rate that was used for multifamily dwellings in prior analyses has been lowered to 0.4 ACH from 0.6 ACH in the current analysis.

Savings from weatherization measures installed in all four house designs were estimated using a two-step process. The first step is to estimate the measures that are cost-effective to install and to develop a relative efficiency improvement from a base case if all cost-effective measures are installed. This first step is done assessing the savings from each measure holding constant other determinants of space heating consumption, such as thermostat settings and room closure behavior. The second step is to take the aggregate efficiency improvement that is identified as cost-effective and run it through the forecast to incorporate consumer behavior changes into the estimate of aggregate savings.

In the first step, the engineering-based SUNDAY computer model,[12] which simulates a building's daily space heating energy needs, is used to evaluate a base case and the savings attributable to each conservation measure, holding behavior constant. This step determines which of the representative measures applied to the prototypes are cost-effective. At this stage, savings are evaluated using an average indoor temperature setting of 65°F, internal gains consistent with the efficient appliances included in the Council's resource portfolio (2,000 Btu/hr), and no reduction in use from room closure and wood heat. This set of assumptions is often called the "standard operating conditions" of a residential building.

These values were selected based on analysis and judgment. They represent a house used at levels that are reasonable if efficiency measures are installed which significantly lower utility bills. Curtailment activities, such as room closure and reduced temperature settings, are less likely to continue after efficiency measures are installed. If the house ends up being operated in the long run at reduced amenity, then potentially a measure was included in the program that should not have been there. However, if less than full amenity were assumed in this step of the analysis, then measures that might have been cost-effective would be lost. The Council has selected the former condition as preferable to the latter, partially to protect against the high load growth scenarios, where every conservation measure is important. The effect on the last measure of changing standard operating conditions is discussed in Step 3 of this section.

It is important to emphasize here that the engineering models are used to determine which representative measures should be incorporated into a program, while holding behavior at pre-determined amenity levels. Once the relative efficiency change is determined, savings are re-estimated using the

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12./ The SUNDAY model simulates space heating needs based on heat loss rate, daily access to solar energy, daily inside and outside temperatures, thermal mass, and the amount of heat given off by lights, people and appliances.

econometrically based forecasting model to incorporate behavioral changes in response to price. In addition, because the forecast implicitly incorporates an estimate of wood heat and room closure, these are also included in the average estimate of savings from weatherizing houses.

Tables 3-6 through 3-8 for single-family and Table 3-9 for multifamily houses show the costs, levelized in mills (tenths of a cent) per kilowatt-hour, and the engineering savings assuming standard operating conditions from weatherizing the typical prototype houses in three representative climate zones in the region. The purpose of these tables is to show the expected reduction in space heating use as weatherization measures are installed. The precise order of the measures, and their location in the list is a function of which one has the least expected cost per savings. Since people often install measures out-of-order, the listings here must be considered as simply representative of the type of expected energy savings that would be secured as insulation is added.

Each measure has its own average, or expected, lifetime, which is used in generating the levelized cost. The levelized costs displayed in these tables reflect financing costs and replacement costs if the life of the measure is less than the lifetime of the major measure in the program (in this case, insulation). Insulation lasts the lifetime of the residence, which for existing stock is expected to be an average of about 60 or more years. This was reduced to 50 years. Storm windows and prime replacement windows are assumed to last an average of about 30 years, as are replacement doors. Caulking and weatherstripping were assumed to last 10 years.

Table 3-6
Representative Thermal Integrity Curve for Single-family House Weatherization Measures
Zone 1 - Seattle

MEASURES	UA	CAPITAL COST TOTAL	CAPITAL COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	PRESENT-VALUE CAPITAL COST	LEVELIZED COST (1988$) (mills/kWh)
HOUSE SIZE - 850 SQUARE FEET							
Base Case	694.92	0.00	0.00	18,504	21.77	0.00	0.00
Ceiling R-0 to R-19	503.67	409.65	0.48	12,241	14.40	454.91	2.82
Walls R-0 to R-11	418.62	1,071.40	1.26	9,223	10.85	1,189.77	9.46
Crawl Space R-0 to R-19	342.12	1,760.36	2.07	6,575	7.74	1,954.84	11.23
Ceiling R-19 to R-30	327.67	1,900.01	2.24	6,099	7.18	2,109.92	12.66
ACH .6 to .4	303.19	2,009.55	2.36	5,305	6.24	2,493.36	18.77
Crawl Space R-19 to R-30	296.39	2,139.89	2.52	5,084	5.98	2,638.10	25.50
Single to Double Glass	251.27	2,942.98	3.46	3,662	4.31	3,831.98	32.63
Ceiling R-30 to R-38	247.87	3,045.39	3.58	3,557	4.19	3,945.70	42.11
Wood to Metal Door	236.67	3,660.75	4.31	3,215	3.78	4,860.49	103.83
HOUSE SIZE - 1,350 SQUARE FEET							
Base Case	1,065.48	0.00	0.00	31,810	23.56	0	0.00
Ceiling R-0 to R-19	761.73	650.62	0.48	20,937	15.51	722.50	2.58
Walls R-0 to R-11	629.29	1,491.83	1.11	16,071	11.90	1,656.65	7.46
ACH .6 to .4	590.41	1,601.36	1.19	14,650	10.85	2,040.08	10.49
Ceiling R-19 to R-30	567.46	1,823.17	1.35	13,825	10.24	2,286.39	11.60
Crawl Space R-0 to R-19	455.41	2,917.39	2.16	9,848	7.30	3,501.50	11.88
Single to Triple Glass	366.01	4,815.45	3.57	6,826	5.06	6,323.15	36.28
Ceiling R-30 to R-38	360.61	4,978.10	3.69	6,646	4.92	6,503.78	38.93
Wood to Metal Door	349.41	5,593.46	4.14	6,278	4.65	7,418.56	96.72
Crawl Space R-19 to R-30[a]	337.26	6,539.82	4.84	5,884	4.36	8,469.48	103.56
HOUSE SIZE - 2,100 SQUARE FEET							
Base Case	1,224.86	0.00	0.00	32,472	15.46	0.00	0.00
Ceiling R-0 to R-19	1,067.36	337.36	0.16	27,306	13.00	374.63	2.82
ACH .6 to .4	1,001.84	446.89	0.21	24,947	11.88	758.06	6.32
Walls R-0 to R-11	803.37	1,757.78	0.84	18,001	8.57	2,213.77	8.15
Ceiling R-19 to R-30	791.47	1,872.78	0.89	17,590	8.38	2,341.49	12.09
Single to Double Glass	640.27	4,563.99	2.17	12,565	5.98	6,342.24	30.94
Ceiling R-30 to R-38	637.47	4,648.33	2.21	12,472	5.94	6,435.90	39.13
Wood to Metal Door	626.27	5,263.69	2.51	12,100	5.76	7,350.69	95.54

[a] The costs of this measure include an estimate for extending the joist to accommodate R-30 insulation.

Table 3-7
Representative Thermal Integrity Curve for Single-family House Weatherization Measures
Zone 2 - Spokane

MEASURES	UA	CAPITAL COST TOTAL	CAPITAL COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	PRESENT-VALUE CAPITAL COST	LEVELIZED COST (1988$) (mills/kWh)
HOUSE SIZE - 850 SQUARE FEET							
Base Case	694.92	$0.00	$0.00	25,257	29.71	$0	0.00
Ceiling R-0 to R-19	503.67	409.65	0.48	17,317	20.37	454.91	2.23
Walls R-0 to R-11	418.62	1,071.40	1.26	13,432	15.80	1,189.77	7.35
Crawl Space R-0 to R-19	342.12	1760.36	2.07	9,968	11.73	1,954.84	8.58
Ceiling R-19 to R-30	327.67	1,900.01	2.24	9,332	10.98	2,109.92	9.48
ACH .6 to .4	303.19	2,009.55	2.36	8,266	9.73	2,493.36	13.97
Crawl Space R-19 to R-30	296.39	2,139.89	2.52	7,970	9.38	2,638.10	18.99
Single to Double Glass	251.27	2,942.98	3.46	6,039	7.11	3,831.98	24.03
Ceiling R-30 to R-38	247.87	3,045.39	3.58	5,896	6.94	3,945.70	30.99
Wood to Metal Door	236.67	3,660.75	4.31	5,430	6.39	4,860.49	76.25
HOUSE SIZE - 1,350 SQUARE FEET							
Base Case	1,065.48	0.00	0.00	42,028	31.13	0	0.00
Ceiling R-0 to R-19	761.73	650.62	0.48	28,322	20.98	722.50	2.05
Walls R-0 to R-11	629.29	1,491.83	1.11	22,169	16.42	1,656.65	5.90
ACH .6 to .4	590.41	1,601.36	1.19	20,371	15.09	2,040.08	8.29
Ceiling R-19 to R-30	567.46	1,823.17	1.35	19,326	14.32	2,286.39	9.16
Crawl Space R-0 to R-19	455.41	2,917.39	2.16	14,259	10.56	3,501.50	9.32
Single to Triple Glass	366.01	4,815.45	3.57	10,303	7.63	6,323.15	27.72
Ceiling R-30 to R-38	360.61	4,978.10	3.69	10,066	7.46	6,503.78	29.55
Wood to Metal Door	349.41	5,593.46	4.14	9,577	7.09	7,418.56	72.78
Crawl Space R-19 to R-30[a]	337.26	6,539.82	4.84	9,051	6.70	8,469.48	77.60
HOUSE SIZE - 2,100 SQUARE FEET							
Base Case	1,224.86	0.00	0.00	43,945	20.93	0.00	0.00
Ceiling R-0 to R-19	1,067.36	337.36	0.16	37,387	17.80	374.63	2.22
ACH .6 to .4	1,001.84	446.89	0.21	34,383	16.37	758.06	4.96
Walls R-0 to R-11	803.37	1,757.78	0.84	25,410	12.10	2,213.77	6.31
Ceiling R-19 to R-30	791.47	1,872.78	0.89	24,879	11.85	2,341.49	9.34
Single to Double Glass	640.27	4,563.99	2.17	18,270	8.70	6,342.24	23.53
Ceiling R-30 to R-38	637.47	4,648.33	2.21	18,147	8.64	6,435.90	29.75
Wood to Metal Door	626.27	5,263.69	2.51	17,658	8.41	7,350.69	72.64

[a] The costs of this measure include an estimate for extending the joist to accommodate R-30 insulation.

Table 3-8
Representative Thermal Integrity Curve for Single-family House Weatherization Measures
Zone 3 - Missoula

MEASURES	UA	CAPITAL COST TOTAL	CAPITAL COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	PRESENT-VALUE CAPITAL COST	LEVELIZED COST (1988$) (mills/kWh)
HOUSE SIZE - 850 SQUARE FEET							
Base Case	694.92	$0.00	$0.00	29,310	34.48	0	0.00
Ceiling R-0 to R-19	503.67	409.65	0.48	20,198	23.76	$454.91	1.94
Walls R-0 to R-11	418.62	1,071.40	1.26	15,732	18.51	1,189.77	6.40
Crawl Space R-0 to R-19	342.12	1,760.36	2.07	11,715	13.78	1,954.84	7.40
Ceiling R-19 to R-30	327.67	1,900.01	2.24	10,976	12.91	2,109.92	8.15
ACH .6 - .4	303.19	2,009.55	2.36	9,761	11.48	2,493.36	12.27
Crawl Space R-19 to R-30	296.39	2,139.89	2.52	9,424	11.09	2,638.10	16.67
Single to Double Glass	251.27	2,942.98	3.46	7,218	8.49	3,831.98	21.03
Ceiling R-30 to R-38	247.87	3,045.39	3.58	7,056	8.30	3,945.70	27.38
Wood to Metal Door	236.67	3,660.75	4.31	6,526	7.68	4,860.49	67.11
HOUSE SIZE - 1,350 SQUARE FEET							
Base Case	1,065.48	0.00	0.00	48,709	36.08	0.00	0.00
Ceiling R-0 to R-19	761.73	650.62	0.48	33,032	24.47	722.50	1.79
Walls R-0 to R-11	629.29	1,491.83	1.11	25,949	19.22	1,656.65	5.13
ACH .6 - .4	590.41	1,601.36	1.19	23,874	17.68	2,040.08	7.18
Ceiling R-19 to R-30	567.46	1,823.17	1.35	22,658	16.78	2,286.39	7.87
Crawl Space R-0 to R-19	455.41	2,917.39	2.16	16,762	12.42	3,501.50	8.01
Single to Triple Glass	366.01	4,815.45	3.57	12,193	9.03	6,323.15	24.00
Ceiling R-30 to R-38	360.61	4,978.10	3.69	11,919	8.83	6,503.78	25.66
Wood to Metal Door	349.41	5,593.46	4.14	11,359	8.41	7,418.56	63.44
Crawl Space R-19 to R-30[a]	337.26	6,539.82	4.84	10,751	7.96	8,469.48	67.27
HOUSE SIZE - 2,100 SQUARE FEET							
Base Case	1,224.86	0.00	0.00	51,223	24.39	0.00	0.00
Ceiling R-0 to R-19	1,067.36	337.36	0.16	43,675	20.80	374.63	1.93
ACH .6 - .4	1,001.84	446.89	0.21	40,205	19.15	758.06	4.30
Walls R-0 to R-11	803.37	1,757.78	0.84	29,820	14.20	2,213.77	5.45
Ceiling R-19 to R-30	791.47	1,872.78	0.89	29,206	13.91	2,341.49	8.09
Single to Double Glass	640.27	4,563.99	2.17	21,611	10.29	6,342.24	20.47
Ceiling R-30 to R-38	637.47	4,648.33	2.21	21,471	10.22	6,435.90	25.89
Wood to Metal Door	626.27	5,263.69	2.51	20,908	9.96	7,350.69	63.21

[a] The costs of this measure include an estimate for extending the joist to accommodate R-30 insulation.

Table 3-9
Representative Thermal Integrity Curve for Multifamily House Weatherization Measures

MEASURE	UA (per unit)	INCREMENTAL CAPITAL COST	CUMULATIVE CAPITAL COST	CUMULATIVE PRESENT VALUE COST	ANNUAL USE (kWh/yr)	(kWh/ sq ft)	LEVELIZED COST
			ZONE 1 - SEATTLE				
Base Case	376	0	0	0	8,891	10.6	0
Ceiling R-0 to R-19	304	$161	$161	$178	6,700	8.0	3.2
Ceiling R-19 to R-30	299	$24	$185	$205	6,510	7.8	5.6
Walls R-0 to R-11	255	$334	$519	$576	5,014	6.0	9.6
Crawl Space R-0 to R-19	229	$248	$767	$852	4,134	4.9	12.2
Ceiling R-30 to R-38	227	$17	$784	$871	4,092	4.9	18.1
Crawl Space R-19 to R-30	225	$49	$833	$925	3,998	4.8	22.5
Single to Double Glass	179	$708	$1,541	$1,977	2,584	3.1	28.9
ACH .4 - .3	165	$141	$1,682	$2,472	2,180	2.6	47.5
Wood to Metal Door	162	$162	$1,844	$2,712	2,093	2.5	108.0
			ZONE 2 - SPOKANE				
Base Case	376	0	0	0	12,424	14.8	0
Ceiling R-0 to R-19	304	$161	$161	$178	9,635	11.5	2.5
Ceiling R-19 to R-30	299	$24	$185	$205	9,393	11.2	4.3
Walls R-0 to R-11	255	$334	$519	$576	7,450	8.9	7.4
Crawl Space R-0 to R-19	229	$248	$767	$852	6,289	7.5	9.2
Ceiling R-30 to R-38	227	$17	$784	$871	6,233	7.4	13.5
Crawl Space R-19 to R-30	225	$49	$833	$925	6,108	7.3	16.9
Single to Double Glass	179	$708	$1,541	$1,977	4,193	5.0	21.4
ACH .4 - .3	165	$141	$1,682	$2,472	3,636	4.3	34.5
Wood to Metal Door	162	$162	$1,844	$2,712	3,518	4.2	78.5
			ZONE 3 - MISSOULA				
Base Case	376	0	0	0	14,594	17.4	0
Ceiling R-0 to R-19	304	$161	$161	$178	11,339	13.5	2.1
Ceiling R-19 to R-30	299	$24	$185	$205	11,055	13.2	3.7
Walls R-0 to R-11	255	$334	$519	$576	8,800	10.5	6.4
Crawl Space R-0 to R-19	229	$248	$767	$852	7,460	8.9	8.0
Ceiling R-30 to R-38	227	$17	$784	$871	7,396	8.8	11.8
Crawl Space R-19 to R-30	225	$49	$833	$925	7,252	8.6	14.7
Single to Double Glass	179	$708	$1,541	$1,977	5,032	6.0	18.4
ACH .4 - .3	165	$141	$1,682	$2,472	4,383	5.2	29.7
Wood to Metal Door	162	$162	$1,844	$2,712	4,245	5.1	67.4

Since each representative measure saves a different amount of energy in each house design and location, an aggregate supply curve must be developed to represent the weighted average efficiency change for all representative measures in the dwelling types. The use and cost from each climate zone were combined according to percentages listed in Table 3-10. The regional average thermal integrity curves for each typical house design appear in Tables 3-11 and 3-12.

Table 3-10
Weights Used to Reflect Regional Weather for Existing Space Heating

	CLIMATE ZONE 1	CLIMATE ZONE 2	CLIMATE ZONE 3
Single-family Houses	84%	11%	5%
Multifamily Houses	73.1%	22.1%	4.8%

Table 3-11
Regionally Weighted Thermal Integrity Curve for Single-family House Weatherization Measures

	LEVELIZED COST (mills/kWh)	CAPITAL COST ($/sq ft)	USE (kWh/sq ft)	PRESENT-VALUE COST	UA
850 SQUARE FOOT HOUSE					
Base Case	0.00	0.00	23.28	0.00	694
Ceiling R-0 to R-19	2.71	0.48	15.53	454.91	503
Walls R-0 to R-11	9.08	1.26	11.78	1,189.77	418
Crawl Space R-0 to R-19	10.74	2.07	8.48	1,954.84	342
Ceiling R-19 to R-30	12.09	2.24	7.88	2,109.92	327
ACH .6 - .4	17.91	2.36	6.89	2,493.36	303
Crawl Space R-19 to R-30	24.35	2.52	6.61	2,638.10	296
Single to Double Glass	31.10	3.46	4.83	3,831.98	251
Ceiling R-30 to R-38	40.15	3.58	4.69	3,945.70	247
Wood to Metal Door	98.96	4.31	4.26	4,860.49	236
1,350 SQUARE FOOT HOUSE					
Base Case	0.00	0.00	25.02	0.00	1,065
Ceiling R-0 to R-19	2.48	0.48	16.56	722.50	761
Walls R-0 to R-11	7.17	1.11	12.77	1,656.65	629
ACH .6 - .4	10.08	1.19	11.66	2,040.08	590
Ceiling R-19 to R-30	11.14	1.35	11.02	2,286.39	567
Crawl Space R-0 to R-19	11.40	2.16	7.91	3,501.50	455
Single to Triple Glass	34.73	3.57	5.54	6,323.15	366
Ceiling R-30 to R-38	37.24	3.69	5.40	6,503.78	360
Wood to Metal Door	92.42	4.14	5.11	7,418.56	349
Crawl Space R-19 to R-30[a]	98.89	4.84	4.80	8,469.48	337
2,100 SQUARE FOOT HOUSE					
Base Case	0.00	0.00	16.51	0.00	1,224
Ceiling R-0 to R-19	2.71	0.16	13.92	374.63	1,067
ACH .6 - .4	6.07	0.21	12.74	758.06	1,001
Walls R-0 to R-11	7.81	0.84	9.24	2,213.77	803
Ceiling R-19 to R-30	11.58	0.89	9.03	2,341.49	791
Single to Double Glass	29.60	2.17	6.50	6,342.24	640
Ceiling R-30 to R-38	37.43	2.21	6.45	6,435.90	637
Wood to Metal Door	91.41	2.51	6.26	7,350.69	626

a The costs of this measure include an estimate for extending the joist to accommodate R-30 insulation.

Table 3-12
Regionally Weighted Thermal Integrity Curve for Multifamily House Weatherization Measures

MEASURE	UA (per unit)	INCREMENTAL CAPITAL COST	CUMULATIVE CAPITAL COST	CUMULATIVE PRESENT VALUE COST	ANNUAL USE (kWh/yr)	(kWh/ sq ft)	LEVELIZED COST
Base Case	376	$0	$0	$0	9,953	11.8	0
Ceiling R-0 to R-19	304	$161	$161	$178	7,578	9.0	2
Ceiling R-19 to R-30	299	$24	$185	$205	7,371	8.8	5
Walls R-0 to R-11	255	$334	$519	$576	5,739	6.8	8
Crawl Space R-0 to R-19	229	$248	$767	$852	4,774	5.7	11
Ceiling R-30 to R-38	227	$17	$784	$871	4,728	5.6	16
Crawl Space R-19 to R-30	225	$49	$833	$925	4,625	5.5	20
Single to Double Glass	179	$708	$1,541	$1,977	3,061	3.6	26
ACH .4 - .3	165	$141	$1,682	$2,472	2,610	3.1	43
Wood to Metal Door	162	$162	$1,844	$2,712	2,514	3.0	99

The cost and use for each of the three single-family houses were merged to estimate regional space heating consumption by cents per kilowatt-hour. The 1979 Pacific Northwest survey indicated that the average pre-1980 house was approximately 1,350 square feet. The 2,100 square foot, 1,350 square foot, and 850 square foot houses were weighted to represent approximately 22, 46 and 32 percent respectively of the regional stock to achieve the appropriate average house size. These weights result in an average house size of 1,355 square feet. Tables 3-13 and 3-14 show the curve of regionally weighted costs and space heating use for single-family and multifamily houses.

The information from Table 3-13 is displayed graphically in Figure 3-3. The curve represents thermal integrity improvements starting with an uninsulated house. Space heating use is reduced and present-value costs increase from adding more insulation to the house. The space heating use of the solid line is based on the SUNDAY model with the assumed standard operating conditions described above. If, for example, a reduced thermostat set point were used instead of the currently assumed standard operating conditions, the curve would be displaced to a lower use for a given amount of conservation investment. The level of use that is predicted at the 55 mill cost-effectiveness cut-off is also identified in Figure 3-3.

The purpose of the thermal integrity curve is to identify the relative efficiency level that is cost-effective, holding amenities constant. The efficiency level is the ratio of the use at the 55 mill cut-off divided by the estimated base case use of a house. As noted earlier, these curves start with an uninsulated house, while the vast majority of houses in the region, even those that are not retrofitted, already have some insulation. Therefore, the base case use on which a relative efficiency change is calculated cannot be taken from the uninsulated case, but must be estimated based on the average energy consumption or average existing insulation levels in the eligible stock.

The data used in this process are described for multifamily buildings first. The Council used work done for the Bonneville Power Administration by ICF Incorporated et. al. to determine the base case insulation values for multifamily units. These base case values for pre-1979 unweatherized stock translated into a heat loss rate per unit of 255 UA.[13] Under standard operating conditions, this implies a use of 5,739

13./ UA is the heat loss rate of a building (expressed as a U-value) times the area of the component. A U-value has units of Btu per farenheight degree per square foot.

kilowatt-hours per year. If all cost-effective measures are added to the structure, the use under standard operating conditions drops to 2,591 kilowatt-hours per year.

Table 3-13
Regionally Weighted Single-family House Thermal Integrity Curve by Levelized Cost Category

LEVELIZED COST (mils/kWh)	COST ($/sq ft)	USE/YR (kWh/sq ft)	PRESENT-VALUE CAPITAL	UA	USE (kWh/yr)	CAPITAL COST
0	$0.00	22.59	$0	981	30,611	$0.00
5	$0.66	14.10	$933	694	19,110	897.56
10	$1.28	10.57	$1,953	567	14,320	1,738.01
15	$2.08	7.72	$3,229	471	10,454	2,817.56
20	$2.33	7.14	$3,828	449	9,673	3,160.92
25	$2.61	6.64	$4,419	428	8,990	3,539.35
30	$3.05	5.84	$5,206	400	7,907	4,128.49
35	$3.26	5.49	$5,569	388	7,437	4,411.34
40	$3.34	5.40	$5,700	385	7,311	4,529.28
45	$3.39	5.37	$5,782	384	7,273	4,589.86
50	$3.43	5.34	$5,863	383	7,236	4,650.38
55	$3.48	5.31	$5,945	382	7,198	4,710.91
60	$3.52	5.29	$6,027	381	7,161	4,771.43
65	$3.57	5.26	$6,108	380	7,124	4,831.95
70	$3.61	5.23	$6,190	379	7,086	4,892.47
75	$3.66	5.20	$6,272	378	7,049	4,952.99
80	$3.70	5.17	$6,353	377	7,011	5,013.51
85	$3.74	5.15	$6,435	376	6,974	5,074.04
90	$3.79	5.12	$6,517	375	6,937	5,134.56
95	$3.95	5.04	$6,758	372	6,834	5,350.27
100	$4.16	4.95	$7,068	368	6,705	5,634.06

Table 3-14
Regionally Weighted Multifamily House Thermal Integrity Curve by Levelized Cost Category

LEVELIZED COST	CAPITAL COST	PRESENT-VALUE COST	ANNUAL USE (kWh/yr)	(kWh/sq ft)
0	$0	$0	9,953	11.8
5	$183	$203	7,390	8.8
10	$628	$697	5,317	6.3
15	$779	$865	4,743	5.6
20	$823	$914	4,647	5.5
25	$1,333	$1,668	3,520	4.2
30	$1,568	$2,072	2,974	3.5
35	$1,609	$2,217	2,842	3.4
40	$1,651	$2,363	2,710	3.2
45	$1,686	$2,477	2,608	3.1
50	$1,700	$2,499	2,600	3.1
55	$1,715	$2,520	2,591	3.1
60	$1,729	$2,542	2,582	3.1
65	$1,744	$2,563	2,574	3.1
70	$1,758	$2,585	2,565	3.1
75	$1,773	$2,606	2,557	3.0
80	$1,787	$2,628	2,548	3.0
85	$1,802	$2,650	2,539	3.0
90	$1,816	$2,671	2,531	3.0
95	$1,831	$2,693	2,522	3.0

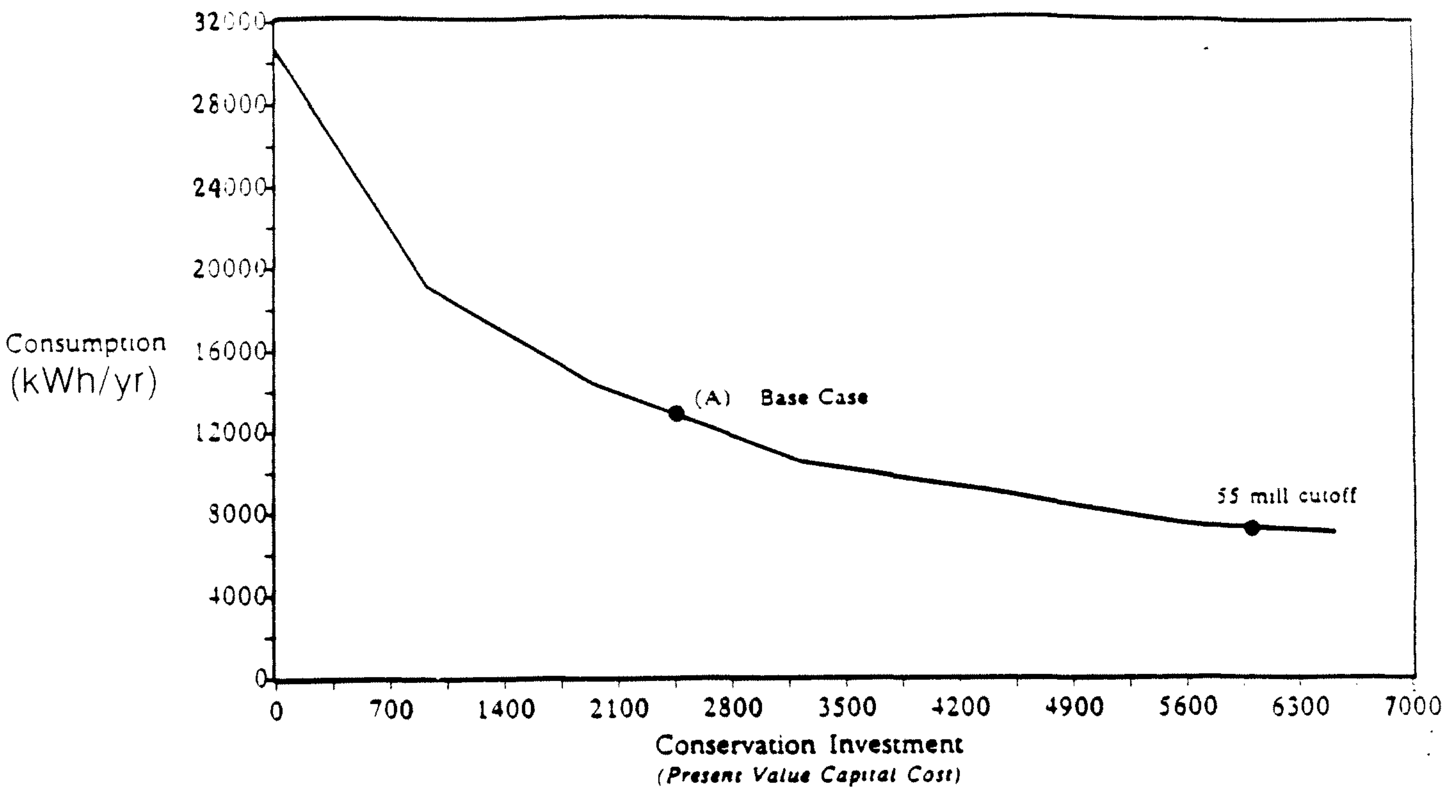

Figure 3-3
Existing Single-family Houses Thermal Integrity Curve

The relative use, after all cost-effective measures are installed with holding amenity and behavior held constant is 0.45 (2,591/5,739). As described in the next section, this efficiency improvement will be used in the forecasting model to incorporate behavioral changes into the estimate of average savings. For single-family houses, the method to determine a relative efficiency level is quite similar.

Some information is available on the average insulation level in pre-1979 vintage unweatherized single-family houses. The best estimate that could be found is from a sample of 228 pre-1979 single-family houses in the End Use Load and Conservation Assessment Program (ELCAP) where the average heat loss rate (specified in terms of UA) was determined from on-site surveys of the houses.[14] The UA value, after normalizing for the regional average square footage of existing houses used in this analysis and including the heat loss effect of infiltration, is approximately 550. If a house with a 550 UA were operated assuming standard operating conditions, it would consume approximately 13,148 kilowatt-hours per year for space heating. If this is the base case, and 7,198 kilowatt-hours per year is the predicted consumption if all cost-effective measures are installed, then the relative electric energy use of the weatherized houses is 0.53. This estimate is for efficiency changes only, and does not incorporate behavioral changes, since amenity and behavior were held constant as insulation was added. However, behavioral impacts on the estimate of savings are incorporated when the new thermal efficiency level is used in the forecasting model.

14./ Only about 13 percent of the houses on which the estimate is based participated in a weatherization program and took at least one major measure. If these houses were removed, the probable effect would be to raise the average UA. On the other hand, some self-weatherization has most likely occurred since the time the ELCAP houses were audited. The size of this action is unknown, but it would act to lower the UA. The judgment was to consider these as off-setting effects.

Figure 3-4 illustrates the derivation of the estimate of thermal efficiency improvement from single-family buildings. The curves reflect the reduction in space heating use from investing in insulation. Space heating use on the solid line is modeled using amenity and behavior at standard operating conditions, while the dashed line represents space heating use with reduced amenities compared to standard operating conditions. The solid line would represent the impact on space heating use from adding insulation if amenity and behavior are held constant at current assumptions similar to those in the Council's forecast.

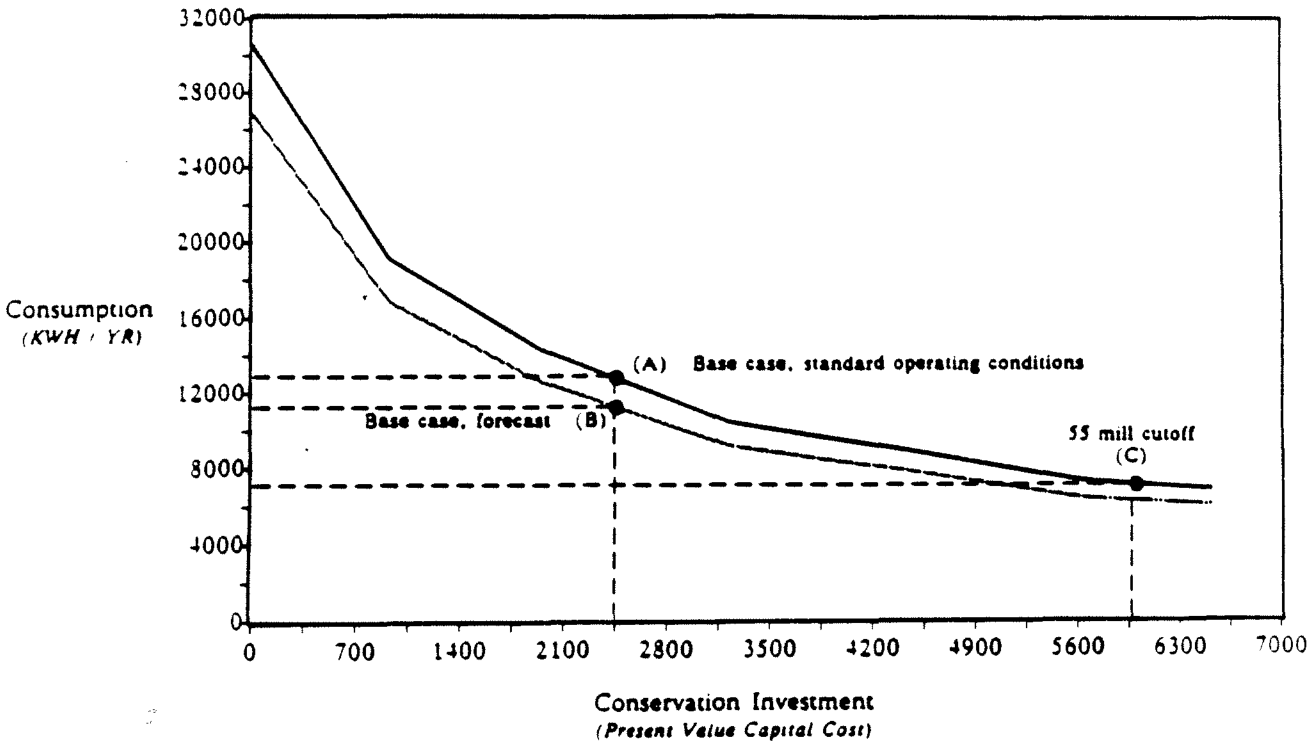

Figure 3-4
Existing Single-family Thermal Integrity Curve based on Standard Operating Conditions (solid line) and Assumed Pre-conservation Forecast Conditions (dashed line) Holding Amenity Constant

Point A on the solid line represents space heating use under standard operating conditions if the average building eligible for weatherization has an existing UA of 550. Use after all cost-effective measures are installed under standard operating conditions is Point C. The relative efficiency level is the use at C divided by use at A, and the costs that are associated with that amount of savings are the costs along the x-axis at A minus the costs at C. Point B is the forecast estimate of space heating consumption for these same houses that are yet to be weatherized.

Step 2. Develop Conservation Savings Estimates that are Consistent with the Council's Forecast and Incorporate Behavioral Impacts

The Council's supply function for the total amount of conservation available in existing residential buildings was developed for the year 2010. This was done for three reasons. First, the supply of energy available through conservation in existing buildings is constrained by the rates at which measures can be implemented. Second, these rates are constrained by the need for additional energy supplies. Third, some existing houses will be torn down by the year 2010, and others may change their primary heating fuel. As a result, the conservation savings from existing buildings diminish with time because of removal and can also change due to new selections of heating fuel. By developing its retrofit supply function for the year 2010, the Council was able to account for demolitions and set deployment schedules based on the need for additional supplies, which is done in the Integrated Systems for Analysis of Acquisitions model.

The forecast model, combined with information from utility weatherization programs, was used to determine the number of electrically heated houses built before 1979 that would survive to 2010 and could still be retrofitted. Houses built after 1979 are not included as weatherization potential. These houses represent a lost conservation opportunity because they are insulated well enough that additional weatherization is generally not cost-effective, yet they are not insulated to the full level that is cost-effective for new homes. Houses that have electric heating systems, but heat primarily with wood, are also not included in the stock remaining to be weatherized. This is because the retrofit savings are estimates that assume that the house is primarily heated with electricity.

In 1979, the stock of primarily electric space heated single-family houses amounted to 871,600 houses. The same value for multifamily units was 322,300. The existing housing stock is estimated to have an average lifetime of approximately 80 years. Today, the average age of the existing stock is approximately 20 years. By the year 2010, a number of these existing houses will have been removed from the housing stock because of such things as fire and decay. In addition, some houses may have changed their primary heating fuel either into, or away from, electricity over this time period, as modeled in the forecast. Consequently, the remaining pre-1980 vintage stock in 2010, given the Council's average lifetime estimates and fuel choice is approximately 638,110 single-family houses and 274,620 multifamily units.

One of the assumptions in this method of counting is that significantly weatherized houses are not as likely to be removed from the housing stock between now and 2010. It seems likely that houses that are considered valuable enough to invest in for weatherization are probably not the houses that will decay out of the housing stock first.

A number of the houses that will survive to 2010 have already been weatherized through either utility-sponsored weatherization programs or by their owner. Therefore, the remaining conservation potential consists only of those houses that have not been fully weatherized. A study conducted for the Pacific Northwest Utilities Conference Committee indicated that the public utilities have weatherized approximately 184,237 single-family houses and approximately 28,845 multifamily houses. The private utilities in the region have completed approximately 139,759 single-family and 38,555 multifamily weatherization jobs.

Not all of these houses use electricity as the primary fuel for space heating, but all of them had electric space heating installed. The number of houses that were weatherized through a utility program because they had electric space heating equipment installed but used primarily wood heat was estimated using the forecast. It was assumed that the same proportion of wood heaters were weatherized by utility programs as the proportion of primary wood heated houses with electricity as back-up represented in the forecast. This means that approximately 85 percent of single-family weatherizations accomplished by utilities were primary electric space heaters and the other 15 percent used primarily wood with electricity as backup. These wood heated houses were subtracted from the utility weatherizations for single-family houses. For multifamily houses the wood heating portion was estimated to be negligible.

In addition, there is some initial indication from the 1987 Oregon Weatherization Study that some homeowners have done some weatherization on their own. These data indicate that for every 100 single-family houses that went through a significant utility weatherization program, an additional 25 single-family households have done something on their own. If this assumption proved to be closer to zero households that weatherized on their own, there would be an additional 14 average megawatts in the supply curve. Zero would be a lower bound, and given information from the Oregon Weatherization Study, the current assumption seems prudent. In multifamily dwellings, the number that have done significant weatherization on their own is assumed to be zero.

The next question to resolve is whether every household that participated in a program, or weatherized significantly on its own, secured the majority of conservation measures. If they had done many of the major measures, but not all, it would be extremely difficult to find the houses to go back, and if they could be found, the measures might not be cost-effective due to additional administration and set-up costs. Information collected by Bonneville in the Data Gathering Project that pertains to the public service territory indicates that the public utilities achieve approximately 85 percent of the measures that are recommended in the audit and about 90 percent of the savings identified in the audit for single-family households. Furthermore, Bonneville staff has indicated that the audits generally approximate measures that are missing from a full cost-effectiveness package that would be something like R-38 ceiling insulation, R-11 or R-19 wall insulation, R-19 floor insulation, double glazing, caulking and weatherstripping. A house that achieved even 85 percent of this level of weatherization would likely not have any further potential. Consequently, this analysis assumes that single-family houses already weatherized under the public utilities' programs achieved approximately 90 percent of all cost-effective savings, and that the remaining 10 percent savings per house cannot be secured through future programs.

Less information is available from the private utilities on the levels of weatherization secured by their programs. Initial information from Puget indicates that it appears to have weatherization patterns similar to Bonneville's, which would indicate little, if no, further potential to secure. However, most of the other private utilities appear to have spent fewer dollars per weatherized house, and probably installed fewer measures. For Pacific Power and Light's territory in Oregon and Portland General Electric, the 1987 Oregon Survey supports preliminary indications that about one-third of the houses that went through the utilities' weatherization programs still have multiple major measures remaining to be secured. The Council is currently assuming that half of the houses weatherized under the private utilities' programs only went half of the way to the full cost-effectiveness level. This means that approximately half of the houses already counted in a private utility weatherization program still have half of the savings left to acquire. Since it is quite possible that some lost opportunities were created when the house was initially weatherized, the analysis assumes that these houses, which have already secured 50 percent of the cost-effective savings, can only secure 40 percent more, which ultimately would put them at a level that is being achieved by Bonneville's program.

Finally, there was very little information available on how much insulation was installed by single-family homeowners who weatherized on their own. It was assumed that these homeowners went half way on their own, and still have 40 percent of the cost-effective savings remaining to secure.

For multifamily units, it was assumed that if the unit were weatherized under any utility program there was nothing remaining to be secured.

For single-family houses, the above discussion results in a total of 297,097 primarily electrically heated houses being weatherized in a program and an additional 74,275 households taking some action on their own. This leaves a potential of 266,738[15] households that can still secure the full savings. In addition, the 74,275 houses that went part way on their own, combined with 69,880 houses weatherized only part way in the private utilities' territories, leaves 144,155 houses that still have an assumed 40 percent of the total savings remaining. For multifamily houses, the potential is 274,620 electrically heated units surviving until 2010 minus 67,400 units already weatherized through a program. The potential is therefore 207,220 multifamily units still to weatherize with the full potential.

The cost-effective efficiency levels derived for single-family (45 percent of base case use) and for multifamily (51 percent of base case use) houses are installed in the forecasting model, and the model modifies electricity intensity due to behavioral responses. These are responses to the effect of lower bills

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15./ This equals 638,110 electrically heated houses left in 2010 minus 371,372 with some weatherization equals 266,738 houses with full potential left.

now that the house is weatherized, and to changing electricity prices and incomes. Cost-effective the efficiency levels resulted in a consumption of electric space heating use from the forecast in 2010 of 7,192 kilowatt-hours per year for single-family and 2,495 kilowatt-hours per year for multifamily houses. Overall savings for the efficiency improvements are derived by subtracting 2010 consumption, including behavior as predicted in the forecast with the efficiency improvements installed, from consumption in 2010 with efficiency held frozen at the pre-conservation level. The values from the forecast for the pre-conservation, frozen-efficiency level are 11,224 kilowatt-hours per year and 4,669 kilowatt-hours per year, respectively. The total technical potential of average megawatt savings can then be calculated:

	266,738 (single-family households with full weatherization potential)
	x
122 MWa =	11,224 - 7,192 (kilowatt-hours per year)
	÷
	8,766,000 (kilowatt-hours per average megawatt)
+	
	144,155 (single-family households with partial weatherization potential)
	x
	11,224 - 7,192 (kilowatt-hours per year)
26 MWa =	x
	.4 (40 percent of total savings remaining)
	÷
	8,766,000 (kilowatt-hours per average megawatt)
+	
	207,220 (multifamily households)
	x
51 MWa =	4,669 - 2,495 (kilowatt-hours per year)
	÷
	8,766,000 (kilowatt-hours per average megawatt)
199 MWa =	Total technical potential savings

The supply curve shown in Table 3-15 reflects the distribution of savings that is expected, given the thermal integrity curve from the engineering model. The cheapest measures were assumed to be used to reduce consumption from the uninsulated house to the base case level used in the engineering models. However, the magnitude of the savings have been adjusted to reflect the consumer response modeled in the forecast.

Table 3-15
Technical Conservation From Existing Space Heating

LEVELIZED COST (cents/kWh)	CUMULATIVE TECHNICAL POTENTIAL (Average Megawatts)		
	SINGLE-FAMILY HOUSES	MULTIFAMILY HOUSES	TOTAL
0	0	0	0
1.0	0	0	0
2.0	90	40	130
3.0	130	50	180
4.0	145	50	195
5.0	150	50	200
5.5	150	50	200

Step 3. Compare Cost and Savings Estimates with Observed Costs and Savings

This section compares measured end use of electricity and other estimates of residential space heating consumption to that projected by the engineering model (SUNDAY) used by the Council. Three questions are addressed:

1. Does the space heating energy use projected by the engineering model agree with measured usage for homes with a wide range of energy efficiency?

2. Do the Council's estimates of single-family weatherization savings agree with savings estimates obtained from the evaluation of regional weatherization programs?

3. Would the use of alternative assumptions regarding long-term occupant behavior eliminate measures found to be cost-effective under the Council's current assumptions?

1. Engineering Use Estimates vs. Measured Use.

The annual space and water heating requirements of over 800 houses were measured in the Residential Standards Demonstration Program (RSDP). Houses that were built to the prevailing building practice between 1979 and 1983, as well as houses that met the Council's model conservation standards, were monitored. Houses that were built to the prevailing building codes and practices between 1979 and 1983 are referred to as "control" dwellings. These houses spanned a wide range of efficiencies and sizes. Some control houses in the RSDP, due to their size and overall insulation levels, had heat loss rates similar to the Council's estimate of a house that has not been through a weatherization program (approximate UA of 550). Other control houses in the RSDP, either due to their small size or insulation levels, were representative of fully weatherized residences and were as efficient as the Council's model conservation standards.

Staff from the Council's Montana office, using a data base prepared by Lawrence Berkeley Laboratories (LBL) for Bonneville developed the estimates shown in Table 3-16 of actual space heating demand for 422 houses in RSDP. Houses that were built at least as efficiently as the Council's residential model conservation standards (MCS) are referred to as "RSDP/MCS" dwellings. These houses all had at least 300 days of measured electricity used for space heating.

Table 3-16
Measured Space Heating Demand for RSDP Houses

HOUSE TYPE	NUMBER	ANNUAL USE (kWh/sq ft) ZONE 1	ZONE 2	ZONE 3	REGIONAL AVG.
Control	244	5.8	5.9	6.4	5.8
RSDP/MCS	178	3.3	3.7	2.9	3.3
Difference		2.5	2.2	3.5	2.5

In its evaluation of the cost effectiveness of the model conservation standards, Bonneville also developed an estimate of the measured space heating use observed in RSDP. These estimates, shown in Table 3-17, were based on a sample of 233 houses for which there were at least 330 days of measured electricity used for space heating.

Table 3-17
Measured Space Heating Demand for RSDP Houses

HOUSE TYPE	NUMBER	ANNUAL USE (kWh/sq ft) ZONE 1	ZONE 2	ZONE 3	REGIONAL AVG.
Control	126	5.8	6.1	7.0	5.9
RSDP/MCS	107	3.4	3.7	3.6	3.4
Difference		2.4	2.4	3.5	2.5

The Council staff's and Bonneville's estimates of measured use are in close agreement for Zones 1 and 2, although they vary significantly for Zone 3. This may be due to differences in the size of the sample and the number of days of measured data. However, both the Council's and Bonneville's estimates of the regionally weighted average are within 0.1 kilowatt-hours per square foot, per year, for both RSDP/MCS and control dwellings. Further, the Council staff's and Bonneville's estimates of the average difference in space heating use observed between the RSDP/MCS and control dwellings are identical and are equal to 2.5 kilowatt-hours per square foot, per year.

The SUNDAY thermal simulation was run using weather data from Seattle, Spokane and Missoula to represent the three climate zones found in the region. Three combinations of inputs to SUNDAY were tested. These input sets varied in their assumptions regarding thermostat set point and the amount of heat loss caused by infiltration. Two thermostat set points were tested, a 65°F constant set point, as had been assumed by the Council and by Bonneville in its cost-effectiveness analysis, and the set points reported by the occupants. Three levels of infiltration losses were tested. The first level was equivalent to that calculated from fan pressurization (blower door) test results using the LBL infiltration prediction model. These averaged 0.32 air changes per hour (ach) for the RSDP/MCS houses and 0.54 ach for the control houses. The second level of infiltration losses assumed was a constant 0.35 ach. This level was adopted by Bonneville in its cost-effectiveness analysis for both control and RSDP/MCS houses. The third infiltration level tested was derived from a weather adjustment made to the LBL model's predictions based on blower test results. This level assumed that control houses had 0.5 ach and that RSDP/MCS had 0.3 ach. The conductance heat loss rates (UA's) assumed for all three sets of infiltration inputs were calculated as they were by the Council in its 1986 plan.

Table 3-18 shows the space heating demand predicted by SUNDAY when thermostat set points are equivalent to those reported by the occupant.[16] These reported set points are 63.7°F for control houses and 67.3°F for RSDP/MCS houses. Infiltration losses underlying the calculations in Table 3-18 are estimated from blower door tests. Table 3-19 shows the space heating use predicted by SUNDAY when thermostat set points are 65°F and infiltration losses are 0.35 ach for both control and RSDP/MCS houses. Conductance losses, except for differential air change rates and internal gains assumptions, are the same in both cases.

Table 3-20 shows the space heating use predicted by SUNDAY when the thermostat set points are equivalent to those reported by the occupants and heat loss rates from infiltration are based on an average 0.5 ach for the control houses and 0.3 ach for the RSDP/MCS dwellings. These infiltration rates are slightly lower than those actually measured because the winter of 1985/86 was slightly warmer and less windy than the 30-year average, which is used in the LBL model. This adjustment was estimated by comparing the weather from 1985/86 to the 30-year average.

Table 3-18
SUNDAY Predicted Space Heating Use
With Occupant Reported Thermostat Setting, 3,000 Btu/hr
Internal Gains, and Blower Door Derived Infiltration Rate

HOUSE TYPE	ANNUAL USE (kWh/sq ft)			
	ZONE 1	ZONE 2	ZONE 3	REGIONAL AVG.
Control	5.8	7.8	6.7	6.1
RSDP	2.8	3.7	4.3	3.0
Difference	3.0	4.1	2.4	3.1

16./ Thermostat set points used are the average, wintertime temperature settings considering the occupants daytime and weekend activities. This temperature setting was chosen because the SUNDAY model uses the mean thermostat set point for all hours during the heating season to compute space heating use.

Table 3-19
SUNDAY Predicted Space Heating Use
With 65°F Thermostat set point, 3,000 Btu/hr Internal Gains
and Infiltration Losses Based on 0.35 ach

HOUSE TYPE	ANNUAL SPACE HEATING USE (kWh/sq ft) ZONE 1	ZONE 2	ZONE 3	REGIONAL AVG.
Control	5.4	7.8	6.6	5.8
RSDP/MCS	2.5	3.5	4.1	2.7
Difference	2.9	4.2	2.5	3.1

Table 3-20
SUNDAY Predicted Space Heating Use
With Occupant Reported Thermostat Set Points, 3,000 Btu/hr
Internal Gains and Infiltration Losses for Control of 0.5 ach
and for RSDP/MCS of 0.3 ach

HOUSE TYPE	ANNUAL SPACE HEATING USE (kWh/sq ft/yr) ZONE 1	ZONE 2	ZONE 3	REGIONAL AVG.
Control	5.6	6.4	7.6	5.8
RSDP/MCS	3.0	3.9	4.7	3.2
Difference	2.5	2.3	3.5	2.6

Note: Numbers may not add due to rounding.

A comparison of Table 3-18 and Table 3-19 shows that very similar SUNDAY results for annual space heating demand are obtained for the two different sets of inputs. The lower set points reported by homeowners are offset by the higher infiltration rate of .54 ach underlying the calculations in Table 3-18. On a regional average basis both sets of model inputs produce an identical estimate of the expected difference in annual space heating needs of the control and RSDP/MCS houses. The differences estimated for any of the three climate zones do not exceed 0.1 kilowatt-hours per square foot, per year. Also, both sets of input assumptions produce results that are in good agreement with the measured space heating use shown in Tables 3-16 and 3-17.

As shown in Table 3-20, once the infiltration rates have been adjusted to reflect the milder winter of 1985/86, the agreement between the SUNDAY predictions and the measured space heating use for both the control and RSDP/MCS houses improves. While there is some variance between measured and predicted within individual climate zones, the regional average predictions of SUNDAY are within 0.2 kilowatt-hours per square foot, per year, of the monitored space heating use for both the RSDP/MCS houses and control houses. This is remarkably good agreement given how little is known about the accuracy of the inputs.

SUNDAY space heating predictions for RSDP houses in Washington were found to agree very well with measured use when input assumptions were estimated for the actual efficiency of the building, weather conditions on the building site and known occupant behavior. Figure 3-5 shows the measured annual space heating consumption of 278 RSDP houses located in Washington state as a function of their estimated heat loss rate, or UA. Also shown in Figure 3-5 is the predicted space heating consumption from SUNDAY for these same houses. Over the range of heat loss rates exhibited by these houses there is very good agreement between the predicted space heating use and the monitored use.[17] For all houses, the average difference between the measured and simulated space heating use was approximately 8 percent.

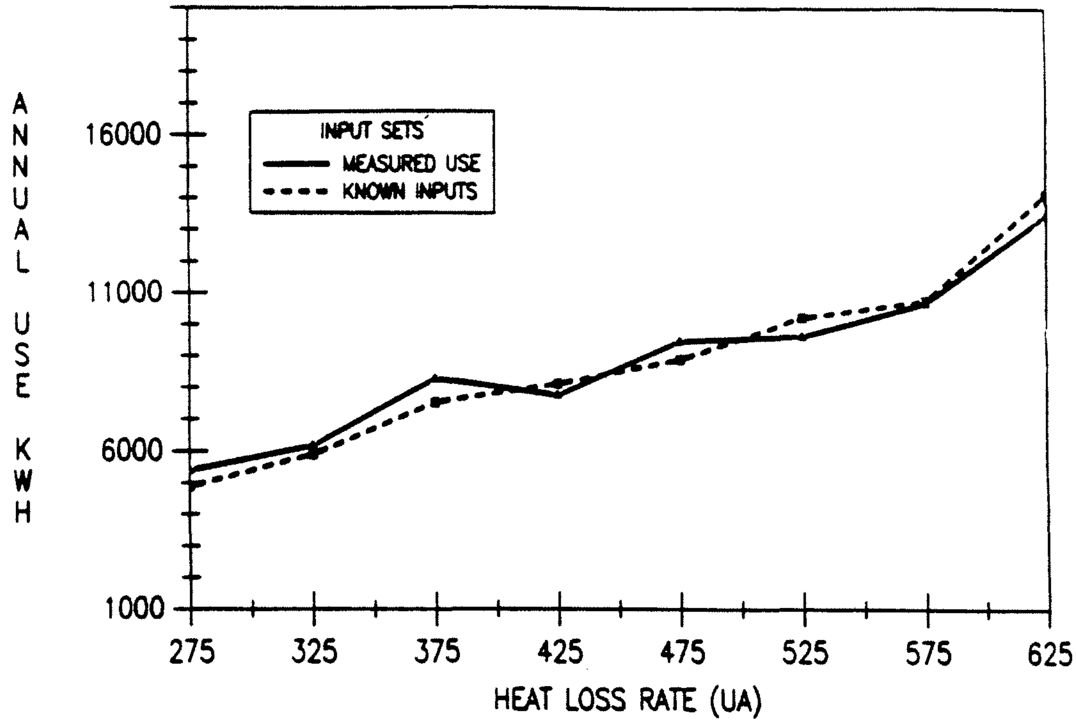

Figure 3-5
SUNDAY Predicted Versus Monitored Space Heating Use in Washington RSDP Houses

The SUNDAY simulation model has also been compared to measured space heating consumption in a small sample of houses (20 houses) in Hood River, before the houses were weatherized in the Hood River Conservation Project. This analysis found that room closure patterns and temperature setbacks had to be modeled in the inputs before SUNDAY, which represents a house as a single temperature zone, matched the monitored space heating use.

2. Weatherization Program Costs and Savings vs. Engineering Estimates.

The Bonneville residential weatherization program has operated in various forms since 1980. Oak Ridge National Laboratory (ORNL), under contract to Bonneville, has evaluated this program's costs and savings. ORNL assessed the effect of the installation of conservation measures on the amount of electricity used for space heating. ORNL used a statistical regression technique (called PRISM)[18] to estimate space

17./ The range of heat loss rates shown in Figure 3-5 encompasses the range being analyzed by the Council for both new and existing residential space heating conservation programs.

18./ PRISM is the Princeton Scorekeeping Model.

heating use from known total electric consumption. For each participating house, annual electricity use, normalized to long-term weather conditions, was compared to its pre-weatherization use. Table 3-21 shows the average estimated use for space heating for pre- and post-retrofit conditions for the four different phases of the Bonneville residential weatherization program. This table also shows the average weatherization package cost of each program phase converted to 1988 dollars.

Table 3-21
Estimated Pre- and Post-Program Participation Energy Use and Retrofit Cost In Bonneville Residential Weatherization Programs

PROGRAM PHASE/ YEAR PARTICIPATING	PRE-PROGRAM USE (kWh/sq ft)	POST-PROGRAM USE (kWh/sq ft)	SAVINGS	COST ($/sq ft)
Pilot/1981	12.1	7.7	4.4	$1.90
Interim/1982	8.9	6.6	2.3	$1.21
Interim/1983	8.0	5.9	2.1	$1.29
Long-Term/1985[a]	8.2	6.5	1.7	$1.58

[a] Floor areas used to calculate the average use and cost per square foot assume that homes weatherized in the long-term program are the same size as those weatherized in the interim program in 1983.

The first step in determining how well the Council's engineering estimates for residential weatherization savings agree with those estimated for Bonneville's program is to compare the estimates of post-retrofit space heating use. Figure 3-6 shows the post-program space heating use estimated by PRISM in Bonneville's evaluations compared to five engineering projections based on five different sets of input assumptions to the SUNDAY thermal simulation model. The five sets of input to SUNDAY are:

Set 1 — 65° F W/2,000 Btu/hr internal gains: The Council's current assumptions for long-term household behavior. Thermostat setting at 65°F for 24 hrs/day. Efficient appliances generating 2,000 Btu/hr internal gains.

Set 2 — 65° F W/3,000 Btu/hr internal gains: Same as Set 1, except current appliance efficiencies are assumed to generate 3,000 Btu/hr of internal gains.

Set 3 — 68° F W/2,000 Btu/hr internal gains: Same as Set 1, except occupants are assumed to set their thermostats at 68°F for 24 hrs/day.

Set 4 — 62° F W/3,000 Btu/hr internal gains: Occupants are assumed to set their thermostats at 62°F for 24 hrs/day and use appliances with current efficiencies generating 3,000 Btu/hr of internal gains. The thermostat set point of 62°F assumes that either approximately 25 percent of the time or 25 percent of the heated area of the home has a thermostat setting of 55°F and the remainder to the time or heated area of the home has a thermostat setting of 65°F.

Set 5 — 65° F W/WOOD: Same as Set 4, except that occupants are assumed to use approximately two cords of wood per year as supplemental heating. A wood stove/fireplace insert conversion efficiency of 50 percent has been assumed resulting in approximately 15 million

Btu (4,400 kilowatt-hours per hour) of useful heat.[19] Wood use is assumed to be proportional to monthly space heating needs; i.e., the months that have the greatest heating demands are the months of greatest wood use.

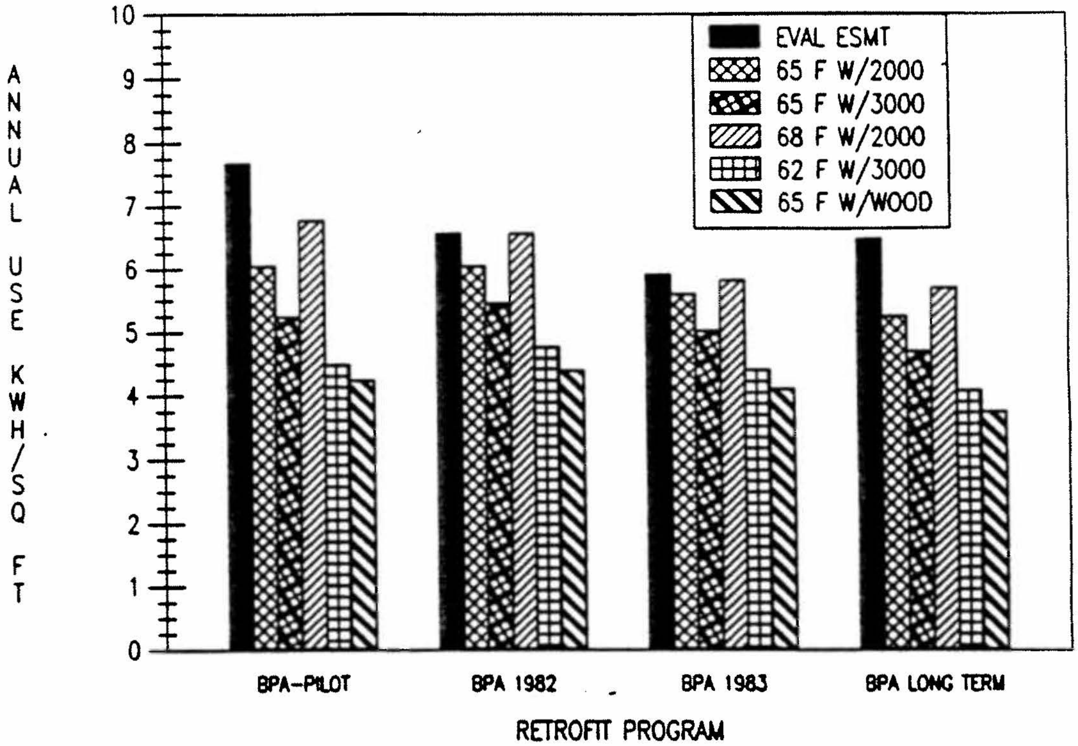

Figure 3-6
Post-weatherization Space Heating Use

The engineering prediction of post-retrofit program use shown in Figure 3-6 is based on pre-program use being equal to the pre-program use estimated in the program evaluation. The engineering estimate of post-program use was determined by assuming that the retrofit costs reported in the evaluations were used to purchase the same measures, in the same order and at the same cost as those identified in the Council's space heating supply curve for existing single-family houses.

As shown in Figure 3-6, the post-retrofit space heating use estimated by PRISM for the Bonneville weatherization program evaluations are higher than the engineering model estimates based on all five input assumption sets. The SUNDAY estimates that most closely match the PRISM estimates of post-retrofit use are based on Sets 1 and 3, with Set 3 the closest. Set 3 uses a three degree higher thermostat setting both pre- and post-retrofit than is presently assumed by the Council. The other three input sets, which assume either lower amenity levels (i.e., lower thermostat settings) or supplemental wood use underpredict post-retrofit use.

Figure 3-7 compares the estimated space heating savings that were obtained from PRISM for the Bonneville weatherization program to SUNDAY estimates of savings based on the five input assumption sets. In all cases, estimates of savings from SUNDAY are higher than those obtained from the PRISM estimates. As was the case with post-retrofit use, the two input sets that produce savings estimates that most closely agree with the PRISM estimates are Sets 1 and 3, with Set 3 once again being in best

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19./ A Bonneville study of residential wood use in the region found that the occupants of single-family electrically heated homes reported approximately two cords of wood use per year on average.

agreement. For all other input sets, which assume either lower amenity levels or supplemental wood, the SUNDAY estimates of savings are higher than the PRISM estimates.

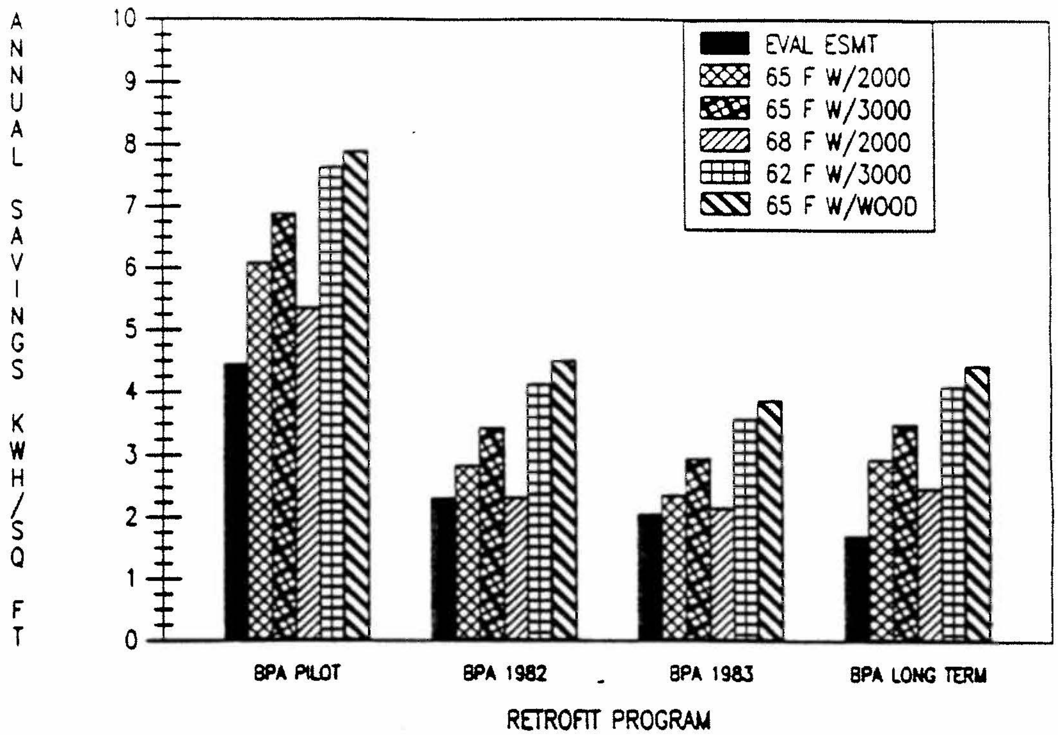

Figure 3-7
Weatherization Savings from Various Estimates

3. <u>Would Revised Occupant Behavior Assumptions Eliminate Measures?</u>

If the PRISM estimates are accurate, and occupant behavior is projected to remain the same over the long term, then the Council should probably revise its assumptions on thermostat setting. However, prior to adopting a revised thermostat set point, several factors must be taken into consideration. First, it has been shown that PRISM systematically overestimates space heating energy use. This is due to the fact that a portion of the increased electricity use caused by colder winter weather results from greater lighting, water heating and cooking use. As the PRISM estimate of electricity used for heating is really an estimate of weather sensitive loads, it is possible and likely that PRISM is including at least a part of this electricity in its heating estimate. Consequently, it is very likely that both pre-retrofit and the post-retrofit use shown in Figure 3-6 based on PRISM are too high. If both pre- and post-retrofit use are overestimated by equivalent amounts, this would not affect savings estimates. Unfortunately, there is conflicting evidence on whether PRISM's overestimates of space heating use for well insulated buildings differs from its overestimates of space heating for buildings that are poorly insulated.[20]

Second, as stated previously, the SUNDAY estimate of both post-retrofit use and program savings are based on the presumption that participants installed the same measures, in the same order and at the same costs as those included in the Council's conservation supply curve for space heating in existing

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20./ It presently appears that PRISM overstates the space heating use of well-insulated buildings more than it does poorly insulated structures. (See Lee, A.D. <u>et al.</u>, <u>Cost-effectiveness of Conservation Upgrades in Manufactured Homes</u>, PNL-6519. September 1988.)

single-family homes. If measures were selected out of their least-cost order, then the PRISM estimates of savings would be less for the same expenditure. Indeed, Bonneville staff have observed that program participants have not always chosen the lowest cost conservation measures to improve efficiency. For aesthetic reasons, for example, many participants make expensive window replacements when a storm window would achieve the same level of efficiency. As a result, because these program participants have deviated from the idealized supply curve, both in terms of the measures selected and the costs of the measures, their post-retrofit use is higher than was predicted, their savings are lower than predicted, and the savings appear to have higher levelized costs.[21] Consequently, the fact that SUNDAY estimates do not align perfectly with PRISM estimates of savings and post-retrofit use is not sufficient justification to indict either estimation technique.

A third issue is the effect of conservation on a consumer's electric bill, which will be lower following weatherization. This may lead to changes in behavior. For example, Figure 3-8 shows the measured space heating energy use in Washington RSDP houses compared to SUNDAY model projections based on four sets of alternative operating conditions described above and model inputs derived from occupant surveys and building audits. Each of the curves shows the predicted annual space heating use for houses as a function of heat loss rates. The two top curves assume efficient appliances and thermostat settings of either 68°F or 65°F. The bottom two curves show the predicted space heating for houses with inefficient appliances and thermostat settings of either 62°F or 65°F. These sets of assumptions bracket the measured use observed in the RSDP houses, shown by the solid line.

An interesting finding is that estimates of space heating use assuming efficient appliances and thermostat settings of either 65°F or 68°F are in better agreement with the measured use in well insulated houses (low UAs); whereas, estimates assuming lower thermostat settings and/or inefficient appliances, more closely match the measured use of high heat loss buildings.

These results appear to indicate that in more energy-efficient houses, occupants operate their houses more like the Council's assumed standard operating conditions, while in less well-insulated houses they operate the home at reduced amenity levels (i.e., lower thermostat settings). Indeed, it is known that both the average measured temperature and occupant reported thermostat settings in the RSDP/MCS houses were higher than those of the control houses. This is consistent with economic theory and suggests that after weatherization, consumers could be expected to raise their thermostat settings, and thus reduce the savings. Moreover, economic theory would also predict that even without weatherization, thermostat settings will tend to rise over time as electricity prices stabilize and individual incomes rise.

21./ Bonneville has revised its Long-Term Weatherization Program financial assistance levels to encourage consumers to select measures that are more closely aligned with the idealized supply curve.

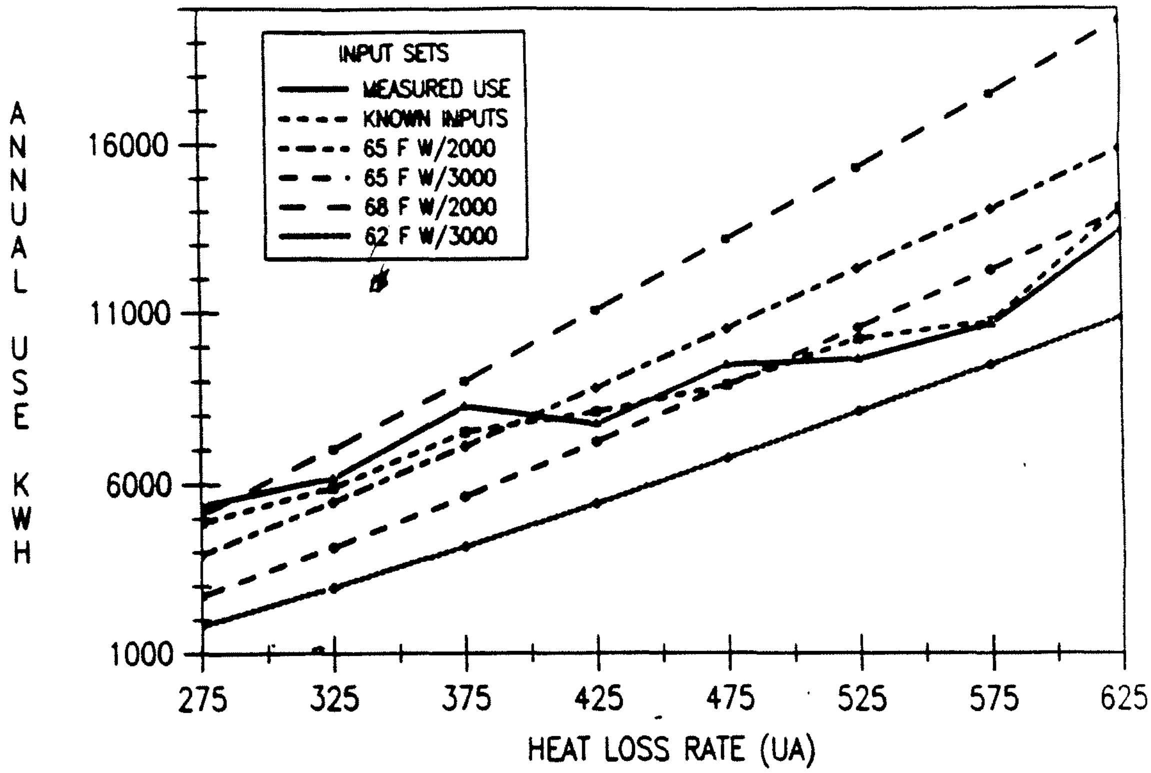

Figure 3-8
SUNDAY Predicted and Actual Use in Washington RSDP Houses Superimposed on Various Alternative Operating Conditions

The standard operating conditions used in SUNDAY determine the set of measures that are cost-effective for the region. When the Council determines which measures are regionally cost-effective, it assumes a constant amenity level over the long term. Given the reduction in savings that appears to occur as a result of changes in occupant behavior between well insulated and less well insulated houses, it is prudent to assess possible changes in the cost-effectiveness of the Council's proposed measures under alternative behavioral assumptions.

In developing its supply curves, the Council applies measures in order of their cost-effectiveness. Many of the measures are very low cost and will remain cost-effective within any conceivable range of behavior. Only those measures that are at or near the cost-effectiveness limit established for conservation resources in the plan could potentially become non-cost-effective with a change in assumed occupant behavior. The first measure to test is the measure closest to the cost-effectiveness limit. If it is still cost-effective, all other measures will be also. If it is not, the next measure should be tested and so forth.

The marginal measure (the most expensive) in the Council's supply curve for space heating in existing single-family residences is the addition of R-8 insulation to ceilings already insulated to R-30 in Zone 1, the warmest weather zone in the region. Table 3-22 shows the effect of five alternative sets of assumptions regarding long-term occupant behavior, including the Council's standard operating condition on this measure's projected savings and levelized cost.

Table 3-22
Effect of Alternative Operating Conditions in the SUNDAY Model
On Post-Weatherization Use, Savings and Levelized Cost

MODEL INPUT SET	USE AT COST-EFFECTIVENESS LIMIT (kWh/yr)	MARGINAL MEASURE SAVINGS (kWh/yr)	LEVELIZED COST (mills)
65° F w/2,000 gains	6,235	177	40
65° F w/3,000 gains	4,818	165	43
68° F w/2,000 gains	7,940	216	33
62° F w/2,000 gains	4,755	142	50
62° F w/3,000 gains	3,503	133	54

Table 3-22 shows that even over a wide range of operating conditions, when constant amenity levels are assumed in the pre- and post-weatherization condition, the marginal measure remains below the regional cost-effectiveness limit of 55 mills per kilowatt-hour for space heating savings in existing houses. The effect of different operating assumptions on levelized cost is much less than on projected post-retrofit use. The highest projected post-retrofit use is 2.25 times higher than the low projection, while the highest projected savings from the marginal measure is only 1.6 times higher than the low. This is because heating needs in better-insulated houses are less sensitive to changes in occupant behavior. Figure 3-9 shows that as the level of total conservation investment in a house increases the difference in space heating energy use based on alternative input assumptions becomes smaller. More importantly, the slope of the curves in Figure 3-9 become nearly identical as expenditures approach approximately $3.00 per square foot, which is about the cost of the most expensive conservation measure in the plan. These sensitivities show that the relative efficiency improvement that is cost-effective in existing residential buildings is quite robust, and does not depend heavily on the particular amenity levels selected for the engineering model, as long as they are the same pre- and post-weatherization.

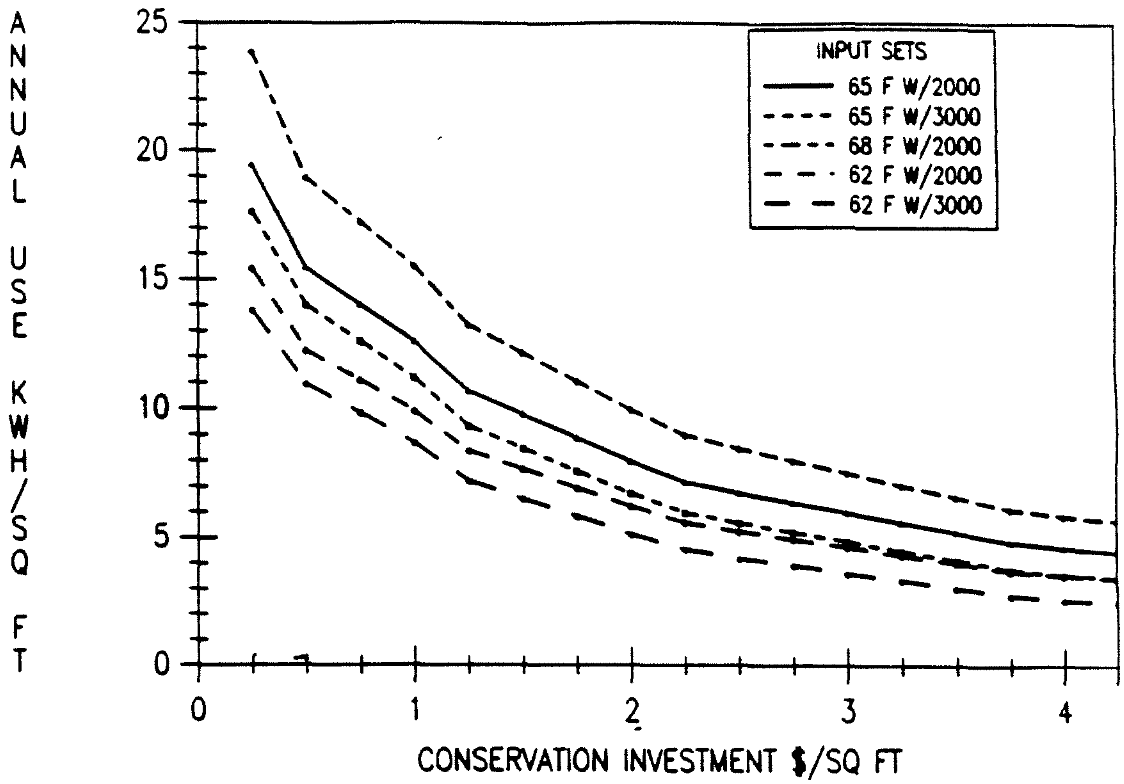

Figure 3-9
Predicted Use Under Alternative Operating Conditions as a Function of Conservation Investment

However, as described elsewhere in this chapter, the Council's forecasting model does forecast some amenity increase following weatherization. In this context, the pre-weatherization use as predicted by the forecast is lower than standard operating conditions would imply, and the use after weatherization is higher. As a result the average levelized costs of realized savings from weatherization are higher than would be the case with constant amenity levels. Efficiency changes, however, are not affected by changes in occupant behavior.

Step 4. Estimate Realizable Conservation Potential

The final step in the Council's assessment of retrofit potential was to develop an estimate of the share of the 200 average megawatt potential that could realistically be achieved over the next 20 years if there were a need to develop energy resources. Given the tools to secure conservation under the Northwest Power Act, the Council estimated that 85 percent of the technical potential is achievable. For example, the Hood River Project, which paid fully for all weatherization measures offered to every electrically heated house in the community of Hood River, Oregon, combined with prior weatherization programs operated in the community, secured weatherization saturations of this magnitude. The 15-percent reduction accounts for less than complete market penetration, and unanticipated building barriers beyond those already credited in the estimate. The energy savings available in the Council's plan under its high growth forecast are 170 average megawatts.

Space Heating Conservation in New Residential Buildings

Figures 3-10, 3-11 and 3-12 show the technical space heating savings available from new single-family and multifamily residences and from new manufactured houses at various costs. New single-family homes represented approximately 730 average megawatts of technical potential if savings are counted from a base that represents building practice in 1983. However, changes to Oregon and Washington building codes will secure about 375 average megawatts of this technical potential if they are completely enforced. This leaves 355 average megawatts of technical potential yet to be secured through further code improvements and programs. Multifamily dwellings represented approximately 95 average megawatts of technical potential beyond 1983 codes. Approximately 55 average megawatts of this technical potential has been secured through the code improvements that occurred between 1983 and 1986. Manufactured houses represent about 210 average megawatts of technical potential. The Council's plan calls for developing 300, 35 and 105 average megawatts of the technical potential beyond current building codes as achievable for single-family, multifamily and manufactured homes, respectively. The average cost of improving the thermal efficiency of new buildings beyond current codes is about 2.8 cents per kilowatt-hour. This increases to about 3.1 cents per kilowatt-hour if administrative costs and transmission and distribution adjustments are included. Figure 3-13 illustrates the savings secured through code improvements adopted in 1986. The difference in the heights of the bars represents the savings that will be secured through the improved codes if they are enforced. The remaining potential beyond 1986 codes is what requires further action.

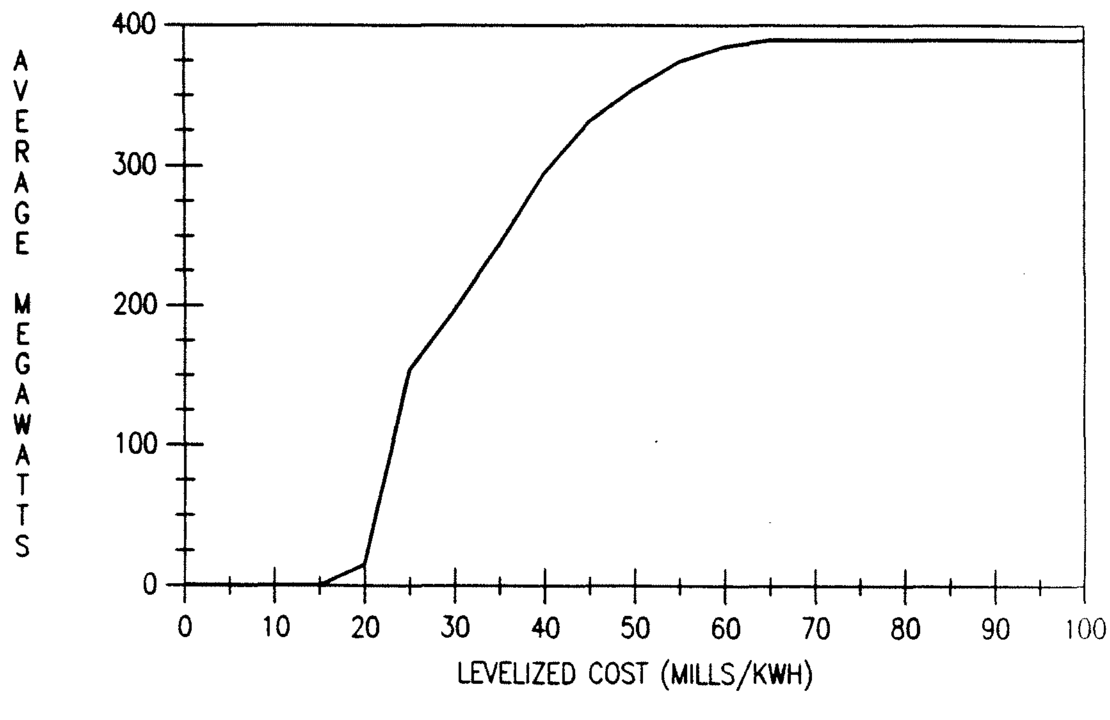

Figure 3-10
Technical Conservation from Space Heating Measures
Beyond 1986 Codes/Practice in New Single-family Residences

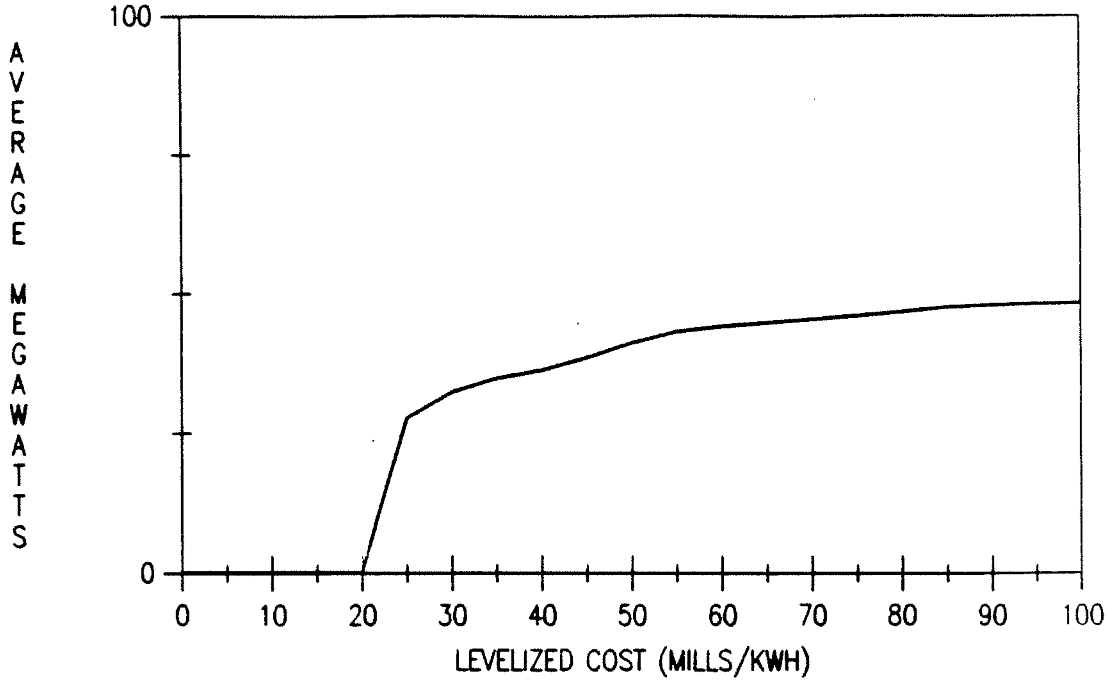

Figure 3-11
Technical Conservation from Space Heating Measures
Beyond 1986 Codes/Practice in New Multifamily Residences

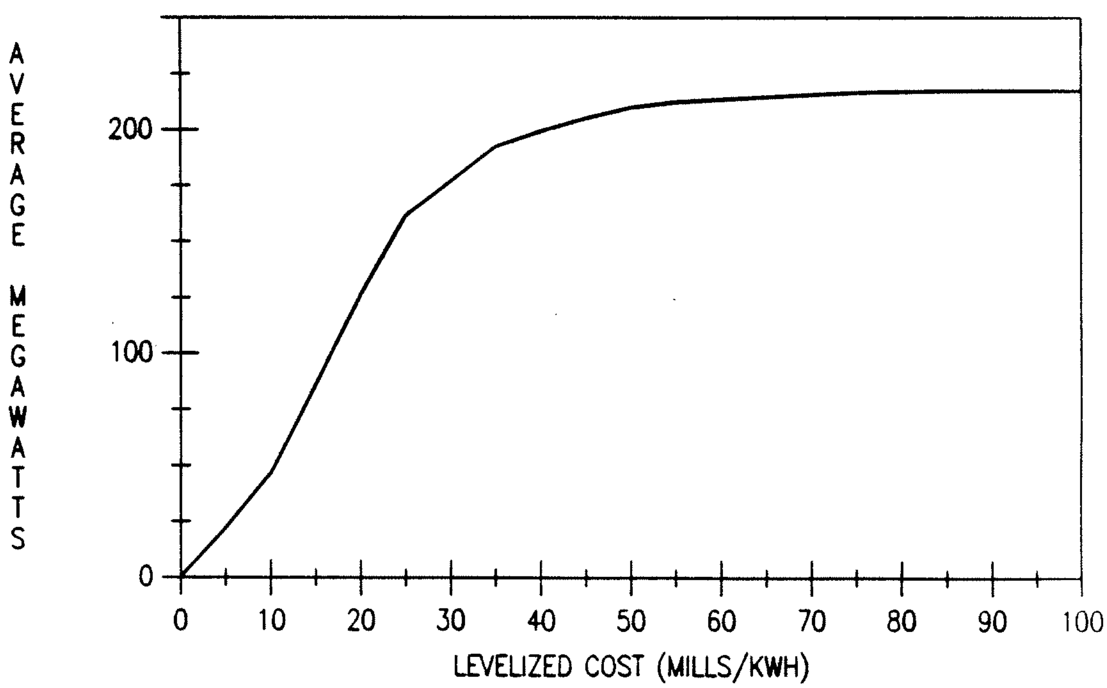

Figure 3-12
Technical Conservation from Space Heating Measures
Beyond 1986 Codes/Practice in New Manufactured Houses

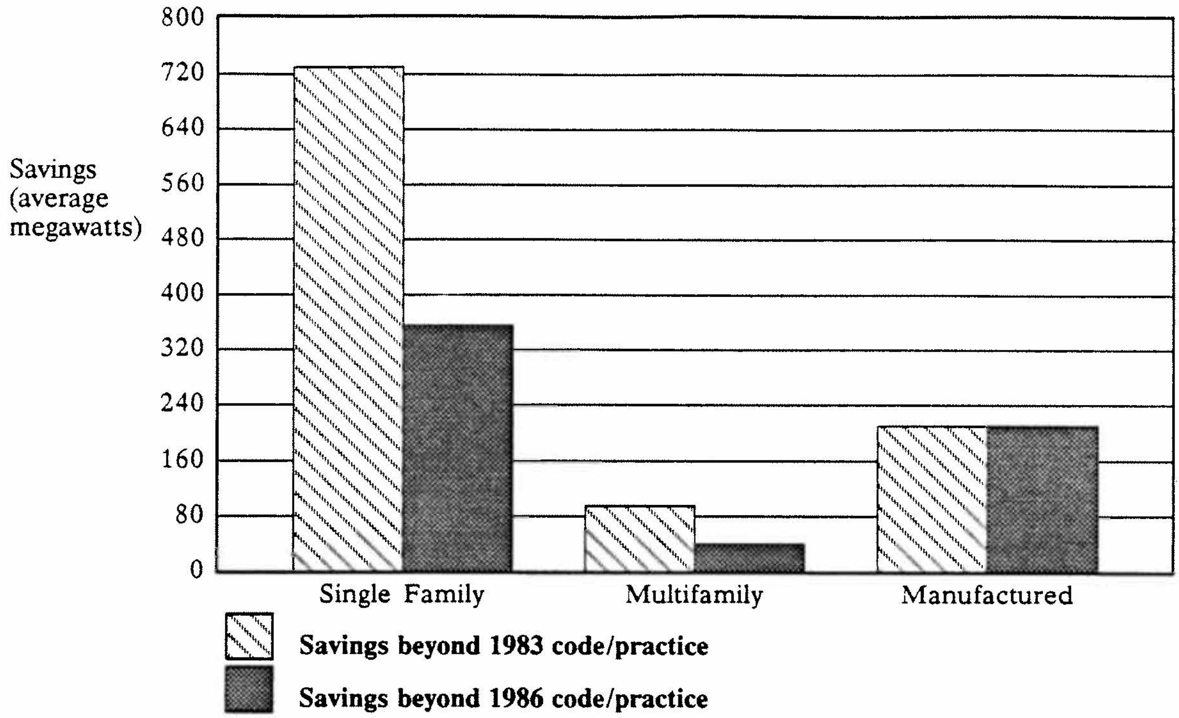

Figure 3-13
Comparison of Conservation Savings from 1983 Practice,
Before Adoption of 1986 Oregon and Washington Building Codes and After Adoption

Making new houses more efficient is a high priority for securing a least-cost energy future for the region. It is important to insulate houses fully at the time they are built, or cost-effective savings can be lost. In addition, while the number of houses eligible for retrofitting will diminish over time, the number of houses that conservation can reach continues to grow as every new house is built.

The conservation potential available through improvements in the energy efficiency of new residential buildings was developed in five steps. These steps were to:

1. Establish the characteristics of current new residential construction.

2. Develop construction cost estimates for space heating conservation measures in new dwellings.

3. Assess the cost-effectiveness of space heating energy savings produced by efficiency improvements in new residential buildings.

4. Estimate the technical potential available from space heating energy conservation in new dwellings.

5. Estimate the achievable conservation potential available from space heating energy conservation in new dwellings.

Separate estimates were prepared for single-family dwellings (up to four units and less than four stories), multifamily dwellings (five-plex and larger) and manufactured housing (e.g., mobile homes). A description of each of these steps, the data and major assumptions used and their sources follows.

Step 1. Establish the Characteristics of New Residential Construction

To determine the potential for improving the energy efficiency of new residential structures it was first necessary to establish their current level of efficiency. In addition to identifying the level of insulation and type of windows commonly installed in new housing, other new home characteristics had to be ascertained, such as average floor area heated, number of stories, window area, "tightness" of the dwelling and foundation type. These characteristics significantly affect the amount of energy needed for space heating.

Tables 3-23 and 3-24 show by climate zone and building type the "base case" insulation levels assumed by the Council in its assessment of space heating conservation potential in new dwellings. The information on new single-family and multifamily housing characteristics shown in Table 3-23 is derived from three sources. The first was a regional residential energy survey conducted for Bonneville in 1983 (Pacific Northwest Residential Energy Survey 1983, "PNRES '83"). This survey was used to estimate the average size of new dwellings. The second data source was the 1977 through 1983 annual survey of new home characteristics prepared by Housing Industry Dynamics (HID) for Bonneville. The HID survey data were used to determine the typical glass area and foundation types, and the most prevalent level of insulation found in new dwellings.

For those areas in the region that enforce an energy code, the requirements of such codes served to establish the minimum thermal-efficiency levels found in typical new single-family and multifamily dwellings. Table 3-24 shows the efficiency levels required by the revised Oregon and Washington state codes. This table also shows the expected annual space heating use for new residences built to the new codes.

Information on the air tightness of new dwellings was obtained from the Residential Standards Demonstration Program (RSDP) sponsored by Bonneville. Data obtained in RSDP appeared to indicate that a house built between 1980 and 1983 experienced between 0.35 and 0.55 air changes per hour, depending on the test method used. Bonneville and the Council have agreed to use the lower value until additional research on this question can be completed.

The base case characteristics for new manufactured housing, shown in Table 3-23, were derived from information obtained from a Bonneville-sponsored study of current construction practices in the Northwest's manufacturing housing industry. The insulation levels assumed were also obtained from the same Bonneville study. These levels slightly exceed the requirements of the U.S. Department of Housing and Urban Development's rules concerning the eligibility of manufactured homes for mortgage insurance under Title II of the National Housing Act.

Table 3-23
New Residential Construction Base Case Efficiency Levels and Annual Space Heating Use Assumptions

BUILDING TYPE	CLIMATE ZONE 1 INSULATION LEVEL	CLIMATE ZONE 1 ANNUAL USE (kWh/sq ft)	CLIMATE ZONE 2 INSULATION LEVEL	CLIMATE ZONE 2 ANNUAL USE (kWh/sq ft)	CLIMATE ZONE 3 INSULATION LEVEL	CLIMATE ZONE 3 ANNUAL USE (kWh/sq ft)	WEIGHTED AVERAGE USE (kWh/sq ft)
Single-family		6.8		9.7		8.2	7.3
Roof (Attic)	R-30		R-30		R-38		
Vaulted Ceiling	R-19/30		R-19/30		R-30		
Walls	R-11		R-11		R-19		
Under Floor	R-11/19		R-19		R-19		
Windows	Double glazed (U-.90)		Double glazed (U-.90)		Double glazed (U-.65)		
Air Tightness	0.35 ACH		0.35 ACH		0.35 ACH		
Multifamily		3.6		6.0		7.1	4.1
Ceiling/Roof	R-30		R-30		R-30		
Walls	R-11		R-11		R-11		
Under Floor	R-11/19		R-19		R-19		
Windows	Double glazed (U-.90)		Double glazed (U-.90)		Double glazed (U-.65)		
Air Tightness	0.35 ACH		0.35 ACH		0.35 ACH		
Manufactured Homes		6.5		10.0		11.8	8.1
Ceiling/Roof	R-11		R-11		R-11		
Walls	R-11		R-11		R-11		
Under Floor	R-11		R-11		R-11		
Windows	Double glazed (U-.90)		Double glazed (U-.90)		Double glazed (U-.90)		
Air Tightness	0.35 ACH		0.35 ACH		0.35 ACH		

Table 3-24
New Residential Construction 1986 Energy Code Requirements and Annual Space Heating Use

	INSULATION LEVEL ZONE 1		ANNUAL USE (kWh/sq ft)		INSULATION LEVEL ZONE 2		ANNUAL USE (kWh/sq ft)	
	OR	WA	OR	WA	OR	WA	OR	WA
Single-family			5.5	4.6			8.6	6.3
Roof	38	38			38	38		
Vaulted	19	30			19	30		
Walls	19	19			19	19		
Under Floors	19	19			19	25		
Windows	R-1.2[a]	R-1.6			R-1.2[a]	R-1.6		
Multifamily			3.0	2.3			5.2	4.0
Roof	38	38			38	38		
Walls	19	19			19	19		
Under Floors	19	19			19	25		
Windows	R-1.2[a]	R-1.6			R-1.2	R-1.6		

[a] Houses receiving building permits after December 31, 1988, must use windows with a tested U-value of 0.65 (R-1.5) or lower. This will reduce the annual space heating use of single-family houses built in Zone 1 to 4.7 kilowatt-hours per square foot and in Zone 2 to 7.5 kilowatt-hours per square foot. Similarly, multifamily use would drop to 2.4 kilowatt-hours per square foot in Zone 1 and 4.2 kilowatt-hours per square foot in Zone 2.

Once the general characteristics of new dwellings had been identified, "typical" building designs were developed for detailed analysis of space heating conservation potential. Three typical single-family detached dwelling designs were developed to represent the mixture of house sizes and foundation types being constructed in the region. A single multifamily building design was chosen to represent new multifamily construction larger than four-plexes. Two manufactured home designs were selected to represent those typically being sold in the region. Table 3-25 summarizes the basic characteristics of the new dwellings used in the Council's assessment. These designs were selected as representative based on features primarily related to their space heating requirements, such as foundation type, secondarily on their architectural styles.

Table 3-25
Typical New Dwelling Characteristics

CHARACTERISTIC	SINGLE-FAMILY DETACHED			MULTIFAMILY	MANUFACTURED HOME	
Prototype Label	A	B	C	12-Units @	A	B
Size-Gross Floor Area (sq ft)	1,344	1,848	2,352	840 sq ft/unit	924	1,344
Foundation Type	Crawl space	Crawl space	Basement	Crawl space	Skirted	Crawl space
Number of Stories	1	2-Split Level	1 w/full basement	3 - 4/w garage	1	1
Window Area (sq ft)	175	240	258	1,140	144	144
Glass Area as a % of Floor Area	13%	13%	11% (of unit's floor area)	11.9%	15.6	10.8
Gross Wall Area						
Above Grade	1,376	2,048	1,596	6,422	1,200	1,200
Below Grade	—	—	736	—	—	—
Total Exterior Envelope Area (sq ft)	4,064	4,624	5,244	14,070	3,048	3,888

Step 2. Develop Construction Cost Estimates for Space Heating Conservation Measures In New Dwellings

In the development of the 1983 plan, the Council conducted an extensive survey of conservation costs in new residential buildings. Pursuant to the Council's plan, Bonneville, in cooperation with the four Northwest states, initiated a regionwide demonstration program on energy-efficient new home construction called the Residential Standards Demonstration Program (RSDP). The Council analyzed the cost reports submitted by builders in this program. Except for one measure, infiltration control with mechanical ventilation, the median costs reported by participating builders agreed with those used by the Council in the 1983 plan. The Council used RSDP median cost updated to 1988 dollars in its cost-effectiveness analysis, and for the conservation analysis presented here.

Not all space heating conservation measures have similar useful lives. Insulation and infiltration control measures (i.e., air/vapor barriers) installed in new single-family and multifamily dwellings are anticipated to last at least 70 years (i.e., about the life of the structure). These same measures installed in new manufactured houses are also expected to last the life of the building (i.e., 45 years). However, the Council has assumed that two measures, insulated doors and energy-efficient windows, must be repaired or replaced before the end of the life of the structure. The Council included the cost of repairing and/or replacing these two space heating conservation measures when calculating their levelized cost. All the windows and insulated doors in new residential structures were assumed to be replaced at 30-year intervals at a cost equivalent to their initial capital cost, plus 0.4 percent per year real cost escalation.

The costs of improvements in the space heating efficiency of new manufactured housing were taken from a study prepared for the Manufactured Housing Institute (MHI) and submitted to the Council by MHI. The costs reported in that study and the Bonneville energy efficient new home demonstration program (RSDP) were adjusted to 1988 dollars from 1984 dollars using the Gross National Product deflator from mid-1984 to January 1988. Tables 3-26 through 3-34 show the retail costs assumed by the Council for potential cost effective space heating conservation measures for new single- and multifamily dwellings and manufactured housing.

Step 3. Estimate the Cost-effectiveness of Space Heating Energy Savings Produced by Efficiency Improvements in New Residential Buildings

Once typical new dwelling designs were selected, the Council used a computer simulation model to estimate potential space heating energy savings that could be produced by each conservation measure. This model, SUNDAY, is also used to estimate savings from weatherization measures (see discussion above). As discussed in Step 3 in the section on residential weatherization above, this model accurately predicts sub-metered space heating consumption in houses with a wide range of insulation levels.

The absolute value (in kilowatt-hours per year) of the space heating energy savings produced by adding an individual conservation measure is a function of the existing thermal efficiency level of the building. The less efficient the existing building, the larger the savings that will be obtained from installing the same measure.

To assess the savings that could be produced by installing each space heating conservation measure, it is necessary to take into account all of the measures' interaction. This was done by determining each measure's benefit (i.e., change in heat loss rate) and cost (i.e., present-value dollars per square foot). The savings produced by each potentially cost-effective measure were then analyzed under the assumption that all measures with higher benefit-to-cost ratios had already been installed in the house.

Figure 3-14 illustrates how the heating requirements of an average current practice house and a model conservation standards house might be met. Heating requirements are met by solar heat, internal gains (the amount of heat released indoors by people and appliances), and the furnace, which can be supplemented by heat from wood burning stoves or other sources. The current practice house reflects average conditions for a house that is primarily heated with electricity. If the house were primarily heated with wood, the contribution from wood would be much larger, but electrical savings would still be significant as long as electricity were the marginal fuel.

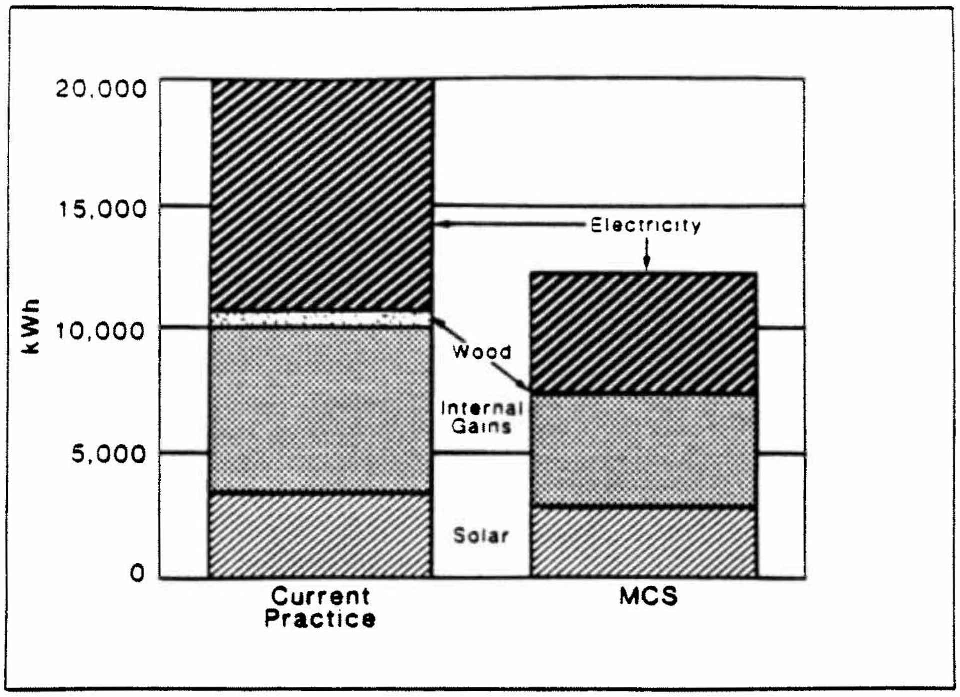

Figure 3-14
Sources of Residential Heating

When determining the electrical savings of measures applied to a current practice house, at least the following three policy considerations must be evaluated: the treatment of wood heating, internal temperature settings for the whole house, and internal gains.[22] The Council assumed no wood heating when evaluating measure savings in new residential buildings. The Council used a constant thermostat setting of 65°F for the whole house to represent a combination of higher temperatures when the house was occupied and the occupants active, and a lower nighttime setback. Finally, the Council assumed a cadre of efficient appliances, reflecting appliances that would be in place for the majority of the life of the house, and are present in the region throughout most of the Council's plan. Appliances currently in place in houses are less efficient than new appliances, but contribute more usable heat to the house, and thus cut space heating loads. This is reflected in Figure 3-14, where internal gains are larger in the current practice house.

The Council re-assessed the planning assumptions described above and feels that these assumptions should be maintained based on the following reasons. First, there is no assurance that occupants of houses built to the standards will continue to use wood heat. Changing wood prices, income levels, wood availability and environmental regulations all could reduce the use of wood heating, leaving the electrical system vulnerable to mass "fuel switching" to electricity, an action that would be difficult if not impossible

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22./ These items are discussed here in terms of the calculated savings per measure. Under Step 5, these items are discussed in terms of differences between the demand forecast estimates of space heating loads and estimates from the engineering model.

to plan resources for. Second, the Northwest Power Act defines conservation as an efficiency improvement, not a change in lifestyle. Current behavior of consumers to close off rooms or lower thermostats may represent curtailment rather than conservation as defined in the Act. Such behavior is not expected to continue after cost-effective efficiency improvements are made. Third, more efficient appliances are clearly cost-effective resources and will be the norm, especially in new houses, in the next decade. Appliance manufacturers have testified that, even without appliance standards such as those adopted in 1987 by Congress, new appliances will be much more efficient. Therefore, the Council's estimates reflect less heat escaping from these appliances to heat the house. Finally, the adoption of planning assumptions different than these would subject the region to greater planning uncertainties than the present set of assumptions. If the energy-efficiency requirements of the standards are made less stringent because it is assumed consumers will continue to close off rooms and heat with wood, the degree of uncertainty the region must plan for increases.

Tables 3-26 through 3-34 show the levelized cost, annual energy use and energy savings produced by the addition of each measure for each dwelling type, building design and for representative climate types found in the region (Zone 1-Portland and Seattle, Zone 2-Spokane and Zone 3-Missoula). The levelized costs shown for single-family and multifamily buildings is based on a 70-year physical life and a financing cost of approximately 4 percent real.[23] Levelization was done using a 3-percent real discount rate. The levelized cost shown for manufactured housing is based on a 45-year economic life and levelization at a 3-percent real discount rate. For planning purposes, it has been assumed that the efficiency improvements in single-family and multifamily houses and manufactured housing will be obtained via a combination of codes, marketing and incentive programs financed through Bonneville, public utilities and the region's investor-owned utilities.

The Council has established model conservation standards for new single-family and multifamily houses heated with electricity. The standards are required to achieve all regionally cost-effective conservation savings. As discussed in Volume II, Chapter 4 of the 1986 plan, the Council has found that power savings that can be achieved at a cost in the range of 4.4 to 4.9 cents per kilowatt-hour represent regionally cost-effective resources. "The Model Conservation Standards (MCS) for New Electrically Heated Residential Buildings, New Commercial Buildings, Residential and Commercial Buildings Converting to Electric Space Conditioning, Utility Residential and Commercial Conservation Programs, and Surcharge Methodology," adopted January 14, 1987, set forth an illustrative prescriptive path for each climate zone that if installed in a typical new house would satisfy the standards. The measures shown in the MCS are all regionally cost-effective for the average 1,650 square foot single-family house (one- and two-family dwelling) currently being constructed in the region. In selecting the measures shown in the MCS, the Council chose a typical structure in a typical location in each climate zone and assumed the building was operated in a typical way. Actual buildings will vary from these typical assumptions.

As shown in Tables 3-27 and 3-28, the installation of R-49 ceiling insulation rather than R-38 ceiling insulation in Seattle and Spokane appears to be regionally cost-effective. However, the Council has not included this measure in its standards for these climate zones, due to concerns about the commercial availability of this measure in these zones.

23./ As noted in the introduction, finance costs are taken from the system models and reflect a sponsorship mixed among Bonneville and investor-owned utilities.

Table 3-26
Costs and Savings from Conservation Measures in New Single-family Houses
Zone 1 - Portland
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 1,344 SQUARE FEET									
Base Case	457	$0	$0	$0.00	8,387	6.2	0	0.0	$0
Floors R11 to R19	437	$221	$221	$0.16	7,785	5.8	602	14.2	$249
Walls R11 to R19	406	$496	$717	$0.53	6,864	5.1	920	20.8	$808
Windows R1.2 to R2.5	327	$870	$1,587	$1.18	4,630	3.4	2,234	23.0	$2,304
Roof R19 to R38 VLT	322	$118	$1,705	$1.27	4,475	3.3	155	29.4	$2,437
Insulated Door	310	$195	$1,899	$1.41	4,169	3.1	305	37.6	$2,772
Floors R19 to R30	296	$427	$2,326	$1.73	3,773	2.8	396	41.7	$3,253
Roof R30 to R38 STD	290	$165	$2,491	$1.85	3,631	2.7	141	44.9	$3,438
Roof R38 to R49 ADV	277	$448	$2,939	$2.19	3,296	2.5	335	51.6	$3,943
Wall R19 to R24 ADV	263	$598	$3,536	$2.63	2,938	2.2	357	64.6	$4,616
TOTAL							5,448	29.1	$4,616
HOUSE SIZE 1,848 SQUARE FEET									
Base Case	586	$0	$0	$0.00	11,339	6.1	0	0.0	$0
Floors R11 to R19	567	$212	$212	$0.11	10,755	5.8	584	14.0	$238
Walls R11 to R19	519	$755	$967	$0.52	9,332	5.0	1,422	20.5	$1,089
Windows R1.2 to R2.5	411	$1,193	$2,160	$1.17	6,226	3.4	3,105	22.7	$3,142
Roof R19 to R38 VLT	405	$113	$2,273	$1.23	6,076	3.3	150	29.1	$3,269
Insulated Door	394	$195	$2,468	$1.34	5,767	3.1	309	37.1	$3,604
Floors R19 to R30	380	$409	$2,877	$1.56	5,379	2.9	387	40.8	$4,065
Roof R30 to R38 STD	375	$167	$3,043	$1.65	5,233	2.8	146	44.0	$4,253
Roof R38 to R49 ADV	362	$452	$3,496	$1.89	4,881	2.6	351	49.8	$4,762
Walls R19 to R24 ADV	340	$910	$4,406	$2.38	4,322	2.3	559	63.0	$5,788
TOTAL							7,017	28.3	$5,788

Table 3-26 (cont.)
Costs and Savings from Conservation Measures in New Single-family Houses
Zone 1 - Portland
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 2,352 SQUARE FEET									
Base Case	598	$0	$0	$0.00	10,667	4.5	0	0.0	$0
Floors R11 to R19	589	$92	$92	$0.04	10,420	4.4	246	14.4	$104
Basement Walls R11 to R19	577	$145	$237	$0.10	10,055	4.3	365	15.4	$267
Walls R11 to R19	542	$546	$783	$0.33	9,059	3.9	995	21.2	$882
Windows R1.2 to R2.5	426	$1,283	$2,066	$0.88	5,845	2.5	3,214	23.6	$3,089
Roof R19 to R38 VLT	420	$128	$2,194	$0.93	5,680	2.4	164	30.0	$3,233
Insulated Door	403	$292	$2,485	$1.06	5,228	2.2	451	38.1	$3,734
Floors R19 to R30	397	$178	$2,663	$1.13	5,063	2.2	165	41.7	$3,935
Roof R30 to R38 STD	391	$179	$2,842	$1.21	4,908	2.1	155	44.4	$4,136
Roof R38 to R49 ADV	377	$485	$3,327	$1.41	4,538	1.9	369	50.7	$4,682
Walls R19 to R24 ADV	362	$658	$3,985	$1.69	4,136	1.8	401	63.4	$5,424
TOTAL							6,531	28.5	$5,424

NOTE: UA: measure of resistance to heat loss
Btu/F: British thermal units per degree of Fahrenheit
ACH air changes per hour

Table 3-27
Costs and Savings from Conservation Measures in New Single-family Houses
Zone 1 - Seattle
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 1,344 SQUARE FEET									
Base Case UA	457	$0	$0	$0.00	9,595	7.1	0	0.0	$0
Floor R11 to R19	437	$221	$221	$0.16	8,912	6.6	683	12.5	$249
Wall R11 to R19	406	$496	$717	$0.53	7,862	5.9	1,049	18.3	$808
Window R1.2 to R2.5	327	$870	$1,587	$1.18	5,313	4.0	2,549	20.2	$2,304
Roof R19 to R38 VLT	322	$118	$1,705	$1.27	5,138	3.8	175	26.0	$2,437
Insulated Door	310	$195	$1,899	$1.41	4,793	3.6	344	33.3	$2,772
Floor R19 to R30	296	$427	$2,326	$1.73	4,347	3.2	446	37.0	$3,253
Roof R30 to R38 STD	290	$165	$2,491	$1.85	4,187	3.1	160	39.8	$3,438
Roof R38 to R49 ADV	277	$448	$2,939	$2.19	3,808	2.8	379	45.7	$3,943
Wall R19 to R24 ADV	263	$598	$3,536	$2.63	3,403	2.5	404	57.2	$4,616
TOTAL							6,192	25.6	$4,616
HOUSE SIZE 1,848 SQUARE FEET									
Base Case UA	586	$0	$0	$0.00	12,971	7.0	0	0.0	$0
Floor R11 to R19	567	$212	$212	$0.11	12,307	6.7	663	12.3	$238
Wall R11 to R19	519	$755	$967	$0.52	10,685	5.8	1,622	18.0	$1,089
Window R1.2 to R2.5	411	$1,193	$2,160	$1.17	7,143	3.9	3,541	19.9	$3,142
Roof R19 to R38 VLT	405	$113	$2,273	$1.23	6,972	3.8	170	25.6	$3,269
Insulated Door	394	$195	$2,468	$1.34	6,621	3.6	351	32.7	$3,604
Floor R19 to R30	380	$409	$2,877	$1.56	6,182	3.3	438	36.1	$4,065
Roof R30 to R38 STD	375	$167	$3,043	$1.65	6,016	3.3	165	38.9	$4,253
Roof R38 to R49 ADV	362	$452	$3,496	$1.89	5,618	3.0	397	44.0	$4,762
Wall R19 to R24 ADV	340	$910	$4,406	$2.38	4,987	2.7	631	55.8	$5,788
TOTAL							7,983	24.9	$5,788

Table 3-27 (cont.)
Costs and Savings from Conservation Measures in New Single-family Houses
Zone 1 - Seattle
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 2,352 SQUARE FEET									
Base Case UA	598	$0	$0	$0.00	12,220	5.2	0	0.0	$0
Floor R11 to R19	589	$92	$92	$0.04	11,944	5.1	276	12.9	$104
Basement Wall R11 to R19	577	$145	$237	$0.10	11,535	4.9	408	13.7	$267
Wall R11 to R19	542	$546	$783	$0.33	10,419	4.4	1,115	18.9	$882
Window R1.2 to R2.5	426	$1,283	$2,066	$0.88	6,775	2.9	3,644	20.8	$3,089
Roof R19 to R38 VLT	420	$128	$2,194	$0.93	6,590	2.8	184	26.7	$3,233
Insulated Door	403	$292	$2,485	$1.06	6,089	2.6	501	34.4	$3,734
Floor R19 to R30	397	$178	$2,663	$1.13	5,907	2.5	182	37.8	$3,935
Roof R30 to R38 STD	391	$179	$2,842	$1.21	5,735	2.4	171	40.4	$4,136
Roof R38 to R49 ADV	377	$485	$3,327	$1.41	5,328	2.3	407	46.1	$4,682
Wall R19 to R24 ADV	362	$658	$3,985	$1.69	4,885	2.1	442	57.5	$5,424
TOTAL							7,334	25.4	$5,424

NOTE: UA: measure of resistance to heat loss
Btu/F: British thermal units per degree of Fahrenheit
ACH air changes per hour

Table 3-28
Costs and Savings from Conservation Measures in New Single-family Houses
Zone 2 - Spokane
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 1,344 SQUARE FEET									
Base Case	437	$0	$0	$0.00	13,074	9.7	0	0.0	$0
Wall R11 to R19	406	$496	$496	$0.37	11,696	8.7	1,378	13.9	$559
Window R1.2 to R2.5	327	$870	$1,366	$1.02	8,305	6.2	3,390	15.2	$2,056
Roof R19 to R38 VLT	322	$118	$1,484	$1.10	8,068	6.0	236	19.3	$2,188
Insulated Door	310	$195	$1,678	$1.25	7,602	5.7	466	24.6	$2,523
Floor R19 to R30	296	$427	$2,105	$1.57	6,993	5.2	608	27.1	$3,004
Roof R30 to R38 STD	290	$165	$2,270	$1.69	6,774	5.0	219	29.0	$3,190
Roof R38 to R49 ADV	277	$448	$2,718	$2.02	6,253	4.7	520	33.3	$3,694
Wall R19 to R24 ADV	263	$598	$3,315	$2.47	5,696	4.2	556	41.5	$4,367
TOTAL							7,377	20.3	$4,367
HOUSE SIZE 1,848 SQUARE FEET									
Base Case	567	$0	$0	$0.00	17,597	9.5	0	0.0	$0
Wall R11 to R19	519	$755	$755	$0.41	15,488	8.4	2,108	13.9	$851
Window R1.2 to R2.5	411	$1,193	$1,949	$1.05	10,815	5.9	4,672	15.1	$2,904
Roof R19 to R38 VLT	405	$113	$2,062	$1.12	10,587	5.7	227	19.2	$3,031
Insulated Door	394	$195	$2,256	$1.22	10,118	5.5	469	24.5	$3,365
Floor R19 to R30	380	$409	$2,665	$1.44	9,528	5.2	589	26.9	$3,826
Roof R30 to R38 STD	375	$167	$2,832	$1.53	9,305	5.0	223	28.9	$4,014
Roof R38 to R49 ADV	362	$452	$3,284	$1.78	8,769	4.7	536	32.6	$4,524
Wall R19 to R24 ADV	340	$910	$4,194	$2.27	7,911	4.3	857	41.1	$5,549
TOTAL							9,685	19.7	$5,549

Table 3-28 (cont.)
Costs and Savings from Conservation Measures in New Single-family Houses
Zone 2 - Spokane
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 2,352 SQUARE FEET									
Base Case	589	$0	$0	$0.00	17,291	7.4	0	0.0	$0
Basement Wall R11 to R19	577	$145	$145	$0.06	16,749	7.1	541	10.4	$164
Wall R11 to R19	542	$546	$691	$0.29	15,267	6.5	1,481	14.3	$779
Window R1.2 to R2.5	426	$1,283	$1,974	$0.84	10,397	4.4	4,870	15.6	$2,985
Roof R19 to R38 VLT	420	$128	$2,102	$0.89	10,146	4.3	250	19.7	$3,129
Insulated Door	403	$292	$2,393	$1.02	9,458	4.0	688	25.0	$3,631
Floor R19 to R30	397	$178	$2,571	$1.09	9,206	3.9	251	27.3	$3,831
Roof R30 to R38 STD	391	$179	$2,750	$1.17	8,969	3.8	236	29.2	$4,032
Roof R38 to R49 ADV	377	$485	$3,235	$1.38	8,405	3.6	563	33.3	$4,579
Wall R19 to R24 ADV	362	$658	$3,893	$1.66	7,791	3.3	614	41.5	$5,320
TOTAL							9,500	19.2	$5,320

NOTE: UA: measure of resistance to heat loss
Btu/F: British thermal units per degree of Fahrenheit
ACH air changes per hour

Table 3-29
Costs and Savings from Conservation Measures in New Single-family Houses
Zone 3 - Missoula
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 1,344 SQUARE FEET									
Base Case	351	$0	$0	$0.00	11,062	8.2	0	0.0	$0
Floor R19 to R30	336	$427	$427	$0.32	10,333	7.7	728	22.7	$481
Window R1.6 to R 2.5	292	$900	$1,327	$0.99	8,208	6.1	2,124	25.0	$2,028
Roof R38 to R49 ADV	279	$448	$1,775	$1.32	7,596	5.7	612	28.3	$2,533
Roof R30 VLT to R38 VLT	278	$65	$1,839	$1.37	7,520	5.6	75	33.1	$2,606
Wall R19 to R26 ADV	257	$954	$2,794	$2.08	6,541	4.9	979	37.7	$3,682
TOTAL							4,521	28.0	$3,682
HOUSE SIZE 1,848 SQUARE FEET									
Base Case	449	$0	$0	$0.00	14,765	8.0	0	0.0	$0
Floor R19 to R30	435	$409	$409	$0.22	14,062	7.6	702	22.5	$461
Window R1.6 to R 2.5	375	$1,234	$1,643	$0.89	11,120	6.0	2,942	24.8	$2,583
Roof R38 to R49 ADV	362	$429	$2,072	$1.12	10,523	5.7	596	27.8	$3,067
Roof R30 VLT to R38 VLT	361	$62	$2,134	$1.15	10,449	5.7	74	32.2	$3,137
Wall R19 to R26 ADV	329	$1,453	$3,588	$1.94	8,935	4.8	1,513	37.1	$4,774
TOTAL							5,829	28.1	$4,774

Table 3-29 (cont.)
Costs and Savings from Conservation Measures in New Single-family Houses
Zone 3 - Missoula
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 2,352 SQUARE FEET									
Base Case	476	$0	$0	$0.00	14,896	6.3	0	0.0	$0
Basement Wall R11 to R19	464	$145	$145	$0.06	14,300	6.1	596	9.4	$164
Floor R19 to R30	458	$178	$323	$0.14	14,007	6.0	293	23.5	$364
Window R1.6 to R 2.5	393	$1,326	$1,649	$0.70	10,970	4.7	3,036	25.8	$2,645
Roof R38 to R49 ADV	379	$485	$2,135	$0.91	10,322	4.4	647	29.0	$3,192
Roof R30 VLT to R38 VLT	378	$70	$2,205	$0.94	10,242	4.4	80	33.6	$3,271
Wall R19 to R26 ADV	355	$1,051	$3,255	$1.38	9,184	3.9	1,058	38.4	$4,455
TOTAL							5,712	26.8	$4,455

NOTE: UA: measure of resistance to heat loss
Btu/F: British thermal units per degree of Fahrenheit
ACH air changes per hour

Table 3-30
Costs and Savings from Conservation Measures in New Multifamily Residences
Dwelling Unit Size 840 Square Feet
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
ZONE 1 - PORTLAND									
Base Case	2,378	$0	$0	$0.00	2,760	3.3	0	0.0	$0
Floor R11 to R19	2,321	$52	$52	$0.06	2,628	3.1	131	15.4	$59
Wall R11 to R19	2,182	$184	$236	$0.28	2,308	2.7	320	22.2	$266
Window R1.2 to R2.5	1,669	$472	$708	$0.84	1,224	1.5	1,084	25.7	$1,078
Insulated Door	1,633	$51	$759	$0.90	1,154	1.4	69	43.2	$1,166
Floor R19 to R30	1,591	$101	$861	$1.02	1,070	1.3	84	46.5	$1,280
Roof R30 to R38	1,572	$49	$909	$1.08	1,030	1.2	39	47.5	$1,335
Roof R38 to R49 ADV	1,526	$133	$1,042	$1.24	934	1.1	95	53.7	$1,485
Wall R19 to R25 STD	1,480	$221	$1,263	$1.50	840	1.0	93	91.4	$1,734
TOTAL							1,919	31.0	$1,734
ZONE 1 - SEATTLE									
Base Case	2,378	$0	$0	$0.00	3,168	3.8	0	0.0	$0
Floor R11 to R19	2,321	$52	$52	$0.06	3,019	3.6	148	13.6	$59
Wall R11 to R19	2,182	$184	$236	$0.28	2,659	3.2	360	19.7	$266
Window R1.2 to R2.5	1,669	$472	$708	$0.84	1,431	1.7	1,228	22.7	$1,078
Insulated Door	1,633	$51	$759	$0.90	1,350	1.6	80	37.6	$1,166
Floor R19 to R30	1,591	$101	$861	$1.02	1,254	1.5	96	40.6	$1,280
Roof R30 to R38	1,572	$49	$909	$1.08	1,208	1.4	45	41.5	$1,335
Roof R38 to R49 ADV	1,526	$133	$1,042	$1.24	1,099	1.3	109	47.0	$1,485
Wall R19 to R25 STD	1,480	$221	$1,263	$1.50	992	1.2	107	79.7	$1,734
TOTAL							2,176	27.4	$1,734

Table 3-30 (cont.)
Costs and Savings from Conservation Measures in New Multifamily Residences
Dwelling Unit Size 840 Square Feet
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
ZONE 2 - SPOKANE									
Base Case	2,378	$0	$0	$0.00	5,011	6.0	0	0.0	$0
Floor R11 to R19	2,321	$52	$52	$0.06	4,810	5.7	201	10.1	$59
Wall R11 to R19	2,182	$184	$236	$0.28	4,318	5.1	492	14.4	$266
Window R1.2 to R2.5	1,669	$472	$708	$0.84	2,617	3.1	1,700	16.4	$1,078
Insulated Door	1,633	$51	$759	$0.90	2,506	3.0	111	27.1	$1,166
Floor R19 to R30	1,591	$101	$861	$1.02	2,371	2.8	135	29.0	$1,280
Roof R30 to R38	1,572	$49	$909	$1.08	2,304	2.7	66	28.4	$1,335
Roof R38 to R49 ADV	1,526	$133	$1,042	$1.24	2,144	2.6	160	32.1	$1,485
Wall R19 to R25 STD	1,480	$221	$1,263	$1.50	1,987	2.4	157	54.5	$1,734
TOTAL							3,024	19.7	$1,734
ZONE 3 - MISSOULA									
Base Case	2,378	$0	$0	$0.00	5,975	7.1	0	0.0	$0
Floor R11 to R19	2,321	$52	$52	$0.06	5,741	6.8	234	8.6	$59
Wall R11 to R19	2,182	$184	$236	$0.28	5,170	6.2	570	12.4	$266
Window R1.2 to R2.5	1,669	$472	$708	$0.84	3,184	3.8	1,985	14.1	$1,078
Insulated Door	1,633	$51	$759	$0.90	3,053	3.6	131	23.0	$1,166
Floor R19 to R30	1,591	$101	$861	$1.02	2,894	3.4	159	24.6	$1,280
Roof R30 to R38	1,572	$49	$909	$1.08	2,816	3.4	77	24.4	$1,335
Roof R38 to R49 ADV	1,526	$133	$1,042	$1.24	2,630	3.1	185	27.6	$1,485
Wall R19 to R25 STD	1,480	$221	$1,263	$1.50	2,447	2.9	183	46.7	$1,734
TOTAL							3,181	16.9	$1,734

NOTE: UA: measure of resistance to heat loss
Btu/F: British thermal units per degree of Fahrenheit
ACH air changes per hour

Table 3-31
Costs and Savings from Conservation Measures in New Manufactured Homes
Zone 1 - Portland
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 924 SQUARE FEET									
Base Case	369	$0	$0	$0.00	6,112	6.6	0	0.0	$0
Roof R11 to R19	352	$68	$68	$0.07	5,619	6.1	493	6.3	$76
Floor R11 to R19	334	$177	$245	$0.27	5,091	5.5	527	15.4	$276
Window R1.2 to R2.5	266	$828	$1,073	$1.16	3,229	3.5	1,862	26.0	$1,463
Roof R19 to R27	255	$182	$1,255	$1.36	2,947	3.2	282	29.7	$1,668
Wall R11 to R19	223	$622	$1,877	$2.03	2,184	2.4	762	37.5	$2,369
Insulated Door	212	$191	$2,069	$2.24	1,973	2.1	211	52.9	$2,643
Floor R19 to R30	193	$526	$2,595	$2.81	1,610	1.7	362	66.7	$3,236
Roof R27 to R38	188	$250	$2,845	$3.08	1,501	1.6	108	105.5	$3,518
TOTAL							4,610	31.1	$3,518
HOUSE SIZE 1,344 SQUARE FEET									
Base Case	432	$0	$0	$0.00	7,937	5.9	0	0.0	$0
Roof R11 to R19	408	$99	$99	$0.07	7,227	5.4	710	6.4	$111
Floor R11 to R19	381	$258	$356	$0.27	6,424	4.8	802	14.8	$401
Window R1.2 to R2.5	313	$828	$1,184	$0.88	4,451	3.3	1,973	24.5	$1,588
Roof R19 to R27	297	$265	$1,449	$1.08	4,081	3.0	370	32.9	$1,887
Wall R11 to R19	265	$622	$2,071	$1.54	3,165	2.4	915	31.2	$2,588
Insulated Door	254	$191	$2,263	$1.68	2,869	2.1	295	37.8	$2,862
Floor R19 to R30	227	$765	$3,028	$2.25	2,351	1.7	518	67.9	$3,725
Roof R27 to R38	219	$364	$3,392	$2.52	2,151	1.6	199	83.6	$4,135
TOTAL							5,785	29.1	$4,135

NOTE:
UA: measure of resistance to heat loss
Btu/F: British thermal units per degree of Fahrenheit
ACH air changes per hour

Table 3-32
Costs and Savings from Conservation Measures in New Manufactured Homes
Zone 1 - Seattle
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 924 SQUARE FEET									
Base Case	369	$0	$0	$0.00	7,002	7.6	0	0.0	$0
Roof R11 to R19	352	$68	$68	$0.07	6,438	7.0	563	5.5	$76
Floor R11 to R19	334	$177	$245	$0.27	5,835	6.3	602	13.5	$276
Window R1.2 to R2.5	266	$828	$1,073	$1.16	3,728	4.0	2,106	23.0	$1,463
Roof R19 to R27	255	$182	$1,255	$1.36	3,417	3.7	311	26.9	$1,668
Wall R11 to R19	223	$622	$1,877	$2.03	2,545	2.8	872	32.8	$2,369
Insulated Door	212	$191	$2,069	$2.24	2,300	2.5	245	45.6	$2,643
Floor R19 to R30	193	$526	$2,595	$2.81	1,878	2.0	421	57.3	$3,236
Roof R27 to R38	188	$250	$2,845	$3.08	1,751	1.9	126	90.8	$3,518
TOTAL							5,251	27.3	$3,518
HOUSE SIZE 1,344 SQUARE FEET									
Base Case	432	$0	$0	$0.00	9,118	6.8	0	0.0	$0
Roof R11 to R19	408	$99	$99	$0.07	8,296	6.2	821	5.5	$111
Floor R11 to R19	381	$258	$356	$0.27	7,393	5.5	903	13.1	$401
Window R1.2 to R2.5	313	$828	$1,184	$0.88	5,184	3.9	2,208	21.9	$1,588
Roof R19 to R27	297	$265	$1,449	$1.08	4,684	3.5	499	24.4	$1,887
Wall R11 to R19	265	$622	$2,071	$1.54	3,759	2.8	925	30.9	$2,588
Insulated Door	254	$191	$2,263	$1.68	3,443	2.6	315	35.5	$2,862
Floor R19 to R30	227	$765	$3,028	$2.25	2,729	2.0	713	49.3	$3,725
Roof R27 to R38	219	$364	$3,392	$2.52	2,501	1.9	228	73.3	$4,135
TOTAL							6,616	25.5	$4,135

NOTE: UA: measure of resistance to heat loss
Btu/F: British thermal units per degree of Fahrenheit
ACH air changes per hour

Table 3-33
Costs and Savings from Conservation Measures in New Manufactured Homes
Zone 2 - Spokane
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 924 SQUARE FEET									
Base Case	369	$0	$0	$0.00	10,539	11.4	0	0.0	$0
Roof R11 to R19	352	$68	$68	$0.07	9,790	10.6	749	4.2	$76
Floor R11 to R19	334	$177	$245	$0.27	8,986	9.7	803	10.1	$276
Window R1.2 to R2.5	266	$828	$1,073	$1.16	6,136	6.6	2,850	17.0	$1,463
Roof R19 to R27	255	$182	$1,255	$1.36	5,694	6.2	441	18.9	$1,668
Wall R11 to R19	223	$622	$1,877	$2.03	4,486	4.9	1,207	23.7	$2,369
Insulated Door	212	$191	$2,069	$2.24	4,142	4.5	344	32.5	$2,643
Floor R19 to R30	193	$526	$2,595	$2.81	3,549	3.8	592	40.8	$3,236
Roof R27 to R38	188	$250	$2,845	$3.08	3,371	3.6	177	64.6	$3,518
TOTAL							7,168	20.0	$3,518
HOUSE SIZE 1,344 SQUARE FEET									
Base Case	432	$0	$0	$0.00	12,945	9.6	0	0.0	$0
Roof R11 to R19	408	$99	$99	$0.07	11,936	8.9	1,009	4.5	$111
Floor R11 to R19	381	$258	$356	$0.27	10,749	8.0	1,186	10.0	$401
Window R1.2 to R2.5	313	$828	$1,184	$0.88	7,886	5.9	2,863	16.9	$1,588
Roof R19 to R27	297	$265	$1,449	$1.08	7,331	5.5	555	21.9	$1,887
Wall R11 to R19	265	$622	$2,071	$1.54	6,025	4.5	1,306	21.9	$2,588
Insulated Door	254	$191	$2,263	$1.68	5,581	4.2	443	25.2	$2,862
Floor R19 to R30	227	$765	$3,028	$2.25	4,744	3.5	836	42.0	$3,725
Roof R27 to R38	219	$364	$3,392	$2.52	4,425	3.3	318	52.4	$4,135
TOTAL							8,520	19.8	$4,135

NOTE: UA: measure of resistance to heat loss
Btu/F: British thermal units per degree of Fahrenheit
ACH air changes per hour

Table 3-34
Costs and Savings from Conservation Measures in New Manufactured Homes
Zone 3 - Missoula
1988$, 0.35 ACH Assumed as Current Practice

CONSERVATION MEASURE	UA Btu/F	COST Incremental	COST Cumulative	COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	ANNUAL SAVINGS (kWh/yr)	LEVELIZED COST (mills/kWh)	PRESENT VALUE ($)
HOUSE SIZE 924 SQUARE FEET									
Base Case	369	$0	$0	$0.00	12,455	13.5	0	0.0	$0
Roof R11 to R19	352	$68	$68	$0.07	11,595	12.5	860	3.6	$76
Floor R11 to R19	334	$177	$245	$0.27	10,669	11.5	925	8.8	$276
Window R1.2 to R2.5	266	$828	$1,073	$1.16	7,359	8.0	3,310	14.6	$1,463
Roof R19 to R27	255	$182	$1,255	$1.36	6,848	7.4	511	16.4	$1,668
Wall R11 to R19	223	$622	$1,877	$2.03	5,451	5.9	1,396	20.5	$2,369
Insulated Door	212	$191	$2,069	$2.24	5,028	5.4	423	26.4	$2,643
Floor R19 to R30	193	$526	$2,595	$2.81	4,297	4.7	730	33.1	$3,236
Roof R27 to R38	188	$250	$2,845	$3.08	4,078	4.4	219	52.4	$3,518
TOTAL							8,377	17.1	$3,518
HOUSE SIZE 1,344 SQUARE FEET									
Base Case	432	$0	$0	$0.00	15,363	11.4	0	0.0	$0
Roof R11 to R19	408	$99	$99	$0.07	14,154	10.5	1,209	3.7	$111
Floor R11 to R19	381	$258	$356	$0.27	12,768	9.5	1,385	8.5	$401
Window R1.2 to R2.5	313	$828	$1,184	$0.88	9,469	7.0	3,299	14.7	$1,588
Roof R19 to R27	297	$265	$1,449	$1.08	8,815	6.6	654	18.6	$1,887
Wall R11 to R19	265	$622	$2,071	$1.54	7,202	5.4	1,612	17.7	$2,588
Insulated Door	254	$191	$2,263	$1.68	6,709	5.0	493	22.7	$2,862
Floor R19 to R30	227	$765	$3,028	$2.25	5,723	4.3	985	35.7	$3,725
Roof R27 to R38	219	$364	$3,392	$2.52	5,351	4.0	372	44.9	$4,135
TOTAL							10,012	16.8	$4,135

NOTE: UA: measure of resistance to heat loss
Btu/F: British thermal units per degree of Fahrenheit
ACH air changes per hour

Step 4. Estimate the Regional Conservation Potential Available from Space Heating Conservation in New Dwellings

The next step in the Council's development of a regional supply curve for space heating conservation potential requires combining the engineering estimates of individual house savings by climate zone to establish a regional total. Because each measure saves a different amount of energy in each house design and in each location, an aggregate supply curve must be developed that represents the weighted average savings for all measures in comparable dwelling types.

Each of the three single-family dwelling designs was assigned a weight based on its foundation type, size and window area. The specific weight assigned to each design approximately reflects that design's share of the new housing stock additions expected over the forecast period. This was also done for the two manufactured housing designs. Building type weighting was unnecessary for multifamily space heating, because only one multifamily design was used. It should be noted that the Council's forecasting model defines all units up to and including four-plexes as "single-family dwellings." Consequently, the weights selected are designed to achieve a much smaller average size for new single-family houses (i.e., 1,400 square feet of floor area) than had they been selected on the basis of the more conventional definition of a single-family home (one- and two-family dwellings) used to establish the model conservation standards. The average size of typical new one- and two-family dwellings recently constructed in the region is between 1,600 and 1,800 square feet of floor area.

Once each building design's weight had been established, the average savings by climate type was calculated for all designs. These savings were then aggregated to the regional level based on the share of new electrically heated dwellings expected to be constructed in each climate over the forecast period. Table 3-35 shows the weight assigned each building design and climate type. Tables 3-36 through 3-38 show the weighted average use, cost and savings available from new single-family, multifamily and manufactured houses at levelized costs less than 10 cents per kilowatt-hour (equivalent to 100 mills per kilowatt-hour).

Table 3-35
Weighting Factors Used to Aggregate
Individual Building & Location Savings to Region

BUILDING TYPE	WEIGHT	MEAN SIZE
Single-family (less than five-plex)		
1,344 square feet - Single Story	90%	
1,848 square feet - Two Story	9%	
2,352 square feet - One Story w/Basement	1%	
		1,400 square feet
Multifamily (five-plex and larger)		
12-Unit	100%	840 square feet/unit[b]
Manufactured Homes		
924 Single Wide	19%	
1,344 Double Wide	81%	1,264 square feet[b]

ZONE	HDD[a]	WEIGHT
Single- and Multifamily Homes		
Zone 1 - Portland	4,786	28%
Zone 1 - Seattle	5,444	52%
Zone 2 - Spokane	6,818	16%
Zone 3 - Missoula	7,773	4%
Region	5,572	
Manufactured Homes		
Zone 1 - Portland	4,786	20%
Zone 1 - Seattle	5,444	44%
Zone 2 - Spokane	6.818	25%
Zone 3 - Missoula	5,372	11%
Region	5,912	

a HDD - Heating Degree Days at 65°F based on Typical Meteorological Year (TMY) weather tape used to estimate savings. TMY weather tapes vary slightly from published long-term averages.

b Table 3-40 shows the mean size of new units used in the forecast model. The unit sizes shown here were scaled to match those assumed in the forecast model.

Table 3-36
Regionally Weighted Savings and Costs in New Single-family Dwellings

LEVELIZED COST (mills/kWh)	CAPITAL COST Total	CAPITAL COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	RELATIVE USE (% of base)	ANNUAL SAVINGS (kWh/yr)	PRESENT VALUE	AVERAGE R-VALUE
0	$0	$0.00	10,210	7.3	100	0	$0	8.96
5	$100	$0.07	9,921	7.1	97	288	$113	9.12
10	$201	$0.15	9,632	6.9	94	577	$226	9.29
15	$531	$0.38	8,664	6.2	86	1,546	$673	9.92
20	$1,272	$0.91	6,741	4.8	66	3,468	$1,777	11.53
25	$1,715	$1.23	5,697	4.1	55	4,512	$2,484	12.38
30	$1,931	$1.38	5,373	3.8	52	4,836	$2,766	12.96
35	$2,212	$1.59	5,025	3.6	49	5,184	$3,129	13.42
40	$2,593	$1.86	4,640	3.3	45	5,569	$3,570	13.98
45	$2,908	$2.09	4,367	3.1	42	5,842	$3,924	14.43
50	$3,150	$2.26	4,192	3.0	40	6,017	$4,197	14.74
55	$3,367	$2.42	4,047	2.9	39	6,163	$4,442	15.02
60	$3,493	$2.51	3,966	2.8	38	6,243	$4,583	15.17
65	$3,553	$2.55	3,930	2.8	37	6,280	$4,651	15.25
70	$3,553	$2.55	3,930	2.8	37	6,280	$4,651	15.25
75	$3,553	$2.55	3,930	2.8	37	6,280	$4,651	15.25
80	$3,553	$2.55	3,930	2.8	37	6,280	$4,651	15.25
85	$3,553	$2.55	3,930	2.8	37	6,280	$4,651	15.25
90	$3,553	$2.55	3,930	2.8	37	6,280	$4,651	15.25
95	$3,553	$2.55	3,930	2.8	37	6,280	$4,652	15.25
100	$3,553	$2.55	3,930	2.8	37	6,280	$4,652	15.25

Table 3-37
Regionally Weighted Savings and Costs in New Multifamily Dwellings

LEVELIZED COST (mills/kWh)	CAPITAL COST Total	CAPITAL COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	RELATIVE USE (% of base)	ANNUAL SAVINGS (kWh/yr)	PRESENT VALUE	AVERAGE R-VALUE
0	$0	$0.00	3,461	4.1	100	0	$0	5.91
5	$20	$0.02	3,399	4.0	98	61	$23	5.97
10	$43	$0.05	3,330	4.0	96	130	$48	6.03
15	$152	$0.18	3,002	3.6	89	458	$195	6.36
20	$343	$0.41	2,530	3.0	76	930	$459	6.93
25	$695	$0.83	1,667	2.0	48	1,793	$1,055	8.36
30	$748	$0.89	1,567	1.9	44	1,893	$1,139	8.55
35	$791	$0.94	1,515	1.8	43	1,946	$1,195	8.65
40	$822	$0.98	1,484	1.8	42	1,977	$1,235	8.72
45	$880	$1.05	1,435	1.7	41	2,025	$1,302	8.83
50	$956	$1.14	1,377	1.6	39	2,083	$1,388	8.96
55	$1,024	$1.22	1,333	1.6	38	2,127	$1,464	9.07
60	$1,063	$1.27	1,313	1.6	37	2,148	$1,508	9.12
65	$1,091	$1.30	1,299	1.5	36	2,161	$1,540	9.15
70	$1,120	$1.33	1,286	1.5	36	2,175	$1,572	9.19
75	$1,148	$1.37	1,272	1.5	36	2,188	$1,604	9.22
80	$1,182	$1.41	1,256	1.5	35	2,204	$1,643	9.26
85	$1,222	$1.45	1,239	1.5	34	2,222	$1,687	9.31
90	$1,239	$1.48	1,231	1.5	34	2,229	$1,707	9.33
95	$1,254	$1.49	1,225	1.5	34	2,235	$1,723	9.35
100	$1,263	$1.50	1,222	1.5	34	2,239	$1,734	9.36

Table 3-38
Regionally Weighted Savings and Costs in New Manufactured Dwellings

LEVELIZED COST (mills/kWh)	CAPITAL COST Total	CAPITAL COST ($/sq ft)	ANNUAL USE (kWh/yr)	ANNUAL USE (kWh/sq ft)	RELATIVE USE (% of base)	ANNUAL SAVINGS (kWh/yr)	PRESENT VALUE	AVERAGE R-VALUE
0	$0	$0.00	10,104	8.1	100	0	$0	8.85
5	$98	$0.08	9,260	7.4	91	844	$111	9.35
10	$284	$0.23	8,477	6.8	84	1,626	$327	9.86
15	$655	$0.52	7,233	5.8	73	2,871	$835	10.85
20	$1,143	$0.92	5,953	4.7	60	4,151	$1,493	12.15
25	$1,656	$1.33	4,843	3.8	48	5,261	$2,135	13.52
30	$1,995	$1.60	4,354	3.5	43	5,750	$2,522	14.40
35	$2,344	$1.88	3,869	3.1	38	6,235	$2,936	15.34
40	$2,539	$2.04	3,644	2.9	35	6,460	$3,172	15.84
45	$2,742	$2.20	3,457	2.7	33	6,647	$3,402	16.31
50	$2,924	$2.34	3,298	2.6	32	6,806	$3,608	16.72
55	$3,026	$2.42	3,221	2.6	31	6,883	$3,722	16.93
60	$3,082	$2.47	3,185	2.5	30	6,919	$3,785	17.04
65	$3,138	$2.51	3,149	2.5	30	6,955	$3,848	17.16
70	$3,189	$2.55	3,117	2.5	30	6,986	$3,906	17.25
75	$3,235	$2.59	3,091	2.5	29	7,013	$3,958	17.34
80	$3,262	$2.61	3,076	2.4	29	7,028	$3,988	17.38
85	$3,279	$2.62	3,067	2.4	29	7,037	$4,007	17.41
90	$3,288	$2.63	3,062	2.4	29	7,042	$4,017	17.43
95	$3,288	$2.63	3,062	2.4	29	7,042	$4,017	17.43
100	$3,288	$2.63	3,062	2.4	29	7,042	$4,017	17.43

Step 5. Estimate the Realizable Conservation Potential from New Residential Space Heating Efficiency Improvements

In order to establish the proportion of technically available space heating conservation that can realistically be achieved, two adjustments must be made to the engineering savings estimates. First, to ensure consistency with the Council's load forecast, the conservation resource based on engineering estimates of current space heating energy use must be adjusted or scaled to account for the forecasting model's estimate of current space heating use.[24] Table 3-39 compares the average space heating energy use by dwelling type, as estimated by the Council's forecasting model for the year 2010 in the medium forecast, and the engineering estimate of space heating use for houses built to 1986 practice. The engineering estimates and the forecasting model estimates of space heating use for single-family and multifamily homes agree very well. However, the forecasting models estimate of use is lower than the engineering model's projected use for space heating in new manufactured housing. The Council is currently investigating reasons for this deviation between the forecasting and engineering use estimates.

Table 3-39
Forecast Model vs. Engineering Estimate for Space Heating in New Dwellings, Regional Average Use in 2010

BUILDING TYPE	FORECASTING MODEL (kWh/yr)	FORECASTING MODEL (kWh/sq ft/yr)	ENGINEERING ESTIMATE (kWh/yr)	ENGINEERING ESTIMATE (kWh/sq ft/yr)
Single-family Home	6,840	4.9	6,850	4.9
Multifamily Home	2,760	2.7	2,790	2.7
Manufactured Home	9,290	6.8	10,895	7.9

The Council's forecasting model does not explicitly assume a specific average dwelling unit size. However, the forecasting model's present implicit assumptions regarding average size for existing dwellings are shown in Table 3-40. Based on survey data, it appears that average new multifamily dwellings (five-plex and larger) and manufactured houses being built today are typically larger than the forecasting model assumes for all existing multifamily dwellings and manufactured houses. However, new single-family housing (less than five-plexes) appears to be the same size as the existing single-family stock. To account for this fact, the forecasting model's projected use for new multifamily units and manufactured homes shown in Table 3-39 has been scaled by the ratio of the size of new stock to existing stock. Similarly, the engineering model's estimates of cost and energy savings from conservation actions in new multifamily dwellings and manufactured homes shown in Table 3-39 were also scaled to match the forecast model's assumptions regarding new unit size. This was done by multiplying the engineering estimates of use, cost and savings by the ratio of average unit size implicitly assumed in the forecast model to the average floor area of new dwelling units. No size adjustment was made for new single-family dwellings, because their size appears to be consistent with the existing stock.

24./ The forecast model estimates shown here assume constant consumer amenity levels. In the Council's medium forecast, consumers are expected to increase their amenity levels by the year 2010. This results in higher space heating use than is shown in Table 3-39. Single-family houses are forecast to use 7,055 kilowatt-hours per year. Multifamily houses are estimated to use 3,035 kilowatt-hours per year. Manufactured homes are expected to use 10,000 kilowatt-hours per year. These utilization changes are accounted for in the Council's final resource portfolio.

Table 3-40
Forecasting Model Dwelling Size vs. Average New Dwellings
(Square Feet)

BUILDING TYPE	MODEL EXISTING STOCK	NEW STOCK	RATIO OF NEW STOCK TO MODEL
Single-family Home	1,400	1,400	1.00
Multifamily Home	840	1,030	1.23
Manufactured Home	900	1,370	1.53

The Council's engineering estimates of space heating energy use in new dwellings and the forecasting model now contain similar underlying assumptions regarding appliance efficiency and family size. In order to match current (1988) consumption, the forecasting model must use current (1988) appliance efficiencies. However, because the Council anticipates substantial efficiency improvements in appliance energy use within the next five to 10 years, the Council's engineering and forecast model estimates of space heating use in 2010 assumes the presence of more efficient appliances.

Table 3-41 shows the difference in waste heat (i.e., internal gains) released inside typical single-family dwellings from people and appliances assumed by the forecasting model in the late 1980s and in 2010. At current efficiencies and persons per household, approximately 6,800 kilowatt-hours of heat are released each year inside the house by people, lights and appliances. However, with anticipated improvements in appliance efficiency and a reduction in the average number of people per household, this will drop to approximately 5,450 kilowatt-hours per year by 2010.

Because this waste heat offsets the need for space heating, more efficient appliances mean larger space heating energy requirements. Had the Council assumed less efficient appliances in its engineering and forecasting model estimates, the regional average space heating energy used in new single-family houses built in 2010 would fall about 1.2 kilowatt-hours per square foot. This reduction amounts to about 1,600 kilowatt-hours per year in the average new single-family house. However, failure to recognize the installation of efficient appliances in this same house by the year 2010 would result in an underestimate of space heating energy needs by 0.9 kilowatt-hours per square foot, per year.

Table 3-42 shows the technical savings per unit and the average megawatts of technical conservation potential from improvements in space heating efficiency in new single- and multifamily dwellings and manufactured houses from a 1983 code base. Table 3-43 shows the same potential from a base that incorporates the more efficient 1986 codes as the base. The achievable conservation potential for new single-family and multifamily dwellings assumes a gradually increasing share of new electrically heated residences that install all regionally cost-effective space heating conservation measures between 1987 and 1991. This share is 10 percent in 1987, 40 percent in 1988, 65 percent in 1989 and 75 percent in 1990. After 1990, 85 percent of all new electrically heated single-family and multifamily units are assumed to install all regionally cost-effective measures. Similarly, gradual increases in the share of new manufactured houses (10 percent in 1988, increasing at an additional 10 percent per year) are assumed to include all regionally cost-effective measures between 1986 and 1991. After 1991, 50 percent of all new electrically heated manufactured houses are assumed to install all regionally cost-effective measures.

Table 3-41
Internal Gain Changes from More Efficient Appliances

APPLIANCE/SOURCE	SATURATION[a] (UNITS/HOUSEHOLD)	ENERGY USE PER UNIT (kWh/yr) AT CURRENT EFFICIENCIES	ENERGY USE PER UNIT (kWh/yr) AT FORECAST EFFICIENCIES	PERCENT INDOORS	INTERNAL GAINS PROVIDED AT CURRENT EFFICIENCIES (kWh/yr)	INTERNAL GAINS PROVIDED AT FORECAST EFFICIENCIES INDOORS (kWh/yr)
Lighting[b]	1.00	690	650	90	620	585
Refrigerator[c]	1.083	1,156[d]	691	100	1,252	748
Range/Cooking	1.00	980	880	100	980	880
Freezer	.53	816[d]	492	50	216	130
Water Heater[e]	1.00	1,300	760	50	645	380
Television	2,000 set-hr/yr	200	200	100	200	200
Clothesdryer	.7	950	900	10	70	60
Dishwashers, Clotheswashers, & Misc. Appliances	--	1,750	1,500	50	875	750
People[f]	2.63/2.22	1,920	1,810	100	1,930	1,720
TOTAL					6,793	5,453

[a] Not updated since the 1986 Power Plan.

[b] Assumes 1,400 square-foot home. For other floor areas, lighting loads should be scaled by floor area.

[c] Assumes one refrigerator is located inside the house and 50 percent of .165 refrigerators are located outside the house.

[d] For these appliances, current efficiencies are the level of the 1990 Federal Appliance Standards.

[e] Waste heat from water use is included with contribution from people.

[f] Contribution from people includes 290 kilowatt-hours per year, per occupant as sensible heat and 230 kilowatt-hours per year, per occupant as latent heat. Also included is 565 kilowatt-hours per year of latent heat provided to the house from the use of warm water for cooking and bathing.

Table 3-42
Potential Savings above 1983 Practice from Space Heating
in New Residential Buildings
Average Megawatts (High Forecast)

LEVELIZED COST (cents/kWh)	SINGLE-FAMILY HOUSES	MULTIFAMILY HOUSES	MANUFACTURED HOUSES	TOTAL
0	0	0	0	0
1.0	5	5	45	55
2.0	390	40	125	555
3.0	570	85	175	830
4.0	670	90	200	960
5.0	730	95	210	1,035
6.0	760	100	215	1,075
7.0	765	100	215	1,080

Table 3-43
Potential Savings above 1986 Practice from Space Heating
in New Residential Buildings
Average Megawatts (High Forecast)

LEVELIZED COST (cents/kWh)	SINGLE-FAMILY HOUSES	MULTIFAMILY HOUSES	MANUFACTURED HOUSES	TOTAL
0	0	0	0	0
1.0	0	0	45	45
2.0	15	0	125	140
3.0	200	30	175	405
4.0	300	35	200	535
5.0	355	40	210	605
6.0	385	45	215	645
7.0	390	45	215	650

Electric Water Heating Conservation

The energy used to heat water represents the second largest end use of electricity in the residential sector. Figure 3-15 shows the technical potential for improving the efficiency of residential water heating at various costs of electricity. These savings represent better insulated water heaters, pipe wraps, and more efficient appliances that use hot water (e.g., clotheswashers and dishwashers).

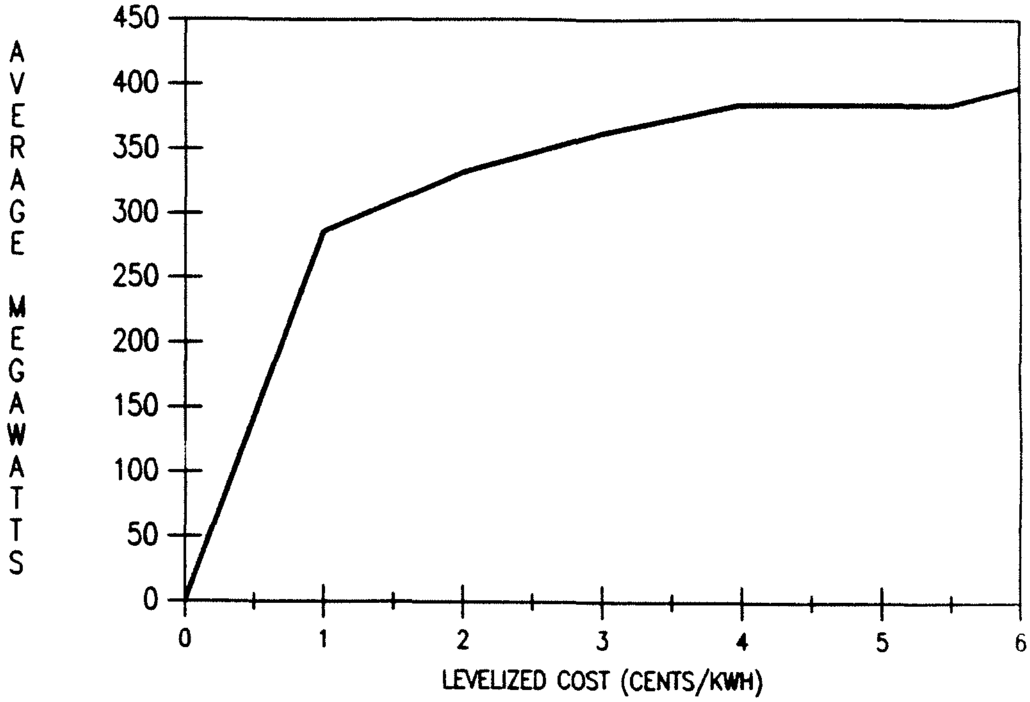

Figure 3-15
Technical Conservation Potential from Residential Water Heating Measures

The cost-effective technical potential identified by the Council for electric water heaters and water consuming appliances is about 385 average megawatts. The achievable portion of this is about 300 average megawatts. The average cost of improving the efficiency of electric water heaters is 1.8 cents per kilowatt-hour, which escalates to 2.0 cents per kilowatt-hour if administrative costs and transmission and distribution adjustments are incorporated.

The Council's assessment of the conservation potential available from improved residential water heating efficiency involved three steps. These were to:

1. Estimate the cost and savings potential available from improved water heating efficiency beyond the new 1990 federal standard.

2. Develop conservation supply functions for technical and achievable potential.

3. Calibrate savings to the Council's forecast.

Step 1. Estimate the Cost and Savings Potential Available from Improved Water Heating Efficiency

The amount of energy consumed for water heating depends on two factors: standby losses and variable use. Standby losses refer to the energy that is used during storage to keep the water hot; they are determined by the temperature of the water and insulation levels of the hot water storage tank and supply piping. Variable use is the amount of hot water actually used in the household. Variable use differs substantially among households, depending upon such factors as the habits and number of occupants, and the stock of appliances that use hot water (such as clotheswashers and dishwashers), as well as the temperature of the hot water and the cold water that enters the tank.

In 1987 a national appliance standards act was passed that regulates the maximum energy consumption of a variety of household appliances, including electric water heaters, refrigerators and freezers. For electric water heaters, the appliance standards regulate the standby losses from the water heater tank. The level of the national standard is about the level or slightly more efficient than the level set by Oregon and Washington for water heaters sold in their states. The federal standard becomes effective in 1990, and a review of the standard by the Secretary of the Department of Energy to see if it should be strengthened is required by 1992. The estimates of conservation potential for water heater tanks developed here are based on going beyond the current federal standard and setting a more stringent standard to the level of some of the most efficient tanks produced today. It is envisioned that this revision to the federal standard would become effective in 1995.

The base use of water heaters from which conservation potential could be estimated was derived by reviewing research on the question. Table 3-44 summarizes available data on standby losses from conventional (typically R-5) tanks. Water heat was directly submetered in all field studies. Laboratory tests on individual units had lower standby losses than those found in field tests. The average value of the full sample is 1,610 kilowatt-hours per year, identical to the Seattle City Light number of 1,610 kilowatt-hours per year, which was used in the 1983 and 1986 plans. This value was compared to an estimate of standby losses from the federal standard which was derived from work done for Bonneville. This indicated that standby losses from the federal standard are on the order of 1,290 kilowatt-hours per year. This lower base was used as the estimate of base case use in both the forecast of electricity demand and the estimate of conservation savings when the federal standard becomes effective in 1990.

Table 3-44
Data on Standby Losses from Conventional Water Heater Tanks

SOURCE	STANDBY (kWh/yr)	N	NOTES
Seattle City Light	1,610	26	All unwrapped, submetered
Biemer/Auburg '84	1,375	1	Laboratory tests
Goldstein/Clear	1,468		Calculated for 1960-1980 vintage tanks
Ek '82 (#36)	1,483	1	Laboratory test
Ecotope '82	1,995	91	Some wrapped, many different locations
Ecotope Heat Pump Study	1,731	39	Median standby losses in three cities are weighted by climate zone's contribution to regional population
AVERAGE	1,610		

Variable use for the pre-conservation situation was estimated from studies that reported the gallons of hot water used per person or per household. Table 3-45 summarizes the empirical data. Hot water demand was actually measured in some cases, while in others it was calculated. If the figures are converted to kilowatt-hours per person,[25] the average kilowatt-hour use per occupant is approximately 1,400 kilowatt-hours per year. Given the tremendous variation inherent in hot water variable use, this number is reasonably close to the value used in the 1983 and 1986 plans, which is 1,310 kilowatt-hour per occupant for an 80° temperature differential. The Council continued using the 1,310 kilowatt-hours per occupant for base year use, since available data did not dictate a change.

Table 3-45
Variable Demand Use for Hot Water

SOURCE	GALLONS/YEAR PER PERSON	N	NOTES
Lawrence Berkeley Laboratories	5,582		
Natural Resources Defense Council	5,411		Calculated
Seattle City Light	6,019	26	Calculated
Ecotope Heat Pump Study	7,680	38	Submetered participants selected on basis of family size and high water use
Bavir	7,094		Regression results from submetered sample
Long Island Light Co.	6,788	257	Submetered
AVERAGE	6,429 gallons/person/year		

At 90° temperature differential this translates to: 1,399 kWh/person/year

In recent years, considerable end-use monitored data has been collected on total electricity consumption for water heating in the Northwest. Table 3-46 summarizes such data collected through the Hood River Conservation Project, which monitored existing houses in Hood River and the Residential Standards Demonstration Project, which monitored new water heaters in new houses. The new houses are more representative of use with the federal standards in place, since the new houses were primarily built in Washington and Oregon, which have standards already that approximate the federal standard. In addition, Table 3-46 shows the average consumption of end-use monitored houses in the End-Use Loads and Conservation Assessment Program (ELCAP). This information was not available as a function of household size. Further draft information is now available from ELCAP but was received too late to incorporate into this document. It will be evaluated for the next power plan.

25./ This assumes a 90°F temperature differential between the incoming water and the tank setting.

Table 3-46
Measured Consumption of Electric Water Heaters

OCCUPANTS PER HOUSEHOLD	HOOD RIVER CONSERVATION PROJECT CONSUMPTION (kWh/yr)	HOOD RIVER CONSERVATION PROJECT SAMPLE SIZE	RESIDENTIAL STANDARDS DEMONSTRATION PROJECT CONSUMPTION (kWh/yr)	RESIDENTIAL STANDARDS DEMONSTRATION PROJECT SAMPLE SIZE
1	2,843	25	2,764	30
2	4,173	78	3,812	109
3	5,756	26	4,817	93
4	6,253	35	5,541	133
5	7,582	9	5,688	34
6	9,504	6	6,730	18
7	--	--	8,143	8

END-USE LOAD AND CONSERVATION ASSESSMENT PROGRAM (ELCAP) CONSUMPTION (kWh/yr)
5,098

The number of occupants per house according to the forecast is about 2.7 occupants per household in the early years. Using 1,310 kilowatt-hours per occupant and 1,290 kilowatt-hours for standby losses puts consumption at about 4,800 kilowatt-hours per household. This is in the range of monitored use in both the Hood River and RSDP samples for this household size, and seems to be an appropriate estimate of base case electric water heating consumption.

The three primary sources for estimating the savings available from various standby conservation measures were a Seattle City Light (SCL) study, which served as the basis for the 1983 plan figures, a laboratory study conducted by Bonneville in 1984 (Biemer and Auburg) and work conducted for Bonneville by the American Council for an Energy Efficient Economy (ACEEE), which estimated costs and savings available from going beyond the federal water heater standard.

The SCL and Bonneville studies tested R-5 tanks. These studies started with different standby losses (1,610 kilowatt-hour per year for SCL compared to 1,375 kilowatt-hour per year for the Bonneville study) and found different absolute savings estimates. However, the two studies produced comparable results in terms of the relative savings attained for all measures combined, and for two of the four individual measures. The results for each study are shown in Table 3-47. Water heater wraps and thermal traps are the individual measures with the greatest difference. The Council used an average of the percent savings reported in both studies for savings from R-11 wraps, and bottom boards.

Savings for tanks more efficient than the federal standard, which are currently manufactured with thermal traps already installed, were taken from the ACEEE work done for Bonneville. Their analysis indicated a savings of 375 kilowat-hours per year if the tank had 3.0 inches of foam insulation and a thermal trap installed during manufacturing, compared to the federal standard.

Table 3-47
Savings from Water Heating Measures
(kWh/yr at 80° Temperature Differential)

MEASURES	SEATTLE CITY LIGHT[a] SAVINGS (kWh)	SEATTLE CITY LIGHT[a] % OF STANDBY LOSSES SAVED	BIEMER/AUBURG '84[b] SAVINGS (kWh)	BIEMER/AUBURG '84[b] % OF STANDBY LOSSES SAVED
R-20 Tank	700	43.5	550	40.0
R-11 Wrap	100	11.0	192	23.3
Bottom Board	40	4.9	19	3.0
Thermal Trap	180	23.4	74	12.1
Total Percent Savings		63.3		60.7

[a] Based on standby losses for R-5 tank of 1,610 kilowatt-hours per year.

[b] Based on standby losses for R-5 tank of 1,375 kilowatt-hours per year.

ACEEE estimated the retail cost of the more efficient tank to be $21.91 compared to the cost of a tank built to the federal standard. Low costs for the incremental cost of efficient tanks compared to the federal standard are further supported by work done for Bonneville by International Energy Associates and by work done for Pacific Power and Light by Beth Petrie and Gil Peach. Costs for water heater wraps are from Bonneville. Costs for bottom boards, and energy-saving showerheads were adapted from work done at Seattle City Light.

Conservation measures for variable use include clotheswashers and dishwashers that use hot water more efficiently, and energy-saving showerheads. The costs and savings available from efficient clotheswashers and dishwashers and costs for showerheads were taken from work done at Lawrence Berkeley Laboratories (LBL). LBL estimated more efficient clotheswashers would save about 355 kilowatt-hours per year and more efficient dishwashers would save 245 kilowatt-hours per year. Estimates of savings made by the Natural Resources Defense Council for dishwashers are somewhat lower. Energy-saving showerheads are assumed to save 35 percent of the hot water used for showers. More recent information on savings from clotheswashers and dishwashers is available and will be considered for the 1990 Power Plan.

The lifetimes of the measures discussed above are 12 years, except for showerheads at 20 years, and clotheswashers and dishwashers assumed to be 10 years.

It should be noted that the savings for standby loss conservation measures have been reduced to reflect the interaction between internal gains from water heaters and space heating electricity consumption. This is described in a section that follows the analysis of refrigerator and freezer conservation potential.

Base case heat pump water heater costs were taken from work done by the Pacific Northwest Utilities Conference Committee. Heat pump water heater savings are from a research study conducted for Bonneville. This report indicated that heat pump water heaters saved an average 40 percent of total hot water use. Savings are calculated based on estimates in the 1986 plan by assuming that all of the less expensive conservation measures have been installed first. The lifetime of heat pump water heaters is assumed to be 12 years. In a recent study conducted for Oregon Department of Energy, heat pump assumed to be 12 years. In a recent study conducted for Oregon Department of Energy, heat pump lifetimes were found to be much shorter than 12 years. However, the units in this study were primarily from one manufacturer and probably don't represent the average technology today. Consequently, the analysis continues to assume a 12 year lifetime. If heat pumps start to approach the cost-effectiveness threshold, this assumption should be reviewed again at that time with further data.

The costs of solar water heaters were taken from work done by the Oregon Department of Energy, where the system costs of the solar water heaters were derived from state tax forms. The average cost for 154 systems installed between 1985 and 1988 was about $2,680. However, there are suggestions that this value might drop even further from previous estimates, especially in light of a particularly good system that is fairly simple to install and has good reliability, which is becoming more and more popular. The installed cost of this system may drop in time to an average installed cost closer to $2,000. In addition, as pointed out by the solar industry lobby, there may be cost efficiencies that could be captured through large volume sales or increased marketing through utilities. Sensitivities to lower costs and high savings are reported below.

In some cases, where the solar system is a one-tank system, and the house is either replacing an existing water heating tank or it is a new house, the capital cost of the system should be reduced by the cost of the new water heater which did not have to be purchased. However, the most typical configuration of solar systems are two-tank systems. The reduction in capital costs from not purchasing a second tank is not frequently realized and is not accounted for explicitly here.

In addition to installed costs of the system, solar water heaters incur maintenance costs. The recent Oregon Department of Energy study indicated between $170 and $350 (present value) costs for maintenance over the life of the solar system. The 1986 plan used $10 per year, which is a present-value cost of $150. This value is used here over the assumed 20-year lifetime.

There have been about seven studies conducted in the Pacific Northwest concerning savings from solar water heating systems. Savings in these reports ranged from 36 percent to 52 percent of total water heating loads. Because base loads were large in these studies, solar savings were between 1,990 and 2,600 kilowatt-hours per year per house. Pre-solar loads were between 5,060 and 5,800 kilowatt-hours per year. These large loads were sometimes due to large family size (large families tend to use more hot water) and sometimes because the solar system necessitated adding a second tank to the water heater, which resulted both in more standby losses, as well as more savings.

One of the more recent and thorough of the solar studies, prepared for Oregon Department of Energy by Dave Robison, reported savings that were right in the range of the previous studies. The sample size in this study was 337, and the results indicated a 43-percent savings, or an absolute value of 2,200 kilowatt-hours per year. Pre-solar use was on the order of 5,300 kilowatt-hours per year. This was for a family size of about 3.2 people per household. Using the water heating values from this chapter, a 40-percent savings off the pre-conservation loads would result in 1,775 kilowatt-hour savings, and a 40-percent savings off the post-conservation loads would result in 1,400 kilowatt-hour savings. These two values probably bracket the average savings that would be expected from an average family in the region after other, more cost-effective measures are applied. This suggests a value on the order of 1,600 kilowatt-hours per year as the base estimate of savings for average conditions. A back-of-the-envelope correction to the Oregon Department of Energy work to account for the smaller average household size in the region compared to the Oregon Department of Energy's sample puts savings at about 1,850 kilowatt-hours per year. However, the Oregon Department of Energy study did not have all conservation measures in the base case, and so solar savings were probably larger than if cheaper conservation measures had been installed first.

As noted above, households that use more than the average amount of hot water would have higher base use than assumed and higher savings. Consequently, in a sensitivity case, savings are taken to be 2,200 kilowatt-hours per year, which was found in the Oregon Department of Energy's study.

As shown in Table 3-48, the levelized cost of solar water heaters under average conditions does not reach the initial cost-effectiveness threshold.

Combining the information on average costs and savings described above results in a levelized cost, assuming a 20-year life of 127 mills per kilowatt-hour. However, if costs were to drop to $2,000 and savings increased to represent the average found in the Oregon Department of Energy's study of 2,200 kilowatt-hours per year, the levelized cost would drop to 70 mills per kilowatt-hour. The 55 mills per kilowatt-hour cut-off would be achieved if installation costs were to drop to $1,550 if savings are 2,200 kilowatt-hours per year and $1,075 if savings are 1,600 kilowatt-hours per year. These values do not say, however, that a solar water heating system would not be cost-effective for a particular family that consumes significant amounts of hot water, or can purchase and install a solar water heater for lower than average costs.

The above assumptions led to the cost-effectiveness calculation for each measure shown in Table 3-48. This table assumes an average household with 2.4 occupants, which is the forecast value for out-years of the forecast. It shows the marginal cost of each water heating conservation measure, starting with a tank that meets the federal appliance standard for 1990. Except for heat pumps, solar water heaters and bottom boards, none of the measures exceeds 5.5 cents per kilowatt-hour, even after taking into account the interactive effect with space heating. Bottom boards are on the margin of being cost-effective and would certainly be so if other measures could not be installed. The analysis suggests that tanks that are more energy efficient than the federal standard,[26] wrapped with insulating blankets, and all variable reduction measures, are cost-effective.

26./ The tank analyzed here incorporates a thermal trap into the unit during manufacture.

Table 3-48
Measure Costs and Savings for Water Heaters

MEASURE	MEASURE COST	SAVINGS	SAVINGS WITH INTERACTION[b]	(mills/kWh)
Base Use = 4,434 kWh/Year (EF = .88)				
Base Case	$0.00	0	0	0.00
Showerhead	$37.46	450	450	5.99
Efficient Clotheswasher	$24.10	355	355	8.67
Efficient Tank w/Thermal Trap (EF = .94)	$21.91	330	273	8.74
Efficient Dishwasher	$24.10	245	245	12.56
R-11 Wrap	$46.44	165	137	37.05
Bottom Board	$13.74	31	26	59.71
Heat Pump	$1,630.00	1,400	1,400[c]	127
Solar Water Heater[a]	$2,680.00	1,600	1,600	127

[a] Without heat pump installed.

[b] This reflects the reduced savings from standby loss measures due to the interaction with electric space heating.

[c] Interaction with space heating is not included in this estimate of savings.

Step 2. Develop Conservation Supply Functions for Technical and Achievable Potential

The savings for each measure were multiplied by the number of units existing in 2010 to which that measure applied. The number of electric water heaters was taken as the number of units existing in 2010. The number of electric water heaters that appears in the forecast between 1995 and 2010 would overcount the number of water heaters in 2010, since the average lifetime of water heaters is shorter than the 15 years between 1995 and 2010 and consequently some replacements would be occurring. The savings from showerheads are assumed to be limited by the number of houses likely to be built between 1995 and 2010 with electric water heaters. However, if every house that has an electric water heater also used an energy saving showerhead, an additional 80 average megawatts of technical potential could be included in the high demand forecast. As a conservatism, this is not currently included in the technical potential. The number of clotheswashers and dishwashers is assumed to track the number of electric water heaters in 2010 with saturations of 78 percent and 50 percent respectively. The number of units was then multiplied by the achievable saturation, also measure-specific, that the Council felt could be secured between 1995 and 2010. The number of units and the achievable saturation for the high demand forecast appear in Table 3-49.

Table 3-49
Number of Eligible Units by 2010 and Achievable Conservation Percent
for Water Heating Measures
High Demand Forecast

MEASURE	NUMBER	ACHIEVABLE PERCENT
Efficient Showerheads	1,814,096	90%
Efficient Clotheswashers	3,737,908	50%
Efficient Dishwashers	2,396,096	50%
Efficient Tanks with Thermal Trap	4,792,192	90%
R-11 Wrap	4,792,192	85%
Bottom Board	4,792,192	85%

Step 3. Calibrate the Supply Curve to the Council's Forecast and Incorporate Behavioral Impacts on the Savings Estimates

The engineering and field measurements described above predict a base water heater use of between 4,434 and 4,827 kilowatt-hours per year depending on the number of occupants in the average household. As mentioned above, these figures represent standby losses at the level of the federal standard. In the medium demand forecast, base case use in 2010 at the frozen efficiency level of the federal standard is 3,923 kilowatt-hours per year. For purposes of the supply curve, the difference between the forecast base case use and the engineering base case use was assumed to be due to variations in the operation of hot water consuming appliances. This difference reduced the supply curve somewhat for each of these appliances to account for the different base case uses. The base case in the forecast is used to derive the relative efficiency changes from conservation measures. Since the consumption of the average water heater at the avoided cost cut-off is 3,219 kilowatt-hours per year, the cost-effective relative efficiency improvement holding behavior constant is 0.82.

This relative efficiency change was incorporated in the forecast and energy consumption after all measures were installed was estimated. The value that resulted from this process is very similar to the engineering estimate and reflects very little forecasted behavioral change. Savings for the average water heater are the difference between base use of 3,923 and use after the conservation measures are installed. Because there are different penetration rates on each measure, and measures can only be applied if the appliance is present (for example, a dishwasher), the savings-weighted penetration rate is 0.77.

The amount of conservation available in the high demand forecast can then be estimated as the number of new water heaters times the weighted penetration rate times the estimate of cost-effective savings. The megawatts available in the high demand forecast at various costs is presented in Table 3-50.

Table 3-50
Conservation Available from Water Heaters

LEVELIZED COST (cents/kWh)	CUMULATIVE TECHNICAL POTENTIAL (average megawatts)
1	285
2	330
3	360
4	385
5	385
6	400
7	400

Conservation in Other Residential Appliances

Approximately one-quarter of the electricity currently consumed in the residential sector is used to operate refrigerators, freezers, stoves and lights. This section describes the conservation assessment for refrigerators that contain freezers (hereafter called refrigerators) and freezers.

The conservation potential from replacing traditional incandescent bulbs with fluorescent bulbs that fit into incandescent sockets in residential applications is not estimated. While the lifetime of the fluorescent replacements is longer than the incandescent bulb, it is still a short-lived measure. There is no guarantee that the fluorescent bulb will be replaced in kind, not only because there is a first-cost barrier, but also because these bulbs are still often perceived as changing the appearance and amenity of a residential setting.

The Council estimates 136 average megawatts of technical savings available from conservation in refrigerators and freezers. At an average levelized cost of 1.1 cents per kilowatt-hour for refrigerators and 1.2 cents per kilowatt-hour for freezers, these savings are one of the most cost-effective conservation resources available to the region. If administrative costs and transmission and distribution adjustments are included, the levelized costs are 1.2 and 1.3 cents per kilowatt-hour, respectively.

The average megawatts currently identified for refrigerators and freezers represent a little less than half of the available conservation presented in the 1986 Power Plan. Most of this reduction results from a new federal appliance efficiency act, discussed below, which regulates the minimum efficiency of new appliances. Some of the savings estimated in the 1986 plan have essentially been incorporated in the forecast of electricity demand as reduced use. This change illustrates the effectiveness of appliance standards at acquiring conservation resources.

The savings identified by the Council are based on cost-effective efficiency improvements that go beyond recent federal legislation. The National Appliance Energy Conservation Act was passed by Congress and signed by President Reagan in early 1987. It sets an initial maximum energy consumption level for refrigerators and freezers (as well as other home appliances) that becomes effective for any unit sold in or after 1990. The federal law also requires a review of these initial standards for refrigerators and freezers in 1990 that could lead to more stringent standards in future years. This initial review has been released in draft form. Any changes to the federal standard will be incorporated into future revisions to the power plan. In the meantime, the Council's forecast of electricity demand has already incorporated the use implied by the federal 1990 standard, which has become the base case against which further efficiency improvements are measured.

The current analysis shows that cost-effective efficiency improvements beyond the 1990 federal standard are achievable. The Council's savings reflect the impact of improving the federal appliance standards during the Energy Secretary's review in 1990. Alternatively, the savings could be secured in this region if the legislatures of the Northwest states adopted more stringent codes and applied to the Department of Energy for an exemption to the federal codes. The conservation resource is modeled as revised appliance standards that become effective in 1995. The level of the estimated revised standard is equivalent to standards set by California before the federal legislation was passed, which would have become effective in that state in 1992.[27] From this point on, this standard is referred to as the 1992 California standard. The Council found that refrigerators and freezers that significantly exceed the California 1992 standard are not yet commercially available, although engineering estimates indicate that technologies able to beat the 1992 standards are attainable. An alternative design refrigerator that exceeds the energy requirement of California's 1992 standard by about two-thirds can be purchased today, but only at a high price because each unit is handmade. This refrigerator further corroborates the engineering estimates that refrigerators can be made to beat the 1992 California standards. Savings from exceeding the standard are substantial and represent a promising resource for future evaluations of conservation potential if such units become commercially available.

The Council used two steps to evaluate the savings available from refrigerator and freezer efficiency improvements. These were to:

1. Estimate the cost and savings potential available from improved refrigerator and freezer efficiency.

2. Develop technical and achievable conservation potential and calibrate the conservation potential to the Council's forecast.

Step 1. Estimate the Costs and Savings Potential Available from Improved Refrigerator and Freezer Efficiency

The potential for saving energy from improved refrigerator and freezer operating efficiencies is well documented. The U.S. Department of Energy (DOE) and the California Energy Commission (CEC) have reviewed the option of appliance efficiency standards. In addition, DOE is currently reviewing further refrigerator and freezer standards. This current review has draft savings and cost information which will be incorporated into the Council's process when the information becomes final. The earlier DOE proceeding, which occurred in the early 1980s, limited investigation of efficiency improvement design options to those based on "available" technology. Available technology was defined by DOE as those technologies implemented in units available and sold in 1980. In addition, the DOE analysis only included options that had a payback period of less than five years. The payback period for an energy-saving design option is the length of time it takes an average consumer (in this case, a national consumer) to recover the higher purchase price through the lower cost of energy used to operate the appliance. Both these limits significantly reduced the efficiency options evaluated by DOE.

The California Energy Commission hearings included technologies that went beyond the measures analyzed in the DOE hearings. Therefore, a larger and broader set of designs was considered for reducing

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27./ California's 1992 standards were also the efficiency level targeted in the 1986 Power Plan. California's 1992 standard is automatically preempted by the Federal standard if the Secretary of the Department of Energy acts to review the level of the federal standards by January 1, 1990. However, California's standard becomes effective automatically in 1993, and is automatically waived from federal pre-emption if the Secretary fails to act.

refrigerator and freezer energy consumption. From these proceedings, the California Energy Commission adopted revised refrigerator and freezer standards.[28] The level of efficiency chosen for California's revised standard, to become effective in 1992, was set at about the strongest level investigated by DOE. As a consequence, this standard did not include the additional measures that emerged during the California Energy Commission hearings.

In 1987, subsequent to the passage of the National Appliance Energy Conservation Act, Geller and Morrill prepared a report for the Bonneville Power Administration that analyzed the impact of the new federal standard for 1990 in the Pacific Northwest and evaluated further efficiency improvements. Their analysis was based on two other reports; one by the Natural Resources Defense Council and the other by researchers at Lawrence Berkeley Laboratories, both of which relied heavily on the earlier DOE and California Energy Commission work. These analyses investigated the potential costs and savings from more energy-efficient freezers and refrigerators. Geller and Morrill expanded these reports and applied them to the Pacific Northwest. In particular, they accounted for the distribution of types of refrigerators and freezers found in the Northwest. These analyses also included both commercially available technology and advanced technology that was known but not yet commercially available. Since Geller and Morrill include the most recent estimates of conservation costs and savings under assumptions that encompass both the federal 1990 standard and efficiency improvements beyond, their work forms the basis for this analysis of conservation potential in refrigerators and freezers. However, information from Geller and Morrill had to be adjusted for the interaction with space heating needs (described in the following section) and for re-ordering measures so they were applied with the most cost-effective measure first.

In this analysis, the Council used a 17-cubic-foot automatic defrost with a top-mounted freezer as a prototype to represent refrigerators, and a 16-cubic-foot manual defrost upright freezer to represent freezers. About 61 percent of the refrigerators sold in the region have top-mounted (as opposed to side-by-side) freezers. Automatic defrost units represent approximately 78 percent of the refrigerators sold today. Likewise, about 62 percent of freezers sold in the region are uprights.

To get a feel for how the various standards affect consumption, take the example of a frost-free 17-cubic-foot refrigerator. The Association of Home Appliance Manufacturers (AHAM) estimates that the average unit of this sort sold in 1983 consumed about 1,156 kilowatt-hours per year. The 1990 federal standard requires that this same refrigerator consume no more than 943 kilowatt-hours per year. Furthermore, the level of consumption used in this analysis, which is equal to California's pending 1992 standard, would be further reduced to only 672 kilowatt-hours, nearly half the consumption in 1983.

This analysis evaluates cost-effectiveness from the perspective of the region and the individual consumer. Table 3-51 presents cost and savings information for the prototype 17-cubic-foot refrigerator. Savings and levelized costs include the interaction of appliance efficiency improvements with space heating requirements, described more fully in the next section.

28./ As noted above, the standard adopted by California that was to become effective in 1992 will be preempted by federal standards if the Secretary of the Department of Energy reviews its standard by 1990. If the Secretary fails, California's 1992 standard will automatically become effective in 1993.

Table 3-51
Measure Cost and Savings for Prototype Refrigerators[a]

	USE (kWh/yr)	MEASURE COST	CUMULATIVE COST	COST OF SAVINGS (cents/kWh)[b]	DISCOUNTED LIFE-CYCLE COST[c]
Base Case in Geller and Morrill	1,100	$0	$0	0	$1,082
Compressor EER 3.65[d]	965	6.57	6.57	0.4	1,046
3.0" Cabinet Insulation, 2.5" Door Insulation[e]	846	8.76	15.33	0.6	1,017
External Fan Motor	796	3.29	18.62	0.6	1,005
2.4" Cabinet Insulation, 2.0" Freezer Insulation	681	23.00	41.62	1.7	992
Compressor 4.5 EER	551	28.48	70.10	1.8	979
More Efficient Fan	520	12.05	82.15	3.3	981
Double Freezer Gasket	508	24.10	106.25	17.1	1,002
Double Gasket - Door	490	54.77	161.01	25.8	1,051

[a] Analysis is for a 17-cubic-foot automatic defrost refrigerator with a top-mounted freezer.

[b] Adjusted for space heat interaction.

[c] Parameters used for the life-cycle cost analysis include: 10 percent consumer discount rate, 22-year lifetime, zero electricity price escalation, and an average residential rate of 4.5 cents per kilowatt-hour.

[d] EER - Energy-Efficiency Ratio.

[e] The costs and savings for the (3.0'/2.5') insulation combination are the marginal costs and savings from increasing insulation from the (2.5"/2.0") combination. In this table, these two measures occur out of order. But, since neither is included in the 1990 standard and both are included in the 1992 standard, this situation does not affect the analysis.

The costs of measures and their savings were evaluated starting with the base case used by Geller and Morrill. These costs and savings are used to represent the relative efficiency improvement available, even though particular refrigerators may have some of the efficiency improvements already installed. If this is the situation, the base case is just moved further down the curve of efficiency and cost to represent currently sold units that have incorporated some of the measures listed in the table. However, since a measure's levelized cost is independent of where the base case originates on the curve, it is probably a reasonable evaluation of levelized costs of representative measures.

Improving the efficiency of the prototype refrigerator to the level where the last measure installed has a marginal cost less than 5.5 cents per kilowatt-hour, a new prototypical 17-cubic-foot refrigerator would save 423 kilowatt-hours per year beyond the federal standard of 943 kilowatt-hours per year. This efficiency improvement results in a total consumption of about 520 kilowatt-hours per year. The purchase and operation costs of the refrigerator over its lifetime (life-cycle cost) at a 10-percent discount rate is less at the cost-effectiveness limit (a consumption of 520 kilowatt-hours per year) than at the base case. However, the 5.5 cents per kilowatt-hour cost-effectiveness limit results in a lower energy use than the 1992 California standard, which has been selected as representing commercial feasibility in this analysis of conservation potential. The 1992 California standard results in electricity use of about 672 kilowatt-hours per year for the prototype refrigerator. This efficiency level can be attained for a marginal measure cost of about 1.7 cents per kilowatt-hour, and results in a net reduction in life-cycle cost.

For the average stock of refrigerators in the Pacific Northwest, instead of the prototype, the level of California's 1992 standard is about 691 kilowatt-hours per year and the level of the federal 1990 standard is about 905 per kilowatt-hour a year. These levels were used for the Council's conservation assessment. Savings per unit were calculated by subtracting this average use from the average use at the 1990 federal standard.

The costs and savings for measures that can be applied to the prototype upright freezer appear in Table 3-52. Slightly less extensive analysis was done on the conservation potential in freezers than on refrigerators in all studies used in this analysis. Consumption of the prototype freezer is reduced from the federal standard level of 724 kilowatt-hours per year to 556 kilowatt-hours per year if the level of California's 1992 standard is adopted either nationally or in the region. All measures investigated resulted in lower purchase and operating costs than the base case over the life of the freezer.

The 1992 California standard for the mix of freezers available in the Pacific Northwest instead of the prototype is about 492 kilowatt-hours per year. The federal 1990 standard is about 636 kilowatt-hours per year. As in refrigerators, this level was used to establish the Council's limit of available and reliable conservation for freezers.

Table 3-52
Measure Cost and Savings for Prototype Freezers [a]

	USE (kWh/yr)	MEASURE COST	CUMULATIVE COST	COST OF SAVINGS (cents/kWh)[b]	DISCOUNTED LIFE-CYCLE COST[c]
Base Case in Geller and Morrill	882	$0	$0	0	$826
Compressor EER 3.65[d]	738	2.19	2.19	0.1	779
Compressor EER 4.5	609	8.76	10.95	0.5	744
2.5" Foam in Door	543	7.67	18.62	0.9	729
More Efficient Fan	490	12.05	30.67	1.8	723
External Fan Motor	477	3.29	33.96	1.9	721
Double Gasket	461	26.29	60.24	12.7	742

[a] Analysis is for a 16-cubic-foot upright freezer with manual defrost.

[b] Adjusted for space heat interaction.

[c] Parameters used for the life-cycle cost analysis are: 10-percent consumer-discount rate, 22-year lifetime, zero electricity price escalation, and an average residential rate of 4.5 cents per kilowatt-hour.

[d] EER - Energy-Efficiency Ratio.

Step 2. Develop Conservation Supply Functions for Technical and Achievable Potential Consistent with the Council's Forecast

The savings resulting from improvement to the level of the 1992 California standards for refrigerators and freezers were multiplied by the number of refrigerators and freezers purchased between 1995 and 2010, as predicted in the Council's high forecast. Since the energy load that has to be met by thermal plants after conservation actions are taken is determined by the forecast, the savings from conservation measures in refrigerators and freezers has to be evaluated consistently with the values carried in the forecasting model.

The Council's forecasting model, which now includes the 1990 federal appliance standards, was used to estimate the base case use of refrigerators and freezers in the year 2010 with efficiencies frozen at the 1990 federal standards. In the medium demand forecast, new refrigerators use 905 kilowatt-hours per year and freezers use 636 kilowatt-hours per year for the average refrigerator and freezer purchased in the region.

For refrigerators, a base use of 905 kilowatt-hours per year and a conservation cut-off of 691 kilowatt-hours per year resulted in a total technical potential:

$$101\ \text{MWa} = \frac{5{,}174{,}000\ (\text{refrigerators purchased 1995 - 2010}) \times (905 - 691)\ (\text{kilowatt-hours per year}) \times (1 - .2)\ (\text{space heat interaction})}{8{,}766{,}000\ (\text{kilowatt-hours per average megawatt})}$$

For freezers, a base case use of 636 kilowatt-hours per year and a conservation cut-off of 492 kilowatt-hours per year, resulted in a total technical potential:

$$35\ \text{MWa} = \frac{2{,}427{,}000\ (\text{freezers purchased 1995 - 2010}) \times (636 - 492)\ (\text{kilowatt-hours per year}) \times (1 - .13)\ (\text{space heat interaction})}{8{,}766{,}000\ (\text{kilowatt-hours per average megawatt})}$$

These technically achievable savings were then reduced by 10 percent to account for non-compliance with the standards, resulting in a total achievable conservation potential for refrigerators and freezers of 122 average megawatts.

The Interaction Between Internal Gains and Electric Space Heat

A house is warmed by a combination of internal and external heat sources. Internal heat comes from incidental or waste heat given off by appliances and people (usually called "internal gains") and from the space heater. The external source of heat is primarily radiant energy from the sun (usually called "solar gains"). These heating sources are in balance, and if the heat produced by any one of them decreases, more heat must be added from the other components to keep the house at the same temperature. This section explains the interaction between the waste heat given off by appliances and the heat supplied by the space heater.[29]

If the efficiency of an appliance, such as a refrigerator, located inside the heated space improves, the unit both uses less energy and gives off less waste heat. This change in turn causes the space heater to use more electricity in order to keep the house at the same temperature it was before the improvement in the refrigerator's efficiency occurred.

The balance between the decrease in electricity consumption by the refrigerator and the increase in use for extra space heating depends on many factors. One prominent factor is the insulation level of the house. The better insulated a dwelling is, the less useful the waste heat from the appliance. For example, the space heater must produce about an additional 5 kilowatt-hours per year for every 10 kilowatt-hours per year saved by the appliance efficiency improvement, assuming all of the following: the appliance is located in the heated space, electricity is the space heating fuel, no air conditioning is installed, and the house is not fully insulated. In other words, only 50 percent of the savings from improving appliance efficiency would be realized. This estimate accounts for periods of the year, such as summer, when additional space heat is not necessary.

29./ Solar gains are considered constant in this discussion.

This estimate must be tempered by other intervening variables to calculate the average expected impact on the Northwest electrical system from improved appliance efficiencies. First, the appliance must be one that produces internal gains. Many do not; for example, about half the electric freezers in the region are located outside heated areas. Waste heat generated from freezers (and other appliances) that are outside the heated shell of the house does not contribute to internal gains. Consequently, any efficiency improvements in appliances located outside the house would be fully realized as 100-percent energy savings and would not require that additional heat be provided by the furnace.

Second, a number of electrical appliances that do produce internal gains, such as refrigerators, are located in houses that do not use electricity for their space heating. In this case, the full amount of electricity saved by improving the appliance's efficiency is realized by the region's electrical system.

Finally, the reduction of internal gains benefits the house if air-conditioning equipment is installed. In this case, less cooling needs to be provided in the summer to offset the internal gains from inefficient appliances.

For water heaters, only the standby use of hot water held in the tank (for units located in the house) is an internal gain. Variable hot water demand does not contribute significantly to internal gains, even though it uses electricity.[30] Consequently, only efficiency improvements in standby use for tanks located in the house increase the heat needed from the space heater.

When all of these factors are considered, electricity used for space heating must make up, on average in the region, about 17 percent, 20 percent and 13 percent of the savings from standby losses on water heaters, refrigerators and freezers, respectively. These figures were used to devalue the savings obtainable from these appliances in the preceding cost-effectiveness evaluations.

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COMMERCIAL SECTOR

The commercial sector consumed approximately 22 percent of the region's total energy sales in 1987, or about 3,530 average megawatts. This sector's energy consumption is dominated by space heating, cooling and lighting.

The commercial sector consists of many diverse buildings that use electricity in myriad ways. Because of the complexity of electricity use, much less precision is possible for estimating the conservation potential in this sector compared to the residential sector. For example, while three prototype residential buildings may encompass a majority of the energy consuming characteristics in residential buildings, the 10 prototypes in the commercial analysis, each modeled twice as new and existing buildings, only start to reflect the wide range of energy consuming characteristics found in commercial buildings.

This section evaluates the conservation potential from the array of traditional commercial buildings, such as offices and schools, as well as from less well known sources, such as pumping in municipal waste-water treatment plants. Because of their unique nature, waste water treatment plants are discussed in a separate section at the end of the text on commercial buildings. The commercial sector estimates include savings from both privately and publicly owned buildings.

The Council's current assessment of cost-effective efficiency improvements for existing and new commercial buildings starts with engineering estimates from 10 prototype commercial buildings. These estimates of savings are translated into relative efficiency improvements which are then installed in the forecasting model to estimate realized savings that are consistent with the load forecast. The engineering estimates of relative savings were also compared to experience from a regional program. The savings presented here from new commercial buildings reflect the conservation potential beyond the savings secured by the 1986 Oregon and Washington Energy Codes. Figure 3-16 shows the amount of commercial sector conservation available at various costs in existing and new buildings and waste-water treatment facilities.

In the high demand forecast, the Council estimates a total of approximately 630 average megawatts of technical conservation potential in existing commercial buildings. This consists of 215 average megawatts in public service territories and 415 average megawatts in private service territories. The Council estimates a total of at least 555 average megawatts from new commercial buildings beyond current state building codes. This estimate consists of 270 average megawatts in public service territories and 285 in private service territories. The measures that were used in the prototype analysis to derive these conservation estimates need to be investigated further before the next power plan is developed. There are very likely further cost-effective efficiency improvements in lighting and heating. That will add to the resource used here. Fifteen average megawatts are available from waste-water treatment facilities, 6 average megawatts from public service territories and 9 average megawatts from private service territories.

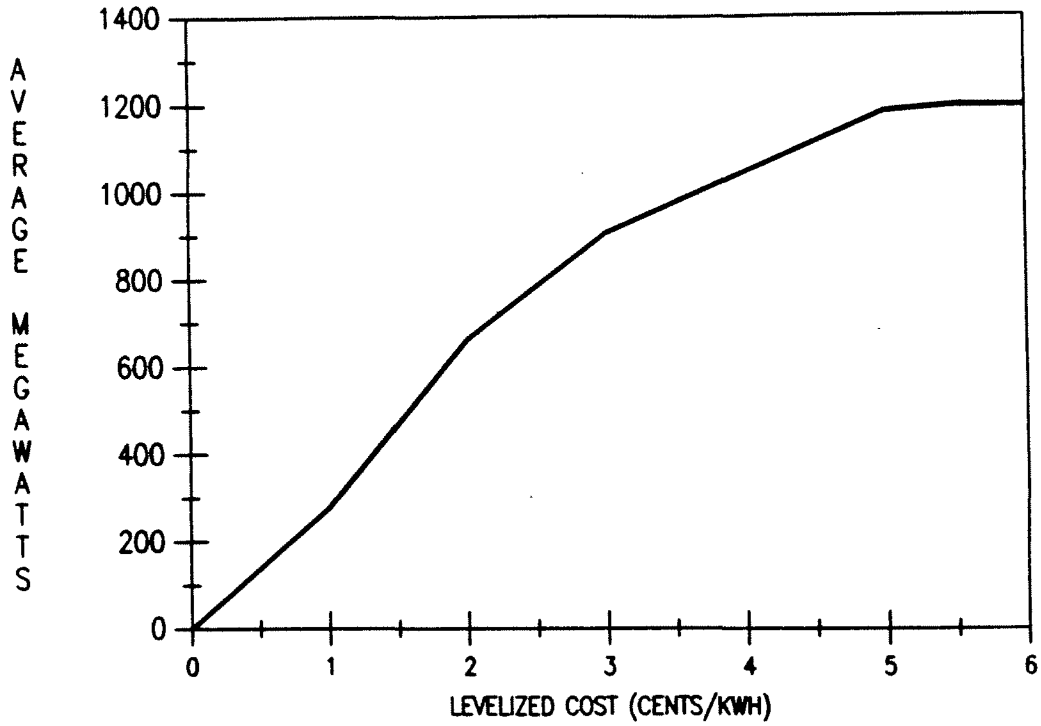

Figure 3-16
Technical Conservation Potential from the Commercial Sector

For existing commercial buildings, 530 average megawatts out of the 630 average megawatts of technical potential are achievable in the high forecast. For new commercial buildings, about 470 average megawatts of the technical potential are achievable in the high forecast. Achievable savings from existing commercial buildings are available at an average cost of 2.3 cents per kilowatt-hour. Achievable savings from new commercial buildings are available at an average cost of about 2.0 cents per kilowatt-hour. These levelized costs escalate to 2.5 and 2.2 cents per kilowatt-hour respectively if administrative costs and transmission and distribution adjustments are included. Like new residences, new commercial buildings will last longer than the current electrical surplus. It is important to build these structures efficiently in order to avoid losing a cost-effective conservation resource.

The Council's estimate of conservation savings from the commercial sector involved the following three steps:

1. Identify the current regional average consumption for typical existing and new commercial buildings.

2. Evaluate cost-effective efficiency improvements in existing and new commercial buildings.

3. Develop estimates of realizable potential for conservation at various costs in new and existing commercial buildings that are consistent with the Council's load forecasts.

Step 1. Identify the Current Regional Average Consumption for Typical Existing and New Commercial Buildings

The Council's commercial sector forecasting model contains representations of 10 building categories. Table 3-53 shows the annual energy use for all-electric[31] commercial buildings that comprised the stock in 1979 as estimated by the Council's forecast. This table also presents billing data information collected by Energuard and billing data information collected by the Commercial Audit Program (CAP). These two programs combined have large sample sizes for many of the building types. There is quite good agreement between the forecast estimates and data from billing records. For the forecast's restaurant category, there is a large discrepancy because the forecast includes all types of restaurants, including sit-down and fast-food, while the billing data is from fast-food restaurants only. Fast-food restaurants have very high energy use per square foot because they usually are quite small and serve a large number of meals per day. The warehouse category also has a large variance between one of the billing data samples and the forecast. This could be due to small sample size. It should be remembered that, while there is reasonable agreement between the forecast and billing data for average values, for most of these building categories a tremendous variation exists in use in any given building.

To convey the relative importance of each building type in the analysis, the last column of Table 3-53 shows the percent of total electricity consumption for existing buildings in 2010 by building type. These percentages account for the fact that not all end uses require electricity as their fuel. Office and retail buildings are far and above the most crucial building types for determining electricity consumption in existing commercial buildings. These two building types alone represent almost 50 percent of projected electricity consumption in the year 2010 in currently existing commercial buildings.

31./ The term all-electric means that every end use in the building uses electricity as the fuel. The electricity consumption of the average building will be lower, since some end uses, for example water heating or cooking, can be fueled by gas.

Table 3-53
Summary of Annual Energy Use for Existing Commercial Buildings Located in the Region
(All-electric Buildings)

BUILDING TYPE (SAMPLE SIZE = N)	COMMERCIAL AUDIT PROGRAM (kWh/sq ft/yr)	ENERGUARD DATA (kWh/sq ft/yr)	COUNCIL'S FORECAST (1979 STOCK) (kWh/sq ft/yr)	BUILDING TYPE'S PERCENT OF TOTAL ELECTRICITY CONSUMPTION IN 2010
Office	28[a] (N=579)	27 (N=157)	27	30%
Retail	21 (N=681)	22 (N=581)	20	19%
Grocery	57[a] (N=198)	61 (N=336)	70	7%
Restaurant			38	5%
Fast-Food	133 (N=47)	116 (N=20)		
Hotel/Motel	26 (N=61)	23 (N=6)	21	2%
Health		29 (N=30)	20	6%
Hospital	81[b] (N=22)			
School	24[b] (N=61)	20 (N=146)	22	9%
College		inc. in "Schools"	20	4%
Warehouse	12 (N=43)	20 (N=77)	23	3%
Other		22 (N=41)	20	16%

[a] Consumption data for this building type was augmented by information from PURPA.

[b] Consumption data for this building type was augmented by information from the Institutional Buildings Program (IBP) and the Institutional Conservation Program (ICP).

In comparing the billing data shown in Table 3-53 and the forecast model assumptions, three factors should be kept in mind. First, the buildings with billing data shown in Table 3-53 were not selected to be statistically representative of the average. Second, the annual use figures in Table 3-53 represent each building's total energy use regardless of the fuel source. Total energy use is then converted to kilowatt-hours per square foot. Since many of these buildings use natural gas or fuel oil for some end uses, the conversion efficiencies of these fuels are included in the figures. In contrast, the figures from the Council's forecast shown here assume that all the energy requirements of the building are supplied by electricity. Third, the year of operation for the buildings in the sample is mostly prior to 1985, and the forecast figures use 1979 as the operating year.

Less data are available on the actual energy use of newly built commercial buildings in the region. Table 3-54 shows energy use data that is available from new commercial buildings. The Council's forecast assumptions on new commercial buildings built to 1980 practice appear first in Table 3-54. These buildings are assumed to meet the level of ASHRAE 90-80A,[32] which represents the level of Oregon and Washington state building codes in 1980. The second column shows available data from work done by a Bonneville contractor and from work at the Oregon Department of Energy on billing information in recently built commercial buildings. This can be compared to billing data collected primarily through the Commercial Audit Program (CAP), which is shown in the third column. The final column in Table 3-54 shows the

32./ ASHRAE stands for the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. This organization sets various standards for building practices based on consensus.

percent of electricity consumption in the year 2010 represented by each building type. Again, offices and retail stores are the most important building types in terms of expected electricity consumption in 2010 if buildings continued to be constructed to 1986 codes. These building types are followed in importance by restaurants and groceries.

Table 3-54
Summary of Annual Energy Use for New Commercial Buildings Located in the Region (All-electric Buildings)

	1980 PRACTICE FROM FORECAST (kWh/sq ft/yr)	SAMPLE OF CURRENT PRACTICE (APPROXIMATELY 1980 CONSTRUCTION) (SAMPLE SIZE = N) (kWh/sq ft/yr)		BUILDING TYPE'S PERCENT OF TOTAL ELECTRICITY CON-SUMPTION IN 2010
		OREGON SURVEY	COMMERCIAL AUDIT PROGRAM	
Office	27	19 (N = 14)	21 (N = 159)	20%
Restaurant	30	–		12%
Fast-Food	n/a		141 (N = 16)	
Retail	20	22 (N = 8)	20 (N = 135)	17%
Grocery	58	44 (N = 1)	70 (N = 46)	11%
Warehouse	34	18 (N = 1)	15 (N = 5)	5%
School	22	16 (N = 3)	12 (N = 2)	9%
College	20	22 (N = 1)	–	3%
Health	16	–	–	9%
Hotel/Motel	13	–	23 (N = 12)	7%
Miscellaneous	14	28 (N = 2)	–	7%

The comparison of values in Table 3-54 needs to be qualified. First, the forecast figures for both 1980 practice and estimated 1988 practice assume an all-electric building; consequently, fuel conversion efficiencies are not incorporated. In contrast, the average use figures for current practice buildings are for total energy and include fuel conversion efficiencies. Second, the sample size of energy consumption in new buildings is very small, except for offices and retail, and buildings were not selected to represent the region.

Step 2. Evaluate the Efficiency Improvement Available in Existing and New Commercial Buildings

For both new and existing buildings, the estimates of cost-effective efficiency changes, and costs to achieve these changes are based primarily on work done for Bonneville by United Industries Corporation. This work develops base case energy use and savings and costs from adding conservation measures for 10 prototype buildings. For existing commercial buildings, each prototype is modeled to reflect existing stock in 1979. To represent new commercial buildings, each prototype was modified to reflect how a new building of this prototype would have been built in 1980. The base case use of each building prototype was calibrated to billing data available for that building type. These are the values that are listed in Tables 3-53 and 3-54 from the Commercial Audit Program.

Costs and savings from installing conservation measures were estimated after the base case was calibrated to billing data. Commercial conservation measures can have significant interaction with one another. For example, making lighting more efficient can save electricity both from the lights and from the cooling load of the building. But if the building has a greater heating load than cooling load, then more heating will be required when the more efficient lights are installed. Because of these and other interactions, savings that are evaluated from installing one individual measure can be under- or overestimated compared to the savings that can be achieved when a package of conservation measures is installed. To the extent possible, the savings estimates take into account the interaction of the package of measures installed in the building.

The types of measures that are applied to the prototype buildings fall primarily into the categories of lighting improvements; improvements to the heating, ventilating and cooling equipment; improvements to the building shell; and refrigeration improvements. Lighting measures include efficient lamps and ballasts, and more efficient reflectors. Heating, ventilating and cooling improvements included such measures as economizers to use outside air to cool, variable air volume controls and radiant heaters where applicable. Building structure measures included roof and wall insulation and more efficient windows. Refrigeration improvements were measured in a study done for Bonneville by ADM Associates. Regrigeration savings applied only to grocery stores and restaurants.

As with any prototype work, some of the measures applied to the prototype building would not apply to a particular building if an audit were done on it. Conversely, there may be measures that can be applied to the audited building that are not included in the prototype analysis. Essentially, the measures used in the prototype analysis are simply a proxy for the costs and savings that one could expect to achieve in the great variety of buildings that the prototype represents. The actual measures that are installed to secure the savings may vary significantly, however, from those in the prototype analysis. The prototype work used here has come under close scrutiny, since there are some indications that significant measures might have been left out. The Council is committed to reviewing this information and has agreed to further refine the numbers for the next power plan.

Table 3-55 shows the present-value cost and the percent savings per square foot if all measures costing less than 55 mills per kilowatt-hour are added to the prototypes that represent existing buildings. The table also shows the pre-conservation consumption estimate for each prototype building, which reflects the stock in 1979. These savings can be compared to savings estimates from Puget Power's retrofit program collected for the 1986 Power Plan. Puget's information is shown in Table 3-56. Some of the prototype buildings in Table 3-55 result in estimates of savings and use close to those reported by Puget, while others are quite different. Some of the differences may stem from the representativeness of the prototypes. For example, the hospital prototype does not encompass general health care buildings such as doctor's offices and laboratories, while Puget's audit program may have included these. The vintage of the buildings in Puget's program is also unknown compared to the prototypes. Finally, it is not clear how the cost of measures recommended in Puget's program compares with the 55 mill levelized cost used to cut off the conservation measures in the prototype analysis. It appears that significant savings can be achieved by retrofitting existing buildings, from 12 percent to over 40 percent of the energy used.

Table 3-55
Costs and Percent Savings for Conservation
in Existing (1979 Vintage) Commercial Buildings:
Prototype Analysis[a]

	PRESENT-VALUE COST (per sq ft)	PERCENT SAVINGS	AVERAGE LEVELIZED COST OF MEASURES (mills/kWh)	BASE CASE USE (kWh/sq ft/yr)
Office	$4.08	25%	26	29
Retail	$2.35	28%	19	19
Fast-Food Restaurant	$22.17	29%	31	123
Warehouse	$1.48	42%	15	12
Hospital	$1.39	12%	9	64
Schools	$3.36	41%	20[b]	21
Grocery	$4.77	25%	17	58
Hotel	$2.35	23%	19	28

[a] These values are for an all-electric building.

Table 3-57 shows cost and savings information similar to Table 3-55 for new buildings. The present-value cost per square foot is based on the installation, operation and maintenance costs of the measures. It includes replacement costs if the measures have a shorter lifetime than the expected lifetime of the building. Currently, the analysis uses 30 years as the remaining life for existing commercial buildings, and 45 years as the expected life of new commercial buildings consistent with assumptions embodied in the load forecast.

Table 3-56
Retrofit Savings from Existing Commercial Buildings:
Puget Power's Program[a]

BUILDING TYPE (Sample Size = N)	PERCENT SAVINGS FROM AVERAGE USE	AVERAGE USE OF PROGRAM BUILDINGS (PRE-RETROFIT) (kWh/sq ft/yr)
Office (N=62)	30%	26
Retail (N=11)	16%	25
Grocery (N=36)	23%	62
Restaurant (N=10)	22%	89
Hotel (N=2)	16%	24
Hospital (N=30)	28%	29
School (N=28)	17%	24
Warehouse (N=4)	26%	16
Other (N=8)	21%	22

Average savings = 22%
Average savings weighted by building type = 22%

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a Program offers measures such as heating, ventilating and air-conditioning modifications, glazing and insulation, lighting measures and some process modifications.

A significant problem that surfaces from the prototype analysis is that in some cases the prototypes used for the conservation analysis poorly represent the building categories used in the load forecast. For example, a fast-food restaurant was modeled as the restaurant prototype, but the restaurant category in the forecast includes fast-food restaurants, cafeterias and leisure dining. Extra care was taken to make the prototypes for offices and retail stores consistent with the categories used in the load forecast because these are the most important building types. However, limited information prevented this kind of extensive modeling on some of the other building types.

A discussion of how the prototypes were used to represent the forecast building categories follows. For the building categories of offices, retail stores, schools and groceries, the levelized costs and percent savings estimates from the prototypes were used directly to represent savings off the 1979 or 1980 base.[33]

For the restaurant category in the forecast, the fast-food prototype was assumed to represent 14 percent of the restaurant floor space and this portion received all the costs and savings for the fast food prototype. The residual 86 percent of restaurant floor space was assumed to save only the costs and savings that were available on the prototype for lights and heating, ventilating and air conditioning.

For hotels/motels, the hotel prototype was assumed to represent 41 percent of the floor space, and this received all the costs and savings modeled in the prototype. The remaining 59 percent of hotel/motel floor space was given the costs and savings from lighting improvements only modeled on the prototype.

33./ As described in subsequent paragraphs, these baselines were reduced to account for retrofitting since 1979, and new building codes that went into effect after 1980.

For warehouses, the prototype was assumed to represent 32 percent of the floor space and all the costs and savings were attributed to this portion. For the remaining 68 percent of floor space, lighting costs and savings only from the prototype were used.

The building categories of health and college were represented as a mix of the other building prototypes. The health sector in the forecasting model includes laboratories, nursing homes, offices and hospitals. The prototype represents only hospitals. The mix of other prototypes that was used to represent the forecast health category was: 49 percent hospital, 34 percent small office and 17 percent hotel. There was no prototype developed for colleges, but the mix of prototypes that was used to represent this forecast category was: 21 percent school, 13 percent small office, 12 percent restaurant, 1 percent hospital, 20 percent hotel and 33 percent miscellaneous.

Finally, the miscellaneous building category was assumed to achieve a 15 percent savings over the 1979 base case for existing buildings and 1980 base case for new buildings at an average cost of 2.5 cents per kilowatt-hour.

Table 3-57
Costs and Percent Savings for Conservation in New (1980 Vintage) Commercial Buildings Prototype Analysis[a]

	PRESENT-VALUE COST (per sq ft)	PERCENT SAVINGS	AVERAGE LEVELIZED COST OF MEASURES (mills/kWh)	BASE CASE USE (kWh/sq ft)
Office	$3.52	32%	20	21
Retail	$2.35	36%	14	18
Fast-Food Restaurant	$21.34	26%	26	126
Warehouse	$1.90	42%	19	9
Hospital	$1.65	14%	8	62
Schools	$0.56	7%	33	10
Grocery	$5.33	28%	12	62
Hotel	$1.46	13%	19	24

a These values are based on an all-electric building.

Table 3-58 shows the actual percent savings and levelized costs that were estimated for each of the forecast building categories at a 55 mill per kilowatt-hour cutoff after all these adjustments were made. The efficiency level achieved after all cost-effective improvements are made in existing buildings built before 1980 is also the efficiency level assumed for buildings constructed between 1980 and 1986. While these buildings are probably more efficient to begin with than the average pre-1979 stock, there are still savings to be secured. The assumption here is that they can be taken to a similar post-conservation efficiency level at a similar cost to the pre-1979 stock.

Table 3-58
Percent Savings and Levelized Cost Estimated for the Forecast Building Categories[a]

	EXISTING STOCK (1979 BASE)		NEW CONSTRUCTION (1980 BASE)	
	% Savings	Levelized Cost (mills/kWh)	% Savings	Levelized Cost (mills/kWh)
Office	25%	26	32%	20
Retail	28%	19	36%	14
Grocery	25%	17	28%	12
Restaurant	24%	35	25%	31
Hotel/Motel	12%	25	8%	18
Health	16%	15	22%	15
Elementary/Secondary	41%	20	7%	33
College	22%	16	17%	25
Warehouse	18%	18	19%	21
Miscellaneous	15%	25	15%	25

[a] Based on an all-electric building.

Another problem that is created by the prototype analysis stems from the year used as the base case. Table 3-58 indicates the cost-effective savings available from existing buildings in 1979, and new buildings built in 1980. However, between 1979 and 1988, some retrofit activity has diminished the conservation resource in existing buildings. And new buildings built after 1980 will already be complying with new energy codes that were adopted after 1980; consequently, the conservation potential in new commercial buildings is also reduced compared to Table 3-58. For existing commercial buildings, the savings that have already occurred through retrofitting are estimated using the forecasting model. The forecast estimates that an average 23 percent of the cost-effective savings available in Table 3-58 have already occurred by 1988 for the existing stock. Since this estimate is derived using the forecasting model, it is consistent with the forecast's estimates of fuel saturations. The fact that 22 percent of the savings is already achieved also means that some of the costs have also been incurred. The simplifying assumption made in this analysis is that the very cheapest measures were used to achieve the 22-percent savings that occurred between 1979 and 1988. This means that the rest of the savings potential identified in Table 3-58 is more expensive than the savings that have already been achieved. Both the average savings and average costs summarized in this chapter incorporate the reduction in savings and increase in cost from retrofit activity that has occurred since 1979.

A similar problem exists for new commercial buildings. Oregon and Washington, which represent a significant portion of expected new commercial growth, adopted more stringent commercial building codes in 1986. Since the savings estimates in Table 3-58 are based on new construction in 1980, the effect of the more stringent codes must be removed to determine the remaining conservation potential that is yet to be secured. For the values in this draft, this was accomplished by estimating the reduction in energy use in new commercial buildings as a consequence of the 1986 codes. This estimate was taken from work done by Battelle Pacific Northwest Laboratories for the Council combined with some estimates using the prototypes in this conservation analysis.

The amount of savings resulting from the 1986 codes was estimated using the forecasting model. About 47 percent of the total savings represented in Table 3-58 are secured through current building codes if those codes are fully enforced. These codes (but with only partial compliance) are represented in the load forecasts. The remaining 53 percent is yet to be achieved through both strengthened codes and programs. It is important to note that this estimate of savings from existing codes assumes that the energy related portions of those codes, such as lighting budgets and insulation, are being enforced. If these codes are not currently enforced, much of the conservation that is already counted as secured will be lost.

Step 3. Develop Estimates of Technical Realizable Potential for Conservation in New and Existing Commercial Buildings, Consistent with the Load Forecast

The total regional savings available from conservation potential in new and existing buildings was estimated using the Council's commercial sector forecasting models as described below.

First, this sector's demand was forecast assuming efficiency improvements that represented retrofitting existing buildings through 1988, and efficiency improvements that represented new buildings built to existing state building codes. Then the percent improvement represented by the 55 mill conservation cutoff was imposed on each building type, and the demand for electricity was re-estimated. The difference between projected demand at current 1988 efficiencies and demand with the technical conservation improvements represented the total technical conservation. Achievable potential was then estimated by reducing the conservation potential by 85 percent.

In the Council's high forecast, approximately 530 average megawatts are achievable in existing buildings and 470 average megawatts in new commercial buildings. As mentioned above, the Council is committed to reviewing further measures that can be applied to these prototype buildings, which is likely to increase savings. Table 3-59 shows the technical conservation that is available at a given cost in the high demand forecast. While the megawatts at 55 mills are based on an aggregation of the prototypes, the shape of the supply curve is based on the distribution of savings from the office and retail prototypes only, and consequently should simply be viewed as an approximation of the shape of the curve.

Table 3-59
Technical Conservation from Commercial Buildings

LEVELIZED COST (cents/kWh)	CUMULATIVE MEGAWATTS NEW	EXISTING	TOTAL
1.0	220	50	270
2.0	415	240	655
3.0	460	435	895
4.0	520	515	1,035
5.0	550	620	1,170
5.5	555	630	1,185

It should be noted that the current estimate does not separate the conservation potential in governmental buildings from the rest of the commercial sector. Bonneville sponsored a project that attempted a census of institutional buildings and extrapolated the results from respondents to non-respondents. Some results from this census produced anomalies when compared to the forecast assumptions in the 1986 plan. For example, the floor space reported in schools exceeded the floor space allocated to this building type in the Council's commercial sector forecast by 24 percent. When additional information becomes available to enable a reasonable calibration, the Council will separate the conservation potential in government buildings from the general commercial sector.

Waste-Water Treatment

A report on waste-water facilities produced by a Bonneville contractor provides some of the information used to estimate conservation potential in this sector. In addition to this work, the Council conducted a telephone survey in 1985 of municipal water systems in the region's major population centers to determine the approximate size of pre-conservation loads.

The Council's assessment of conservation relies on data collected in the telephone survey and on a review of Environmental Protection Agency data on the 550 waste-water treatment plants in the Pacific Northwest. In addition, energy use and energy conservation audit information from plants outside the region were used to assess the costs and potential energy savings from 15 cost-effective conservation measures.

In waste-water treatment plants the treatment processes themselves account for the largest use of energy. Energy required for lighting and heating, ventilating and air conditioning equipment is less significant than the energy required for pumping, aeration and sludge treatment. Of these in-plant processes, the electrical energy used to operate pumps and motors accounts for the largest energy demand. The conservation potential estimated here does not include potential generation of electricity from methane cogeneration potential.

Of the 15 energy conservation measures analyzed, only one, the installation of high-efficiency motors, was found to exceed 5.5 cents per kilowatt-hour and was therefore not considered in the analysis. Table 3-60 shows the total estimated technical savings at about 15 average megawatts based on an estimated load of 68 average megawatts. Achievable savings were estimated to be about 85 percent of the technical potential, or about 13 average megawatts. This achievable proportion was separated into public and private utility service territories according to the conservation potential estimated for existing commercial buildings.

Table 3-60
Technical Conservation from Waste-Water Treatment Facilities

LEVELIZED COST (cents/kWh)	CUMULATIVE MEGAWATTS
1.0	8
2.0	8
3.0	10
4.0	14
5.0	15
5.5	15
6.0	15

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INDUSTRIAL SECTOR

In 1987, firm sales to the industrial sector were 6,620 average megawatts, which is about 41 percent of firm loads. About 37 percent of total industrial demand for electricity was consumed by the direct service industries, which are mainly the aluminum industry, and some chemical and other primary metal producers. The largest consumers among the non-direct service industries are lumber and wood products, pulp and paper, chemicals, food processing and primary metals.

The Council assumes 260 average megawatts as the technical and achievable conservation potential from non-direct service industries, and an additional 20 megawatts from direct service industries. Savings from the conservation/modernization program for direct service industries have already been incorporated as a reduction in the load forecast. The savings from the conservation/modernization program are expected to be 220 megawatts when the smelters are operating at full capacity. The estimated conservation potential for the non-direct service industrial customers is about 6.5 percent of industrial use in 1986. These 280 megawatts of savings from direct service industries and non-direct service industry customers cost an average of about 1.9 cents per kilowatt-hour. This escalates to about 2.1 cents per kilowatt hour if administrative costs and transmission and distribution adjustments are incorporated. Figure 3-17 depicts the amount of conservation available at various costs. Conservation in new industrial plants and processes will increase this estimate. Programs are currently being developed by Bonneville to capture lost-opportunity conservation in the industrial sector.

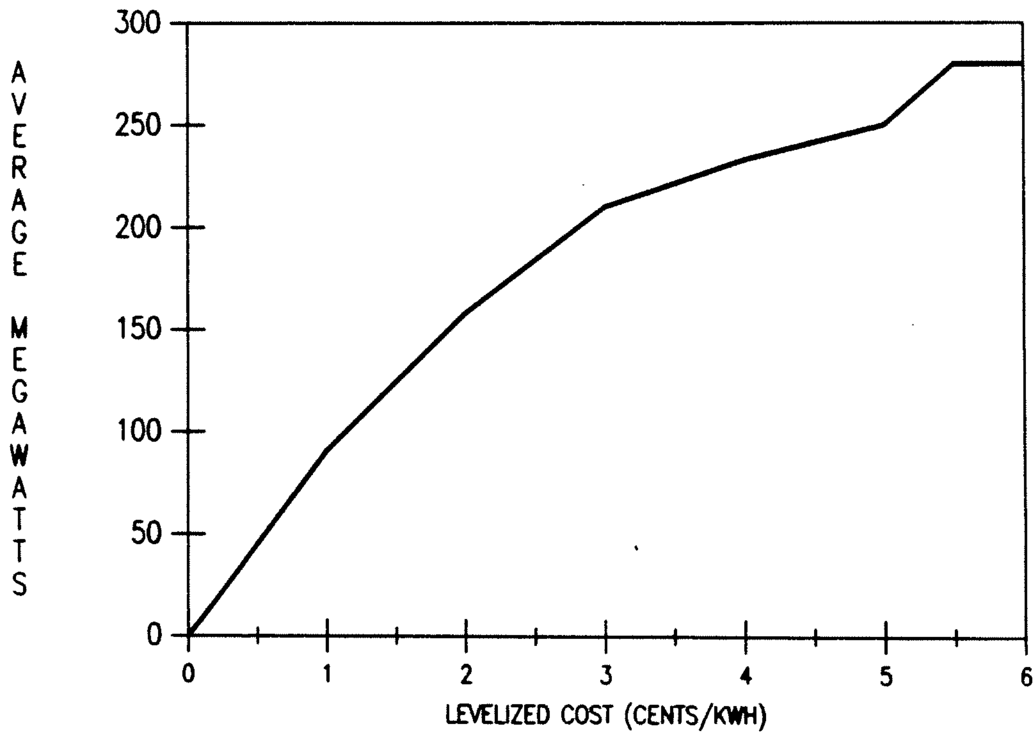

Figure 3-17
Technical Conservation Potential from the Industrial Sector

Assessing the technical and economic potential for industrial conservation presents a more difficult problem than in any other sector. Not only are industrial uses of electricity more diverse than in the commercial sector, but the conservation potential is also more site-specific. Moreover, because energy use frequently plays a major role in industrial processes, many industries consider energy-use data proprietary. For new industrial plants, estimating conservation potential is not yet possible, because incoming plants are quite specific in their energy use, and a "base-case" plant from which to estimate savings has not been established. All these factors make it difficult to estimate conservation savings. However, the Council is committed to reviewing the estimate of industrial conservation and lost-opportunity resources in the industrial sector over the next year. Preliminary indications are that considerably more conservation may be achievable from the industrial sector.

In the past, industrial representatives have been skeptical of studies that estimate the potential of industrial conservation based on a typical plant within an industry. Such studies extrapolate results from a typical plant to estimate the potential for the whole industry. Industry spokespeople argued that "typical" plants do not exist for most industries. Among other reasons, differences in product lines and the age of plants do not allow comparison of individual plants within the same industry. Industrial representatives were concerned that even though their plants were not like the typical plant used in the analyses, policies and programs affecting them would be developed based on those analyses.

For these reasons, in the 1983 and 1986 power plans the Council did not attempt to draw upon or redo studies based on the typical plant approach. Instead, in the 1983 plan, the Council relied on estimates supplied by industry in response to a Council survey. The Council also conducted an analysis of its own that attempted to estimate industrial conservation potential by specific end uses, such as motors, lights, etc. This approach had some of the same problems of the typical plant analysis--lack of information about how electricity was used in the various plants.

In preparation for the 1986 Power Plan, the Council considered ways to estimate conservation potential in the region's industries that would have the support of industrial representatives. The approach that received such support was a survey asking individual plant managers to estimate conservation potentials in their specific plant. The surveys were coordinated by industry trade associations such as Northwest Pulp and Paper Association and the Industrial Customers of Northwest Utilities. Data from specific firms were masked to protect proprietary data. Each firm was asked how much conservation would be available at specified prices in each of four areas: 1) motors, 2) motor controls, 3) lighting, and 4) other, a category that depended on the nature of the firm. The firm was also asked to estimate the lifetime of equipment in each of the four categories. Finally, since the Council and industrial representatives did not want to follow this survey with yet another, firms were asked to estimate how much cogeneration would be available to the region at specified prices per kilowatt-hour.

The survey was sent to over 200 industrial firms in the Northwest. Forty-seven of the surveys were returned, representing 70 percent of industrial electricity use in the region. Non-direct service industries that returned surveys represent 52 percent of the non-direct service industry regional load. The results of survey respondents were extrapolated to non-respondents in order to capture regional conservation potential in the industrial sector.

The results of this survey, less most of the conservation from the direct service industries, which has already been included as a reduction in the load forecast, are presented in Table 3-61. The Council's plan includes developing 280 average megawatts of the currently identified conservation potential in the industrial sector at an average cost of 1.9 cents per kilowatt-hour. This escalates to 2.1 cents per kilowatt hour if administrative costs and transmission and distribution adjustments are included. This conservation is both technically available and achievable, since the survey identified what could and would be done for given prices.

Table 3-61
Industrial Sector Technical Conservation Potential

LEVELIZED COST (cents/kWh)	CUMULATIVE POTENTIAL (Megawatts)
1.0	90
2.0	160
3.0	210
4.0	235
5.0	250
5.5	280
8.0	285

References

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IRRIGATION SECTOR

In 1987, the region's irrigated agriculture consumed nearly 620 average megawatts of electricity, less than 4 percent of the region's total consumption. The technical potential for conservation measures, evaluated with a marginal measure not exceeding a cost of 5.5 cents per kilowatt-hour, is 90 average megawatts. The Council's plan calls for developing up to 85 percent of this potential, or 75 average megawatts. This represents about 12 percent of electricity use for irrigation in 2010 and is available at an average cost of about 1.7 cents per kilowatt-hour. This average cost increases to 1.9 cents per kilowatt hour if administrative costs and transmission and distribution adjustments are incorporated. Figure 3-18 depicts irrigation sector conservation available at various costs.

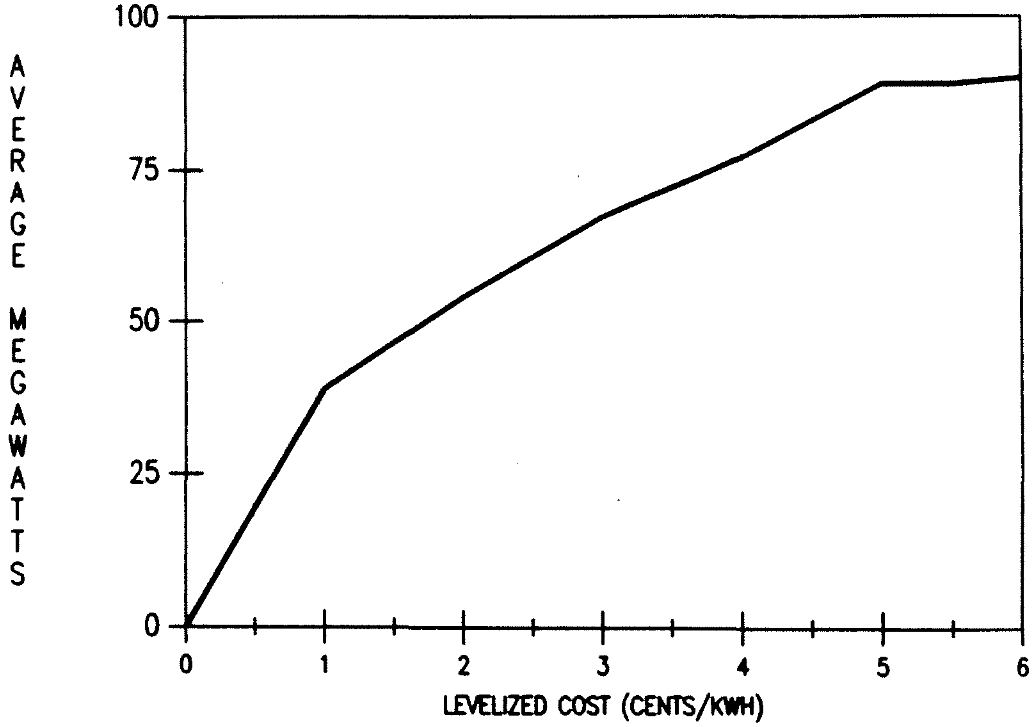

Figure 3-18
Technical Conservation Potential from the Irrigation Sector

The conservation resource in public utility service areas is estimated to be 30 megawatts or 40 percent of the total potential. The conservation resource in the private utility service areas is 46 megawatts or 60 percent of the total potential. This split is based on the proportion of total irrigation loads in the Council forecast, not including Bureau of Reclamation loads.

The Council's assessment of conservation potential for this sector involved the following two steps:

1. Evaluate the end-use conservation measures to be included in the supply curve analysis.

2. Estimate realizable conservation potential by using the cost and potential savings data available from the Irrigation Sector Energy Planning Model, and compare the relationship of the cost and savings data derived from the base load forecast used by Bonneville with the Council's load forecasts.

Step 1. Evaluate the End-use Conservation Measures to be Included in the Analysis

In the 1986 Power Plan, the Council relied on estimates of conservation potential in irrigated agriculture provided by a Bonneville contractor. At the time, the research represented the most complete picture of energy conservation opportunities in the region's irrigation sector. Since that time, Bonneville's irrigation research contractor has updated its analytical studies in order to better characterize the irrigation sector. This effort has produced improved baseline data which the Council used to prepare its assessment of the conservation potentials in this sector. The primary effect of this updated information is a reduction in the potential savings previously estimated for the 1986 supply curve for irrigation.

A major reason for this reduction is based on evidence from the Bonneville Irrigation Conservation Program that indicates irrigators are unwilling at this time to adopt use of low pressure measures on many handmove and sideroll systems. While Bonneville is sponsoring research on low pressure nozzles for application in these systems, there is sufficient uncertainty at this time about when significant penetration of this measure would occur.

In addition, based on survey results, irrigators are continuing to take conservation actions at a greater rate than previously assumed, thereby reducing the amount of potential conservation available.

Finally, a new conservation measure, energy-efficient motors, is now included in this supply curve.

The conservation opportunities considered in the 1988 irrigation supply curve estimates include:

- low pressure irrigation on center-pivot systems;
- fittings redesign;
- main line modifications;
- improved scheduling; and
- energy-efficient motors.

Low pressure irrigation involves using sprinkler or spray application devices designed to operate at lower pressures than conventional sprinkler devices. These low pressure devices can be divided into three major types: low pressure spray heads, low pressure impact sprinklers and drop tubes.

The fittings of an irrigation system include valves, elbow joints and other components used to connect the irrigation pump to the pipes of the system and to connect the pipes within the system to each other. Fittings redesign involves using larger tapered fittings to replace valves and elbows that are too small or that change abruptly in size and direction.

Main line modification involves increasing the size of the system's main line, resulting in decreased energy losses due to friction. This redesign generally can be accomplished most economically by installing a second main line pipe parallel to the existing one.

Improved scheduling involves the improvements in both timing and amount of water applications. This reduces water use without reducing crop yields, and energy use is reduced due to a decrease in pumping requirements. Scheduling is the cornerstone of a basic comprehensive management approach to efficient water and energy management, with all other conservation measures being necessary components. Research results indicate that scheduling is easier to implement on center pivot systems than on handmove and sideroll systems.

Energy-efficient electric motors are those that are manufactured with materials and designs that reduce the level of energy losses compared to standard electric motors. The electric motors are used to operate water pumps.

Step 2. Estimate Realizable Conservation Potential

Conservation supply estimates for the irrigation sector were developed using the Irrigation Sector Energy Planning Model (ISEP). The model combines both engineering and economic principles to derive energy savings and levelized costs per kilowatt-hour for conservation investments. The average megawatts available at various costs are displayed in Table 3-62.

The model uses a number of baseline data inputs, including estimates of crop-specific acreages in 11 subbasins in the region; type of irrigation systems used; pumping lift; pumping plant efficiencies; estimates of water application volumes to specific crops by irrigation system type; and system operating pressures. The model also uses rough estimates of conservation measures believed to have been applied on existing acreages and subtracts these estimated savings prior to calculating the remaining conservation potential. ISEP has incorporated new information from Bonneville's Stage I irrigation system audits and irrigator surveys which indicates that irrigators have increased conservation achievements over previous estimates assumed in the model.

In a test of the model to estimate the baseline energy use for 1985 regional irrigation loads, the ISEP model estimates were within 3 percent of the load estimated from 1985 billing records. This indicates a high degree of confidence for this part of the model.

Table 3-62
Irrigation Sector Technical Conservation Potential

LEVELIZED COST (cents/kwh)	AVERAGE MEGAWATTS EXISTING LAND	NEW LAND	TOTAL
1	10	20	30
2	30	25	55
3	40	25	65
4	50	30	80
5	60	30	90
6	60	30	90

References

Harrer, B.J., Bailey, B.M., A Reassessment of Conservation Opportunities in the Irrigated Agriculture Sector of the Pacific Northwest Region, Battelle Pacific Northwest Laboratory, December 1987.

Chapter 4

Generating Resources

THE COST AND AVAILABILITY OF NEW HYDROELECTRIC POWER

Existing Pacific Northwest hydropower projects provide about 29,800 megawatts of capacity and about 12,300 megawatts of firm energy (Appendix 6-A of Volume II of the 1986 Power Plan). But most environmentally acceptable large-scale hydropower sites in the Pacific Northwest have been developed. Hydropower that can still be developed includes irrigation, flood control and other non-power water projects that could be retrofitted with generation equipment; addition of generating equipment to existing hydropower projects; plus some undeveloped sites that may be suitable for development.

Generation Technology

Hydropower projects extract energy from falling water and require operating head (vertical drop) and water flow. Projects may be instream, diversions, canals or conduits. Instream projects use operating head created by a dam, which backs water up the stream channel. Sometimes the dam may impound sufficient water to permit regulation of streamflow so power can be generated when needed. Such projects are called storage projects. If sufficient reservoir storage is not present to allow streamflow regulation, power is generated as streamflows permit. These are called run-of-river projects.

In a diversion project, water is diverted from the stream by a diversion structure (dam or weir) and transmitted to a downstream powerhouse by a canal or conduit. The operating head is determined by the difference in elevation between the diversion structure and the powerhouse. Sometimes the diversion structure is a high dam that may provide additional operating head or storage to permit regulated power production.

A canal or conduit project involves a powerhouse using operating head present on non-power water conveyance structures such as irrigation canals and municipal water supply conduits.

Constraints to Development

Hydropower is a renewable energy source and is free from toxic emissions. However, its effect on stream characteristics may create environmental problems. Dams and reservoirs transform a portion of the natural stream channel to a slack water impoundment. This may inundate land and stream features and will cause ecological changes to the stream and adjacent areas. In a diversion project, adequate streamflows must be maintained in the natural channel for biological and aesthetic purposes. Dams, diversion structures and powerhouses may form barriers to the natural movement of fish. Provisions for fish passage and protection from turbines may be required. Canal and conduit projects are generally environmentally benign; however, because conduits and canals are themselves conveyance structures for a non-power diversion, consideration must be given to effects of project operation on flows in the natural channel.

The Council intends that future hydropower development be undertaken in an environmentally responsible manner. To achieve this objective, future hydropower development is expected to comply with the Council's protected areas policies. In addition, all hydropower development, regardless of location, should include actions to mitigate environmental impacts to the extent practicable. Unavoidable impacts should be thoroughly considered when assessing the cost-effectiveness of a project. The Council expects that future hydropower development will comply with the conditions of development set forth in Appendix II-B of the 1986 Power Plan and Section 1100 of the 1987 Fish and Wildlife Program.

Resource Cost and Availability

When developing the 1983 Power Plan, the Council reviewed estimates of achievable new hydropower ranging from 450 average megawatts to as much as 2,377 average megawatts at a levelized cost of 4 cents per kilowatt-hour, or less (1980 dollars). The Council included 920 megawatts of firm energy (1,150 megawatts of average energy) of cost-effective new hydropower in the 1983 Power Plan.

Concerns regarding the environmental impact of new hydropower, and particularly, the possibility of conflict with the Council's fish and wildlife program led the Council to seek improved information regarding potential new hydropower sites and the streams potentially impacted by this development. The need for better information concerning hydropower sites resulted, through the joint efforts of the Council, the Corps of Engineers and Bonneville, in development of the Pacific Northwest Hydropower Site Database (Corps of Engineers, 1986). This database contains location, cost, and performance information on all hydropower projects in the Pacific Northwest that have been submitted to the Federal Energy Regulatory Commission for permitting, licensing or exemption. It also includes sites identified by the Corps of Engineers National Hydropower Survey. Associated with the site database are computer algorithms for estimating project capacity, energy production and cost.

The need to better understand the qualities of streams affected by proposed hydroelectric development led the Council and Bonneville, with the assistance of federal agencies, the states and the tribes, to undertake a comprehensive assessment and evaluation of regional river resource values. The scope of this work included anadromous fish, resident fish, wildlife, natural features, cultural features, recreation and Indian cultural sites. Approximately 134,000 stream miles were surveyed, representing 39 percent of the region's total. Not included in this inventory are most streams that are currently protected from hydropower development by federal legislation (for example, streams located within National Wilderness Areas), and small headwater streams. Each stream reach is classified as to the presence or absence of anadromous fish and ranked, using four levels of value, on each of the other resources. The resulting information is maintained by Bonneville and the Council on a computer database.

The Hydropower Site Database and the Hydropower Assessment Study were incomplete at the time the 1986 Power Plan was developed. For that reason, the Council used a conservative estimate of 200 megawatts of firm energy potentially available from future hydropower development. This represented the proportion of 920 megawatts of firm hydropower appearing in the 1983 plan that could be obtained by development of sites having existing dams, diversions or other water control structures.[1]

The Hydropower Site Database and the results of the river values assessment are now available. In addition, the Council has designated protected stream reaches to assist in maintaining high value anadromous fish, resident fish and wildlife habitat. The availability of new hydropower can now be assessed using considerably improved information.

Using the information from the Hydropower Site Database and the river values assessment process, and considering the constraints to development established by existing federal stream protection and the

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1./ Less about 55 megawatts of firm energy that had been obtained by development of existing water control structures between the 1983 and 1986 plans.

Council's protected areas, the Council has concluded that about 410 megawatts of firm energy is potentially available from new hydropower development at costs of 6 cents per kilowatt-hour or less. This estimate was derived as described below:

Technical Potential

The technical potential for new hydropower development is based upon an inventory of physically independent proposed projects located within the four-state region. (The portion of Montana east of the Continental Divide was excluded.) Projects include those that have been active, at any time, in the Federal Energy Regulatory Commission permitting and licensing process. Pumped storage projects are excluded since these are not net energy producers. Proposed federal projects are not included because of the current lack of information on these projects. Though it is planned to expand the Hydropower Site Database to include federal projects, their current omission should not greatly affect the estimate of developable hydropower since many of the better federal sites have been filed on by non-federal developers and therefore are included in the technical potential.

Institutional Constraints

Projects included in the technical potential were screened to eliminate those that are prohibited by institutional constraints. Two screens were used--current federal stream protection and the Council's protected areas policy. It was assumed that no development would occur in areas currently having federal protection. These areas include wilderness areas, national parks, and stream reaches included in the National Wild and Scenic Rivers System. Projects not complying with the Council's protected areas rule were eliminated from further consideration. The protected areas rule permits no new hydropower development within protected stream reaches, except for projects meeting the following criteria:

- Projects located within protected reaches, but licensed or exempted prior to August 10, 1989 are considered to potentially be developable.
- Power additions to existing power or non-power water control structures located within protected areas are considered to potentially be developable.

Developable Potential

About 590 projects passed the institutional screens described above (Table 4-1, end of this chapter). The Council recognizes that even projects passing these screens could have environmental problems that may preclude development. Moreover, the technical characteristics of many of these sites have not been fully explored, leading to the possibility that development may not be feasible from engineering or economic bases. Probabilities of development were estimated to account for this. Probabilities of development were estimated using the Hydropower Supply Model developed for the Bonneville Power Administration by Ott Water Engineers (Ott, 1987). This model calculates two probabilities of development for each project.

One probability is based upon the river resource values of the affected stream reach. This probability is provided in Table 4-1 under the column entitled "River." A second probability is based upon the current permitting or licensing status of the project. This probability is shown in Table 4-1 under the heading "Regul." The lowest of the two probabilities is selected as the probability of development for the project. This probability is shown in Table 4-1 under the heading "Final." The final probability of development is applied to the energy potential of the project to obtain a probable energy contribution. (Two columns on the right of Table 4-1.) The probable contributions of individual projects are summed to obtain regionwide potential. (In real life, projects will either be developed or they will not. This method, however, produces a statistical estimate of the expected developable hydropower energy without the need to determine if specific individual projects should be developed--a determination that would be inappropriate given the limited information available to the Council on specific projects and stream reaches.)

Economic Potential

No cost constraints were placed upon the estimate of developable potential. The process of estimating potential yielded about 1,230 megawatts of hydropower capacity, sorted into "bins" representing different levels of capital cost.

The levelized life-cycle energy cost of each "bin" of potential was calculated using assumptions consistent with other resources being assessed in the 1988 Power Plan Update. These assumptions are as follows:

- Year dollars - January 1988
- Operating life - 50 years
- Amortization period - 30 years
- Tax depreciation period - 20 years
- Discount rate - 3 percent real / 8.2 percent nominal
- Cost of equity - 8.5 percent real / 13.9 percent nominal
- Cost of debt - 7.0 percent real / 12.4 percent nominal
- Debt/equity ratio - 80/20

These assumptions are representative of those used by investor-owned utilities. They were used here to simulate energy cost at a level of risk equivalent to that implicit in the financial assumptions used for other resources. The actual price of power from these projects would vary by the type of developer (investor-owned utility, publicly owned utility or independent power producer), and the specific allocation of risk between the purchasing utility and the developer.

Developer-supplied cost information was used where available. Where developer-supplied information was not available, the cost algorithm of the Hydropower Site Database was used to estimate project development costs. Neither developer-supplied nor algorithm-generated costs were available for some projects. The energy contribution of these projects was distributed in proportion to the energy contribution of projects for which cost estimates were available. As described in the "Institutional Constraints" paragraph above, certain projects, though located in protected stream reaches, could be developed providing they meet certain criteria. The estimated cost of developing these projects was increased by 10 percent, because it is expected that the costs for licensing and engineering these projects would be greater than if the projects were not located in protected areas.

The resulting supply curve of likely developable hydropower is shown in Table 4-2. The "likely developable" supply of new hydropower is estimated to consist of about 1,060 megawatts of new hydropower capacity. This capacity would be capable of supplying about 510 megawatts of average energy and about 410 megawatts of firm energy at costs of 6 cents per kilowatt-hour or less.[2]

2./ Energy costs were computed on the basis of average energy for the purposes of this assessment. The differing values of firm and secondary energy are accounted for when new hydropower resources are evaluated in the Decision Model.

Table 4-2
Cost and Availability of New Hydropower - Likely Developable

LEVELIZED COST[a] (cents/kWh)	AVERAGE ENERGY INCREMENTAL (MWa)	AVERAGE ENERGY CUMULATIVE (MWa)	FIRM ENERGY INCREMENTAL (MWa)	FIRM ENERGY CUMULATIVE (MWa)
0 - 1.1	9	9	7	7
1.2 - 1.6	33	42	26	33
1.6 - 2.2	14	56	11	44
2.3 - 2.7	58	114	46	90
2.7 - 3.3	74	188	59	149
3.4 - 3.8	55	243	44	193
3.9 - 4.4	86	329	69	262
4.4 - 4.9	72	401	58	320
5.0 - 5.5	88	489	70	390
5.6 - 6.0	23	512	18	408

a 1988 dollars.

Two additional studies were conducted to estimate possible upper and lower bounds to new hydropower availability. To estimate the possible upper bound of hydropower availability, a study was performed in which each potentially developable site (sites passing the institutional screens) was assumed to be developed with a 100-percent probability of development. This assumption yields about 2,300 megawatts of new hydropower capacity, capable of producing about 1,100 megawatts of average energy and about 900 megawatts of firm energy at 6 cents per kilowatt-hour, or less. This upper-bound supply curve is tabulated in Table 4-3.

Table 4-3
Cost and Availability of New Hydropower - Upper Bound

LEVELIZED COST[a] (cents/kWh)	AVERAGE ENERGY INCREMENTAL (MWa)	AVERAGE ENERGY CUMULATIVE (MWa)	FIRM ENERGY INCREMENTAL (MWa)	FIRM ENERGY CUMULATIVE (MWa)
0 - 1.1	16	16	13	13
1.2 - 1.6	145	161	116	129
1.6 - 2.2	35	196	28	157
2.3 - 2.7	207	403	166	323
2.7 - 3.3	127	530	102	425
3.4 - 3.8	106	636	85	510
3.9 - 4.4	132	768	106	616
4.4 - 4.9	179	947	143	759
5.0 - 5.5	119	1066	95	854
5.6 - 6.0	70	1135	56	910

a 1988 dollars.

In the lower-bound study, development was limited to sites having existing water control structures (power or non-power). The probabilities of project development estimated for the "likely developable" supply curve (i.e., those shown in Table 4-1) were applied to this set of sites. This yielded about 484 megawatts of new hydropower capacity, capable of producing about 230 megawatts of average energy and about 185 megawatts of firm energy at 6 cents per kilowatt-hour, or less. This lower-bound supply curve is tabulated in Table 4-4.

Table 4-4
Cost and Availability of New Hydropower - Lower Bound

LEVELIZED COST[a] (cents/kWh)	AVERAGE ENERGY INCREMENTAL (MWa)	AVERAGE ENERGY CUMULATIVE (MWa)	FIRM ENERGY INCREMENTAL (MWa)	FIRM ENERGY CUMULATIVE (MWa)
0 - 1.1	2	2	2	2
1.2 - 1.6	12	14	10	12
1.6 - 2.2	4	18	3	15
2.3 - 2.7	31	49	25	40
2.7 - 3.3	17	66	14	54
3.4 - 3.8	24	90	19	73
3.9 - 4.4	50	140	40	113
4.4 - 4.9	30	170	24	137
5.0 - 5.5	47	217	38	175
5.6 - 6.0	13	230	10	185

a 1988 dollars.

The supply of "likely developable" new hydropower appearing in Table 4-2 represents the amount of this resource that the Council will count on in its planning. The supply curve of likely developable hydropower in Table 4-2 represents the cumulative contribution of several hundred potential hydropower projects. Because of the wide range of estimated cost, the supply curve of Table 4-2 was divided into four resource blocks for use in the Council's resource portfolio analysis. The planning characteristics of these blocks are shown in Table 4-5.

Table 4-5
New Hydropower Block Planning Characteristics

	NEW HYDRO 1	NEW HYDRO 2	NEW HYDRO 3	NEW HYDRO 4
Total Capacity	190	290	340	240
Total Average Energy (MWa)	110	130	160	110
Total Firm Energy (MWa)	91	100	130	89
Seasonality	Spring peaking[b]	Spring peaking[b]	Spring peaking[b]	Spring peaking[b]
Siting & Licensing Lead Time (mos)	36	36	36	36
Probability of S&L Success (%)	50	50	50	50
Siting & Licensing Shelf Life (yrs)	4	4	4	4
Probability of Hold Success (%)	75	75	75	75
Construction Lead Time (mos)	36	36	36	36
Construction Cash Flow (%/yr)	25/50/25	25/50/25	25/50/25	25/50/25
Siting & Licensing Cost ($/kW)	$74	$93	$130	$160
Siting & Licensing Hold Cost ($/kW/yr)	$3	$4	$4	$5
Construction Cost ($/kW)	$985	$1,240	$1,700	$2,060
Operating Cost ($/kW/yr)	$21	$27	$37	$44
Operating Life (yrs)	50	50	50	50
Energy Cost (cents/kWh)[a]	1.9	3.2	4.3	5.3

a Levelized revenue requirements, based on average energy.

b The estimated energy availability, by month, as a percent of the annual total is as follows: January - 6 percent, February - 7 percent, March - 8 percent, April - 12 percent, June - 12 percent, July - 12 percent, August - 7 percent, September - 6 percent, October - 5 percent, November - 6 percent, December - 6 percent.

Through the work of resource agencies, project developers and others, additional information concerning hydropower sites and stream values continually becomes available. Bonneville, the Corps of Engineers and the Council continually update the river values data base and the Hydropower Site Database, so that this improved information becomes available for hydropower resource assessment. For this reason, the Council expects to reassess periodically its estimate of developable hydropower.

References

Corps of Engineers, 1986: U.S. Army Corps of Engineers. Pacific Northwest Hydropower Database and Analysis System: Data Items Descriptions Manual. June 1986.

Ott, 1987: Ott Water Engineers, Inc. Pacific Northwest Hydropower Supply Model. Prepared for the Bonneville Power Administration, Portland, Oregon, June 1987.

Table 4-1
Potentially Developable Hydropower Sites[3]

(table follows)

FERC NO.	PROJECT NAME	LOCATION ST	CO[b]	DEVELOPMENT PROBABILITY RIVER	REGUL	FINAL	TYPE CODE[c]	COST ($/kWa)[d]	INSTALLED CAPACITY (MW)	AVERAGE ENERGY (MWa)	PROBABLE ENERGY (MWa)
00044-00	Hugh L. Cooper	WA	051	1.00	0.60	0.60	I	0	22.371	22.380	13.428
01815-03	Mahoney Springs Minor	MT	053	1.00	0.60	0.60	F	0	0.004	0.001	0.001
02151B00	Beaver Creek Hydroelectric	WA	007	1.00	0.80	0.80	I	4,781	14.000	7.000	5.600
02316B00	E.F. Griffin Creek	WA	033	0.65	0.75	0.65	O	0	29.381	20.566	13.409
02316C00	Carnation	WA	033	0.65	0.75	0.65	O	6,102	34.100	17.050	11.117
02494A02	White River	WA	053	0.69	0.90	0.69	J	6,050	14.000	9.532	6.598
02507A00	Flathead	MT	089	1.00	0.60	0.60	L	0	120.000	67.831	40.699
02507B00	Flathead 2	MT	047	1.00	0.60	0.60	L	0	120.000	45.662	27.397
02526-13	Sullivan Lake Dam	WA	051	1.00	0.85	0.85	F	2,664	13.600	7.050	5.992
02657-00	Thunder Creek	WA	073	0.60	0.10	0.10	C	0	1.305	13.014	1.301
02811D03	White Salmon Wallace Bridge	WA	039	0.64	0.10	0.10	F	0	30.000	12.000	1.200
02811G03	White Salmon Conduit	WA	039	0.91	0.20	0.20	J	0	42.000	29.400	5.880
02833-13	Cowlitz Falls	WA	041	1.00	0.99	0.99	C	4,534	70.000	30.502	30.197
02844-01	Tumwater	WA	007	0.69	0.25	0.25	G	0	4.000	2.511	0.628
02899-03	Milner	ID	083	1.00	0.95	0.95	P	2,636	43.650	16.210	15.400
02952-21	Gem State	ID	011	1.00	1.00	0.95	I	4,023	22.300	14.283	13.569
02959-17	South Fork Tolt	WA	033	0.55	0.95	0.55	D	5,027	15.000	8.596	4.737
02973-04	Island Park	ID	043	0.92	0.99	0.92	J	0	4.800	1.347	1.239
03073-01	Clifford Rosenbalm	ID	015	1.00	0.92	0.92	D	0	0.008	0.003	0.003
03109-01	Blue River	OR	039	0.92	0.90	0.90	J	4,938	14.650	3.930	3.537
03111-01	Dorena	OR	039	0.70	0.20	0.20	M	0	2.900	1.689	0.338
03112B02	Minto 2A Powerhouse B	OR	047	1.00	0.10	0.10	O	7,702	32.770	16.233	1.623
03210-01	Gold Hill	OR	029	0.56	0.60	0.56	D	1,366	3.000	2.540	1.425
03239A09	Koma Kulshan	WA	073	0.50	0.95	0.50	F	1,770	5.600	4.154	2.096
03239B09	Koma Kulshan-Sandy Cr	WA	073	0.50	0.95	0.50	F	2,263	5.600	4.154	2.096
03257-05	Zillah Wasteway	WA	077	0.54	0.92	0.54	D	4,466	11.900	3.379	1.832
03347-01	Sunset Falls Water Power Plant	WA	061	0.55	0.20	0.20	D	0	7.500	7.192	1.438
03378-00	Ochoco Project	OR	013	0.93	0.20	0.20	A	0	1.600	0.457	0.091
03385-02	Oxbow Ranch	ID	059	0.92	0.25	0.25	D	10,366	1.800	1.370	0.342
03403-00	Mora Canal Drop	ID	001	1.00	0.95	0.95	P	5,815	1.900	0.926	0.880
03466A01	Columbia Southern Canal	OR	017	1.00	0.30	0.30	P	0	3.200	1.573	0.472
03466B01	Columbia Southern Canal 2	OR	017	1.00	0.30	0.30	P	6,095	3.200	1.573	0.472
03466C01	Columbia Southern Canal	OR	017	0.92	0.25	0.25	A	7,801	2.400	1.180	0.295
03473-13	North Canal Dam	OR	017	0.91	0.90	0.90	G	3,875	2.825	0.809	0.728
03486-01	Easton Dam	WA	037	0.61	0.92	0.61	D	4,283	1.500	0.840	0.513
03489-01	Roza Dam	WA	037	0.71	0.60	0.60	A	4,686	2.400	1.573	0.944

Table 4-1
Potentially Developable Hydropower Sites[a]

FERC NO.	PROJECT NAME	LOCATION ST	CO[b]	DEVELOPMENT PROBABILITY RIVER	REGUL	FINAL	TYPE CODE[c]	COST ($/kWa)[d]	INSTALLED CAPACITY (MW)	AVERAGE ENERGY (MWa)	PROBABLE ENERGY (MWa)
03560-01	Wickiup	OR	017	0.91	0.90	0.90	G	3,950	7.000	2.979	2.682
03571-08	Central Oregon Siphon	OR	017	1.00	0.60	0.60	P	2,953	5.500	3.209	1.925
03672-00	Horn Rapids Water Power	WA	005	0.69	0.25	0.25	A	32,494	1.395	0.822	0.205
03701-01	Tieton	WA	077	0.70	0.90	0.70	G	3,099	13.600	5.651	3.937
03717-00	Ringold Wasteway	WA	021	1.00	0.30	0.30	P	3,350	3.100	1.228	0.368
03784-00	Bend Diversion Dam	OR	017	0.91	0.20	0.20	G	10,256	2.300	0.662	0.132
03827-00	Haystack	OR	031	1.00	0.30	0.30	P	0	2.500	1.027	0.308
03828A00	North Unit Canal Mile 45	OR	031	1.00	0.30	0.30	P	2,591	2.200	1.256	0.377
03828B00	North Unit Canal Mile 51	OR	031	1.00	0.30	0.30	P	3,293	1.900	1.027	0.308
03840-01	Unity	OR	001	0.95	0.25	0.25	G	11,487	0.500	0.171	0.043
03867-01	McKay Dam	OR	059	0.97	0.25	0.25	G	4,658	2.500	0.674	0.168
03913-01	Thunder Creek	WA	057	0.90	0.85	0.85	F	1,758	9.425	5.800	4.930
03918-02	Gold Ray	OR	029	0.68	0.20	0.20	M	7,452	7.200	0.936	0.187
03975-00	Deschutes Main Canal Mile 45	OR	031	1.00	0.20	0.20	P	0	4.000	1.393	0.279
03989-00	Savage Rapids Diversion Dam	OR	029	0.68	0.20	0.20	J	5,292	9.400	4.646	0.929
03991-06	Cross Cut Diversion	ID	043	0.91	0.95	0.91	G	5,351	1.754	1.239	1.132
04061-00	Eagle Creek	OR	001	1.00	0.30	0.30	P	0	1.800	1.142	0.342
04159-00	Magic Springs	ID	047	1.00	0.20	0.20	S	0	2.531	2.278	0.456
04160-02	Rangen Research	ID	047	1.00	0.30	0.30	P	0	0.250	0.179	0.054
04188-01	John W. Jones Jr.	ID	047	1.00	0.92	0.92	D	0	0.105	0.111	0.102
04217-00	Rock Creek	WA	045	1.00	0.10	0.10	F	9,196	1.800	0.696	0.070
04220-01	Park Creek	WA	073	1.00	0.85	0.85	F	3,984	1.900	1.062	0.902
04227-00	Snake River Trout	ID	047	1.00	0.20	0.20	S	0	0.150	0.138	0.028
04243-00	Saddle Springs	ID	047	1.00	0.20	0.20	S	0	0.100	0.085	0.017
04269-00	Manson Hydroelectric Project	WA	007	0.95	0.25	0.25	D	0	1.800	1.621	0.405
04295-00	Aldrich Creek	WA	073	1.00	0.10	0.10	F	5,088	0.575	0.394	0.039
04308-01	Mud Mountain-White River	WA	033	0.69	0.25	0.25	G	0	5.800	2.968	0.742
04358-00	Scooteney Inlet	WA	021	1.00	0.30	0.30	P	8,515	2.800	1.142	0.342
04408-00	Mill City Diversion	OR	047	0.53	0.25	0.25	D	4,219	60.000	30.137	7.534
04435-05	Damnation Peak	WA	057	1.00	0.60	0.60	F	3,333	5.000	2.127	1.276
04458A04	Middle Fork Irrigation Dist PH 1	OR	027	1.00	1.00	0.60	M	3,466	2.130	1.724	1.034
04458B04	Middle Fork Irrigation Dist PH 2	OR	027	1.00	1.00	0.60	M	7,315	0.593	0.475	0.285
04458C04	Pressure Reducing Station 1	OR	027	1.00	1.00	0.60	M	2,232	0.399	0.367	0.220
04458D04	Pressure Reducing Station 2	OR	027	1.00	1.00	0.60	S	0	0.236	0.217	0.130
04458E04	Middle Fork Irrigation Dist PH 3	OR	027	1.00	1.00	0.60	S	0	0.584	0.395	0.237
04458F04	Pressure Reducing Station 3	OR	027	1.00	1.00	0.60	M	7,303	0.078	0.071	0.043

Table 4-1
Potentially Developable Hydropower Sites[a]

FERC NO.	PROJECT NAME	LOCATION ST	LOCATION CO[b]	DEVELOPMENT PROBABILITY RIVER	DEVELOPMENT PROBABILITY REGUL	DEVELOPMENT PROBABILITY FINAL	TYPE CODE[c]	COST ($/kWa)[d]	INSTALLED CAPACITY (MW)	AVERAGE ENERGY (MWa)	PROBABLE ENERGY (MWa)
04458G04	Pressure Reducing Station 4	OR	027	1.00	1.00	0.60	S	0	0.092	0.084	0.051
04458H04	Pressure Reducing Station 5	OR	027	1.00	1.00	0.60	M	136,223	0.027	0.008	0.005
04458I04	Pressure Reducing Station 7	OR	027	1.00	1.00	0.60	S	0	0.077	0.002	0.001
04458J04	Pressure Reducing Station 6	OR	027	1.00	1.00	0.60	M	8,085	0.062	0.017	0.010
04479-00	Howard Prairie Hydroelectric	OR	029	0.94	0.25	0.25	A	18,688	0.224	0.148	0.037
04507-00	Lost Lake	WA	037	1.00	0.10	0.10	F	6,063	2.000	0.639	0.064
04539-01	Clear Lake Hydro Project	WA	077	1.00	0.60	0.60	A	4,128	1.230	0.445	0.267
04574A06	Three Lynx Creek	OR	005	0.58	0.95	0.58	F	1,001	0.565	0.203	0.119
04574B06	Three Lynx Creek	OR	005	0.65	0.95	0.65	D	2,560	0.565	0.079	0.052
04586-06	Swamp Creek	WA	073	0.76	0.95	0.76	F	3,877	3.500	1.712	1.305
04587-07	Ruth Creek	WA	073	0.65	0.95	0.65	F	4,402	2.800	1.313	0.856
04606-01	Little Rattler Hydro Project	WA	077	0.73	0.25	0.25	G	0	12.400	6.804	1.701
04656-02	Arrowrock Dam	ID	039	0.94	0.90	0.90	G	3,959	60.000	19.132	17.219
04698-01	Nevada Creek	MT	077	1.00	0.25	0.25	G	0	1.480	0.320	0.080
04709-00	Lake Como	MT	081	1.00	0.20	0.20	J	9,260	0.570	0.320	0.064
04710-00	Potholes Canal Chute 1158	WA	001	1.00	0.20	0.20	P	4,869	7.630	3.105	0.621
04711-01	Potholes E Canal Sta 1720+44	WA	021	1.00	0.30	0.30	P	0	0.690	0.297	0.089
04712-00	Dry Falls Dam Canal	WA	025	1.00	0.20	0.20	M	5,427	20.860	9.418	1.884
04732-00	Applegate Lake	OR	029	0.95	0.60	0.60	J	3,302	9.000	4.292	2.575
04748-00	Potholes Canal Chute 3480&43	WA	021	1.00	0.20	0.20	P	0	10.150	4.292	0.858
04750-02	Eltopia Branch Canal 625+90	WA	021	1.00	0.95	0.95	P	3,299	0.682	0.352	0.334
04759-00	West Canal Station 1992+00	WA	025	1.00	0.20	0.20	P	4,269	9.120	3.858	0.772
04763-01	EL 85 Station 125+25	WA	001	1.00	0.30	0.30	P	0	0.400	0.148	0.045
04764-01	EL 68 Station 31+00	WA	001	1.00	0.30	0.30	P	0	0.420	0.160	0.048
04765-01	EL 68 Station 65+54.65	WA	001	1.00	0.30	0.30	P	0	0.390	0.148	0.045
04766-01	EL 68 Station 135+76.24	WA	001	1.00	0.30	0.30	P	0	0.350	0.126	0.038
04768-01	EL 85 Station 140+10	WA	001	1.00	0.30	0.30	P	0	0.440	0.160	0.048
04776-01	Experimental Forest Hydro Project	ID	017	1.00	0.10	0.10	F	21,439	0.100	0.048	0.005
04778-01	Morris Creek	ID	017	1.00	0.10	0.10	F	22,980	0.200	0.102	0.010
04780-00	Keokee Creek	ID	017	1.00	0.10	0.10	F	45,106	0.100	0.043	0.004
04858-00	Arena Drop	ID	027	1.00	0.95	0.95	P	0	0.540	0.188	0.179
04885-20	Twin Falls	WA	033	0.68	0.95	0.68	F	3,609	20.000	8.801	5.985
04886-02	Sand Hollow	WA	025	1.00	0.30	0.30	P	0	1.700	0.993	0.298
04887-02	CCL4 Hydroelectric Project	WA	025	1.00	0.30	0.30	P	0	0.600	0.354	0.106
04890-01	Bumping Lake	WA	077	0.69	0.25	0.25	G	2,108	31.000	18.493	4.623
04905-03	Big Lost River	ID	037	0.94	0.60	0.60	M	10,648	3.000	0.491	0.295

Table 4-1
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04948-02	Thief Valley	OR	061	0.94	0.60	0.60	G	0	0.712	0.331	0.199
05038-00	Main Canal 6	ID	001	1.00	0.95	0.95	S	8,554	1.200	0.480	0.456
05039-00	Golden Gate	ID	027	1.00	0.95	0.95	S	0	0.700	0.313	0.298
05040-00	Fargo Drop 2	ID	027	1.00	0.95	0.95	P	15,955	0.175	0.076	0.072
05041-00	Main Canal 10	ID	027	1.00	0.95	0.95	P	12,165	0.500	0.241	0.229
05042-00	Fargo Drop 1	ID	027	1.00	0.95	0.95	P	5,709	0.650	0.277	0.263
05043-00	Waldvogel Bluff	ID	001	1.00	0.95	0.95	P	14,581	0.300	0.130	0.124
05056-00	Low Line 8	ID	027	1.00	0.95	0.95	P	8,611	0.385	0.175	0.166
05074-06	Mill Creek	OR	019	0.49	0.95	0.49	F	3,296	10.500	3.702	1.830
05094-01	Barnum Creek	MT	053	0.91	0.10	0.10	F	12,409	0.300	0.150	0.015
05097-01	Lime Creek	MT	047	1.00	0.10	0.10	F	24,366	0.100	0.057	0.006
05098-00	Hall Creek	MT	047	0.99	0.10	0.10	F	4,736	0.400	0.238	0.024
05100-01	Indian Springs	MT	053	0.96	0.10	0.10	F	6,009	0.375	0.169	0.017
05101-01	Deep Creek	WA	065	1.00	0.10	0.10	F	12,172	0.150	0.084	0.008
05102-01	Brush Creek	MT	053	1.00	0.10	0.10	F	7,833	0.100	0.057	0.006
05104-01	Ruby Creek	MT	053	0.99	0.10	0.10	F	5,412	0.300	0.148	0.015
05106-01	Highland Creek	ID	021	1.00	0.10	0.10	F	9,930	0.150	0.080	0.008
05107-01	Spruce Creek Water Power	ID	021	1.00	0.10	0.10	F	13,333	0.200	0.087	0.009
05108-01	Curley Creek	ID	021	0.88	0.60	0.60	F	3,597	0.500	0.285	0.171
05109-01	Hellroaring Creek	ID	021	1.00	0.10	0.10	F	16,043	0.125	0.065	0.007
05110-01	Curtis Creek	ID	017	0.98	0.10	0.10	F	16,095	0.050	0.032	0.003
05112-01	Falls Creek	ID	017	0.86	0.10	0.10	F	13,518	0.100	0.056	0.006
05113-01	Canyon Creek	ID	017	0.86	0.10	0.10	F	22,637	0.075	0.033	0.003
05116-01	Tieton Canal Drop	WA	077	1.00	0.30	0.30	P	3,735	10.000	3.002	0.901
05208A02	Lower Crow Creek	MT	047	1.00	0.20	0.20	G	0	1.000	0.500	0.100
05241-01	Wallace Creek Hydro Project	WA	073	1.00	0.20	0.20	O	8,647	3.000	1.484	0.297
05242-01	Warm Creek	WA	073	1.00	0.10	0.10	F	0	3.200	1.484	0.148
05278-03	N. Fork Flume Creek Hydro Project	WA	051	1.00	0.87	0.87	D	0	0.100	0.060	0.052
05279-05	Birch Creek	WA	073	1.00	1.00	0.87	D	0	0.010	0.007	0.006
05290-01	Pugh Creek	WA	061	0.98	0.10	0.10	F	4,943	2.800	1.427	0.143
05299-00	Ana Springs	OR	037	0.82	0.25	0.25	D	5,901	0.350	0.251	0.063
05301A00	Drews 2	OR	037	1.00	0.30	0.30	P	0	0.300	0.104	0.031
05301B00	Drews 1	OR	037	1.00	0.30	0.30	P	8,771	0.186	0.078	0.024
05341-01	Mineral Butte	WA	061	0.51	0.90	0.51	F	0	5.000	2.235	1.145
05349-00	Swift Creek	WA	073	0.98	0.85	0.85	F	3,478	17.500	6.279	5.337
05364-00	Deschutes-Tumwater	WA	067	0.70	0.60	0.60	G	7,121	2.500	0.890	0.534

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05376-06	Horseshoe Bend	ID	015	0.63	0.95	0.63	F	4,043	9.500	5.959	3.730
05396-00	Fairwell Bend	OR	029	0.83	0.10	0.10	F	0	3.100	1.998	0.200
05407-00	Oakley Dam	ID	031	0.97	0.25	0.25	G	0	0.836	0.325	0.081
05409-00	C. Ben Ross Dam	ID	003	0.98	0.25	0.25	G	17,503	2.050	0.394	0.099
05415-00	Trail Creek	ID	013	0.94	0.25	0.25	G	0	0.300	0.150	0.038
05418-01	Big Creek	WA	057	0.98	0.60	0.60	F	3,211	17.500	6.621	3.973
05454-00	Sheep Creek Falls	WA	065	0.51	0.60	0.51	L	1,143	4.900	3.430	1.736
05467-01	Little North Fork	MT	053	0.99	0.10	0.10	F	0	0.150	0.077	0.008
05468-01	Flower Creek	MT	053	0.99	0.10	0.10	F	9,952	0.400	0.190	0.019
05470-01	North Meadow Creek	MT	053	0.97	0.10	0.10	F	11,084	0.150	0.076	0.008
05471-02	Upper Tenmile Creek	MT	053	0.91	0.10	0.10	F	27,676	0.300	0.110	0.011
05475-01	O'Brian Creek	MT	053	0.89	0.10	0.10	F	10,839	0.250	0.120	0.012
05476-09	Lower Tenmile Creek	MT	053	0.91	0.10	0.10	F	28,091	0.200	0.090	0.009
05477-01	Whitetail Creek	MT	053	1.00	0.10	0.10	F	15,790	0.050	0.021	0.002
05478-00	Boulder Creek	MT	053	0.89	0.10	0.10	F	5,783	0.750	0.367	0.037
05479-01	Camp Creek	MT	053	0.78	0.10	0.10	F	11,893	0.225	0.095	0.009
05480-01	Pheasant Creek	MT	053	1.00	0.10	0.10	F	11,135	0.075	0.050	0.005
05481-01	Middle Parsnip Creek	MT	053	1.00	0.10	0.10	F	114,133	0.075	0.037	0.004
05482-01	Gold Creek	MT	053	1.00	0.10	0.10	F	29,471	0.200	0.064	0.006
05483-01	Flat Creek	MT	053	1.00	0.10	0.10	F	31,652	0.150	0.080	0.008
05484-01	Sutton Creek	MT	053	1.00	0.10	0.10	F	18,676	0.260	0.153	0.015
05485-00	Sullivan Creek	MT	053	0.89	0.10	0.10	F	6,415	0.500	0.264	0.026
05486-01	Arbo Creek	MT	053	1.00	0.10	0.10	F	5,880	0.230	0.114	0.011
05487-01	Independence Creek	MT	053	1.00	0.10	0.10	F	12,776	0.100	0.050	0.005
05488-01	Alexander Creek	MT	053	1.00	0.10	0.10	F	13,365	0.060	0.036	0.004
05489-01	Cyclone Creek	MT	053	1.00	0.10	0.10	F	9,156	0.150	0.064	0.006
05491-01	Cadette Creek	MT	053	1.00	0.10	0.10	F	11,255	0.200	0.071	0.007
05497-04	Falls Creek Small Hydro Project	WA	009	1.00	1.00	0.10	F	6,242	0.200	0.160	0.016
05498-00	Kaster Riverview	ID	083	1.00	0.90	0.90	F	0	0.316	0.315	0.283
05507A00	Crooked River (Mile 2)	OR	017	1.00	0.30	0.30	P	0	2.200	0.970	0.291
05507B00	Crooked River (Station 688)	OR	017	1.00	0.30	0.30	P	0	1.400	0.674	0.202
05507C00	Crooked River (C)	OR	017	1.00	0.30	0.30	P	0	10.700	2.694	0.808
05513-00	Napoleon Gulch	MT	053	1.00	0.10	0.10	F	10,373	0.125	0.060	0.006
05517-01	Scout Creek	MT	047	1.00	0.10	0.10	F	0	0.407	0.281	0.028
05521-02	Porcupine Creek	MT	047	0.99	0.10	0.10	F	4,446	0.259	0.179	0.018
05522-02	Bethal Creek	MT	047	1.00	0.10	0.10	F	3,634	0.263	0.182	0.018

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05851-00	Black Creek	OR	039	0.93	0.20	0.20	M	0	9.000	4.589	0.918
05853-00	Olney Creek Falls	WA	061	0.70	0.60	0.60	G	2,590	1.500	1.062	0.637
05877-00	Dodge Creek	MT	053	0.76	0.10	0.10	F	13,210	0.760	0.524	0.052
05882-00	Roaring Creek	WA	007	1.00	0.10	0.10	F	5,491	0.600	0.282	0.028
05883-00	Resort Creek	WA	037	1.00	0.10	0.10	F	6,106	0.350	0.165	0.017
05884-00	Rocky Run Creek	WA	037	1.00	0.10	0.10	F	7,851	0.525	0.207	0.021
05898-00	Bliss Diversion	ID	047	1.00	0.30	0.30	P	0	0.550	0.331	0.099
05899-00	Mill Creek Waterpower Project	WA	037	1.00	0.10	0.10	F	0	0.225	0.100	0.010
05903-01	Black Canyon	ID	045	0.91	0.45	0.45	M	0	24.000	7.078	3.185
05926A02	North Fork Snoqualmie River (A)	WA	033	0.73	0.60	0.60	C	37	14.800	7.400	4.440
05926B02	North Fork Snoqualmie River (B)	WA	033	0.73	0.60	0.60	I	0	20.000	10.000	6.000
05932-00	Crane Creek	MT	047	0.91	0.10	0.10	F	4,819	0.210	0.145	0.014
05939-00	Granite Creek Power Project	WA	019	1.00	0.60	0.60	G	0	0.050	0.040	0.024
05957-01	Reed Road Pump Generator	OR	027	1.00	0.95	0.95	S	0	0.160	0.086	0.081
05978-03	Diamond Creek	WA	073	1.00	0.90	0.90	F	5,677	0.350	0.171	0.154
05979-01	I Coulee Hydroelectric	ID	083	1.00	0.60	0.60	F	5,075	0.299	0.186	0.111
05982-00	Smith Creek Project	WA	073	0.64	0.90	0.64	F	16,697	0.093	0.054	0.035
06003-00	Watson Creek	WA	045	1.00	0.10	0.10	F	7,264	0.973	0.411	0.041
06007-00	Boulder Creek	WA	045	1.00	0.10	0.10	F	3,953	3.000	1.438	0.144
06089-03	Skate Creek	WA	041	0.71	0.90	0.71	F	2,428	5.000	3.653	2.601
06092-05	Butter Creek	WA	041	0.70	0.90	0.70	F	0	2.785	1.210	0.842
06138-11	Pine Creek	MT	053	1.00	0.60	0.60	F	6,471	0.350	0.138	0.083
06143-00	Mt. Rose Hydroelectric Project	WA	045	1.00	0.10	0.10	F	4,364	0.200	0.199	0.020
06151-06	Cabin Creek	WA	031	1.00	0.95	0.95	F	2,948	2.890	1.355	1.287
06165-00	Dixie Waterworks	WA	041	1.00	0.60	0.60	F	0	0.001	0.001	0.000
06169-00	Dupris Hydro	WA	073	1.00	0.60	0.60	F	0	0.009	0.006	0.003
06221-01	Black Creek	WA	033	1.00	0.95	0.95	F	8,659	3.700	1.199	1.139
06231-01	Wardenhoff Creek	ID	085	1.00	0.90	0.90	F	3,425	0.392	0.120	0.108
06247-00	Upper Big Creek	WA	057	0.98	0.60	0.60	F	2,534	2.700	1.397	0.838
06248-01	Waste Waterway 68D Dike 9	WA	001	1.00	0.30	0.30	P	12,883	0.250	0.114	0.034
06254-00	Lower Big Creek	WA	057	0.98	0.60	0.60	F	0	3.610	1.842	1.105
06259-00	Little Squaw Creek	ID	045	0.98	0.20	0.20	F	0	0.800	0.320	0.064
06260-01	Shafer Creek	ID	015	0.86	0.60	0.60	F	0	0.150	0.060	0.036
06263-01	Waste Waterway 68D Dike 8	WA	001	1.00	0.30	0.30	P	0	0.190	0.094	0.028
06264-01	Waste Waterway 68D Dike 6	WA	001	1.00	0.30	0.30	P	0	0.220	0.108	0.033
06271B00	White Water Ranch	ID	047	1.00	0.90	0.90	F	59,523	0.030	0.022	0.020

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05525-02	Cedar Creek	MT	047	0.89	0.10	0.10	F	0	0.377	0.260	0.026
05544-00	Tomyhoi Creek	WA	073	1.00	0.10	0.10	F	6,783	3.200	1.484	0.148
05545-02	White Salmon Creek	WA	073	1.00	0.82	0.82	F	6,716	1.300	0.765	0.627
05554-01	Iron Mountain Project	WA	057	0.64	0.90	0.64	F	3,653	1.620	0.836	0.539
05556-01	South Fork Woodward Creek	MT	047	0.99	0.10	0.10	F	4,093	1.411	0.974	0.097
05558-01	Cold Creek	MT	063	0.91	0.10	0.10	F	5,041	0.929	0.641	0.064
05562-01	Upper Oak Grove Fork	OR	005	0.76	0.10	0.10	F	3,339	10.500	7.420	0.742
05584-01	Coffee Pot	OR	037	0.61	0.10	0.10	L	0	3.750	1.027	0.103
05600-01	Springfield Canal	OR	039	1.00	0.30	0.30	P	0	0.300	0.263	0.079
05608-00	McCully Creek	OR	063	1.00	0.60	0.60	P	6,416	0.200	0.084	0.050
05616-01	Icicle Creek	WA	007	0.98	0.10	0.10	F	1,181	80.000	34.247	3.425
05617A00	Meadows Waterpower (A)	WA	059	1.00	0.10	0.10	F	2,830	10.000	5.936	0.594
05617B00	Meadows Waterpower (B)	WA	059	1.00	0.10	0.10	F	0	31.000	17.808	1.781
05650-02	Kanaka Creek	ID	047	1.00	0.60	0.60	P	12,250	0.090	0.046	0.027
05653-00	Mission Dam	MT	047	1.00	0.20	0.20	J	10,950	0.300	0.148	0.030
05654-01	Hubbart Dam	MT	029	0.99	0.20	0.20	J	41,394	0.250	0.070	0.014
05655A00	Post Creek (A)	MT	047	1.00	0.20	0.20	A	0	0.400	0.153	0.031
05655B00	Post Creek (B)	MT	047	1.00	0.20	0.20	G	5,895	1.500	0.793	0.159
05656A00	Dry Creek (A)	MT	047	1.00	0.20	0.20	G	13,155	0.500	0.217	0.043
05656B00	Dry Creek (B)	MT	047	1.00	0.20	0.20	P	0	5.000	0.234	0.047
05658-00	Stahl Creek	MT	053	0.97	0.10	0.10	F	4,690	0.750	0.518	0.052
05659-00	Williams Creek	MT	053	0.99	0.10	0.10	F	4,393	1.300	1.036	0.104
05660-00	Deep Creek	MT	053	0.99	0.10	0.10	F	9,963	1.500	1.053	0.105
05661-00	Kopsi Creek	MT	053	1.00	0.10	0.10	F	4,838	0.500	0.345	0.035
05663-01	Foundation Creek	MT	053	0.99	0.10	0.10	F	6,929	0.350	0.242	0.024
05664-00	Blue Sky Creek	MT	053	0.97	0.10	0.10	F	6,046	1.000	0.690	0.069
05699-00	Victor Falls	WA	053	0.73	1.00	0.73	M	0	0.125	0.070	0.052
05711-01	Nespelem River	WA	047	1.00	0.25	0.25	D	2,574	1.800	1.027	0.257
05719-00	Bond Creek	MT	047	0.96	0.20	0.20	F	0	0.367	0.254	0.051
05733-00	Groom Creek	MT	047	1.00	0.10	0.10	F	4,965	0.376	0.260	0.026
05783-00	Woodward Tributary	MT	047	0.99	0.10	0.10	F	13,485	0.200	0.100	0.010
05819-00	Johnson Creek	WA	061	1.00	0.10	0.10	F	4,503	4.700	1.781	0.178
05823-00	Boulder Creek	OR	039	0.87	0.10	0.10	F	2,553	4.900	2.694	0.269
05825-00	May Creek	WA	061	1.00	0.10	0.10	F	3,665	0.800	0.571	0.057
05829-01	Beckler River Hydroelectric Proj	WA	061	0.50	0.90	0.50	F	6,152	3.000	2.100	1.060
05830-02	New Willamette Falls	OR	005	0.68	0.25	0.25	G	0	60.000	34.932	8.733

Table 4-1
Potentially Developable Hydropower Sites[a]

FERC NO.	PROJECT NAME	LOCATION ST	CO[b]	DEVELOPMENT PROBABILITY RIVER	REGUL	FINAL	TYPE CODE[c]	COST ($/kWa)[d]	INSTALLED CAPACITY (MW)	AVERAGE ENERGY (MWa)	PROBABLE ENERGY (MWa)
06272-00	Grade Creek Project	WA	057	1.00	0.60	0.60	F	3,856	3.240	1.651	0.990
06273-00	Big Creek	WA	057	0.98	0.60	0.60	F	7,067	2.600	1.336	0.801
06283B02	Twin Lakes/Goose Lake/Brundage R	ID	003	0.49	0.90	0.49	F	11,997	0.250	0.126	0.061
06283C02	Twin Lakes/Goose Lake/Brundage R	ID	003	0.69	0.60	0.60	M	7,577	0.985	0.492	0.295
06283D02	Twin Lakes/Goose Lake/Brundage R	ID	003	0.49	0.90	0.49	F	3,763	2.800	1.400	0.681
06286-00	Little Wolf Creek	WA	047	1.00	0.30	0.30	P	0	0.100	0.100	0.030
06287-02	Lena Creek	WA	031	1.00	0.60	0.60	F	2,485	5.000	2.671	1.603
06301-00	Trout Creek	WA	061	0.50	0.90	0.50	F	5,187	5.000	1.884	0.950
06316-00	Carroll Creek	WA	033	1.00	0.20	0.20	I	2,629	0.900	0.884	0.177
06331-03	McGowan Properties	WA	049	1.00	0.87	0.87	D	0	0.030	0.022	0.019
06343-00	Dinner Creek	OR	005	0.89	0.10	0.10	F	10,129	0.568	0.252	0.025
06348-01	Harlan Creek	WA	033	1.00	0.60	0.60	F	0	2.000	1.370	0.822
06381-00	Little Goose Creek	ID	003	1.00	0.82	0.82	F	3,146	0.730	0.307	0.252
06382-00	Lemah Creek	ID	085	1.00	0.60	0.60	F	2,751	0.559	0.264	0.158
06385-00	Wind River	WA	059	0.60	0.25	0.25	D	0	0.500	0.197	0.049
06400-00	Mann Creek	ID	087	0.95	0.25	0.25	G	10,115	0.365	0.160	0.040
06401-00	Tyee/Jumbo Basin	ID	085	1.00	0.60	0.60	F	3,072	0.741	0.298	0.179
06406-01	Gerber Reservoir	OR	035	0.95	0.25	0.25	A	0	0.190	0.095	0.024
06407-00	K I D Upper "C" Drop	OR	035	1.00	0.30	0.30	P	0	0.760	0.308	0.092
06415-03	Bagley Creek	WA	073	1.00	0.60	0.60	F	4,078	3.000	1.427	0.856
06422-06	Wyeth	OR	027	0.64	0.90	0.64	F	5,571	1.000	0.308	0.199
06434-06	Ditch Creek	ID	085	1.00	0.85	0.85	F	3,826	0.440	0.137	0.116
06437-05	Upper Glacier Creek	WA	073	0.50	0.90	0.50	F	5,776	3.300	1.815	0.910
06444-02	Cedar Creek	MT	053	0.97	0.90	0.90	F	553	1.300	1.300	1.170
06460-00	Dry Creek	OR	001	1.00	0.95	0.95	P	0	0.421	0.235	0.224
06461-08	Morse Creek	WA	009	1.00	1.00	0.95	D	3,106	0.465	0.348	0.331
06468-01	Star Creek	MT	053	0.97	0.60	0.60	F	0	2.000	0.571	0.342
06472-01	King Hill/Draper	ID	039	1.00	0.95	0.95	P	0	0.175	0.088	0.084
06477-01	Lilborn Creek	WA	041	1.00	0.60	0.60	F	2,911	0.861	0.651	0.390
06481-00	Beyer	OR	005	0.97	1.00	0.97	G	0	0.024	0.008	0.007
06496-00	Skykomish Tributaries Project	WA	061	1.00	0.10	0.10	F	4,410	3.260	1.631	0.163
06504-04	Upper Found Creek	WA	057	0.90	0.82	0.82	F	3,985	1.870	0.936	0.768
06505-00	Howard Creek	WA	061	1.00	0.10	0.10	I	5,089	3.450	1.727	0.173
06506-00	Excelsior Creek	WA	061	1.00	0.10	0.10	F	2,795	1.630	0.816	0.082
06510-00	Trout Creek Water Power	ID	021	0.77	0.10	0.10	F	0	3.780	1.941	0.194
06524-05	Elk Creek Falls	ID	035	0.62	0.85	0.62	F	2,515	4.320	2.167	1.344

Table 4-1

Potentially Developable Hydropower Sites[a]

FERC NO.	PROJECT NAME	LOCATION ST	LOCATION CO[b]	DEVELOPMENT PROBABILITY RIVER	DEVELOPMENT PROBABILITY REGUL	DEVELOPMENT PROBABILITY FINAL	TYPE CODE[c]	COST ($/kWa)[d]	INSTALLED CAPACITY (MW)	AVERAGE ENERGY (MWa)	PROBABLE ENERGY (MWa)
06538-00	Helena Creek	WA	061	1.00	0.20	0.20	F	4,840	1.810	1.084	0.217
06552-08	Sprague River	OR	035	0.66	0.95	0.66	F	6,073	1.119	0.656	0.433
06558-00	Sullivan Springs	ID	047	1.00	0.60	0.60	F	6,168	0.170	0.118	0.071
06568-04	Grave Creek 2	OR	033	0.49	0.95	0.49	F	7,154	2.500	1.267	0.627
06582-00	Woodcock Creek	OR	005	0.87	0.60	0.60	F	0	0.082	0.046	0.027
06600-03	Silver Creek	WA	041	0.75	0.90	0.75	F	0	4.900	3.425	2.562
06616-00	Sky Creek	WA	057	1.00	0.60	0.60	F	0	1.900	1.427	0.856
06636-00	Big Elk Creek YMCA Camp	ID	019	1.00	1.00	0.60	F	0	0.007	0.003	0.002
06654-00	Fall Creek	OR	005	0.82	0.10	0.10	F	0	1.400	0.848	0.085
06656-00	McGee/Elk Creek	OR	027	0.87	0.10	0.10	F	0	1.870	0.928	0.093
06659-00	Sardine Creek	OR	047	0.87	0.10	0.10	F	0	1.720	0.909	0.091
06663-04	KTFI Creek	ID	083	1.00	0.82	0.82	F	20,732	0.034	0.033	0.027
06667-00	Battle Ridge	ID	049	0.51	0.60	0.51	D	5,599	0.908	0.794	0.406
06675-01	Spruce	WA	059	0.69	0.60	0.60	A	3,556	0.385	0.170	0.102
06692-01	Ollalie Creek	OR	043	0.80	0.10	0.10	F	2,000	4.550	3.901	0.390
06707-05	Sheep Falls	ID	043	0.74	0.60	0.60	F	5,936	4.200	2.486	1.492
06709-00	Cortright Creek	WA	041	1.00	0.82	0.82	F	4,162	4.900	2.397	1.966
06711-01	Crystal Springs Hatchery	ID	047	1.00	0.60	0.60	S	7,182	0.200	0.182	0.109
06717-00	Thunder Creek 3	WA	073	0.95	0.82	0.82	F	3,913	5.000	3.699	3.033
06719-00	Thunder Creek 2	WA	073	0.95	0.82	0.82	F	2,995	5.000	3.699	3.033
06737-00	Thunder Creek 1	WA	073	0.95	0.82	0.82	F	6,661	5.000	3.699	3.033
06741-00	Blackfoot Dam	ID	029	0.92	0.25	0.25	G	9,729	1.000	0.685	0.171
06760-00	Oroville-Tonasket Canal	WA	047	1.00	0.20	0.20	P	2,434	2.000	1.438	0.288
06769-00	Sixmile Creek	MT	047	1.00	0.10	0.10	F	5,812	0.200	0.137	0.014
06788-02	Deep Creek	ID	083	0.75	0.82	0.75	F	19,794	0.280	0.127	0.095
06798-00	Tunnel Creek	OR	047	1.00	0.10	0.10	F	27,767	1.100	0.590	0.059
06799-00	Lost Creek	OR	039	1.00	0.10	0.10	F	0	3.200	2.797	0.280
06800-00	White Water Creek	OR	047	0.82	0.10	0.10	F	7,865	3.600	1.901	0.190
06801-02	FID Project 3	OR	027	1.00	1.00	0.10	P	0	1.800	0.850	0.085
06804-01	Downing Creek	OR	043	0.89	0.10	0.10	F	2,936	3.277	1.802	0.180
06824-02	Silver Creek	WA	053	0.58	0.95	0.58	F	4,007	3.800	2.426	1.407
06828-00	Lower Palouse River	WA	021	0.32	0.10	0.10	O	0	50.000	13.402	1.340
06832A00	Basin Creek (A)	MT	093	0.91	0.10	0.10	F	0	0.190	0.076	0.008
06832B00	Basin Creek (B)	MT	093	0.82	0.10	0.10	O	0	0.090	0.063	0.006
06836-00	Dryden	WA	007	1.00	0.20	0.20	P	3,531	4.000	2.511	0.502
06842-14	Wynoochee River	WA	027	0.69	0.95	0.69	G	3,708	10.800	4.811	3.335

Table 4-1
Potentially Developable Hydropower Sites[a]

FERC NO.	PROJECT NAME	LOCATION		DEVELOPMENT PROBABILITY			TYPE	COST	INSTALLED CAPACITY	AVERAGE ENERGY	PROBABLE ENERGY
		ST	CO[b]	RIVER	REGUL	FINAL	CODE[c]	($/kWa)[d]	(MW)	(MWa)	(MWa)
06850-00	Cox's Hydro Project	ID	083	0.75	0.90	0.75	F	0	0.300	0.088	0.066
06854-00	Brown's Pond	ID	085	0.96	0.25	0.25	G	0	0.750	0.288	0.072
06857-01	Yakima Diversion Dam	WA	077	0.71	0.25	0.25	A	0	0.650	0.400	0.100
06858-00	Honeymoon Creek	MT	089	0.95	0.10	0.10	F	4,150	0.950	0.329	0.033
06859-00	Bull Run Creek	ID	035	0.98	0.10	0.10	F	0	2.580	1.008	0.101
06874-00	South Fork Eagle Creek	OR	005	1.00	0.10	0.10	F	4,086	6.861	4.498	0.450
06895-01	Fisher Creek	ID	085	0.81	0.60	0.60	F	5,104	5.000	1.461	0.877
06921-00	Dry Ridge	OR	005	1.00	0.10	0.10	F	2,568	1.400	0.878	0.088
06965-00	Hecla Power Project	ID	079	1.00	1.00	0.10	G	0	0.000	0.878	0.088
06978-00	Fern Ridge	OR	039	0.91	0.20	0.20	G	0	2.500	0.822	0.164
06979-00	Huckleberry Creek	OR	039	0.87	0.20	0.20	F	0	5.700	5.575	1.115
06989-01	Little Sardine Creek	OR	047	1.00	0.10	0.10	F	0	0.305	0.153	0.015
07018-00	Goldsborough Creek	WA	045	0.72	0.25	0.25	G	8,563	0.380	0.151	0.038
07028-00	Cottage Grove Dam	OR	039	0.91	0.20	0.20	J	5,997	1.400	0.628	0.126
07032-00	Gresham Brothers Lake Creek 3	ID	079	1.00	0.10	0.10	F	0	0.185	0.126	0.013
07036A00	Stillaguamish Tributaries (A)	WA	061	1.00	0.20	0.20	F	0	1.600	0.799	0.160
07036E00	Stillaguamish Tributaries (E)	WA	061	1.00	0.20	0.20	F	0	1.810	0.905	0.181
07036F00	Stillaguamish Tributaries (F)	WA	061	1.00	0.20	0.20	F	0	2.340	1.171	0.234
07036G00	Stillaguamish Tributaries (G)	WA	061	1.00	0.20	0.20	F	0	3.580	1.790	0.358
07038B00	Wallace-Isabel (B)	WA	061	1.00	0.20	0.20	F	2,572	2.628	2.591	0.518
07039-01	Bob Moore Creek	ID	059	1.00	0.20	0.20	F	28,975	0.550	0.201	0.040
07065-00	Long Lake Dam	WA	043	1.00	0.30	0.30	P	2,247	67.610	30.537	9.161
07074-00	Snowshoe Creek	MT	053	0.89	0.60	0.60	F	0	4.500	2.051	1.231
07075-00	McNary Fish Attraction	WA	005	0.76	0.30	0.30	B	0	7.000	4.680	1.404
07076-00	The Dalles	WA	039	0.77	0.99	0.77	H	3,116	4.200	3.687	2.827
07083-01	Savage Rapids	OR	029	0.68	0.20	0.20	J	0	7.500	3.750	0.750
07089-00	Alfred Teufel Nursery	OR	067	0.91	0.85	0.85	F	10,433	0.040	0.012	0.010
07092-00	P.E. 16.4 Wasteway Hendricks	WA	021	1.00	0.30	0.30	P	4,114	0.790	0.587	0.176
07097-01	Rainbow Creek Hydro	WA	009	1.00	0.95	0.95	P	3,626	3.000	2.100	1.995
07110-00	Boulder Creek	ID	079	1.00	0.10	0.10	F	7,040	0.185	0.126	0.013
07111-01	Wright Creek	WA	027	1.00	0.60	0.60	F	6,740	0.500	0.251	0.151
07134-00	Squirrel Creek	OR	047	0.87	0.20	0.20	F	0	0.510	0.319	0.064
07166-00	Diamond Cogeneration	OR	027	1.00	0.60	0.60	P	0	0.050	0.035	0.021
07174-05	Cottrell	WA	059	0.49	0.99	0.49	I	4,089	3.000	1.142	0.563
07182-06	Davis Creek	WA	041	0.77	0.82	0.77	F	2,422	1.600	0.742	0.570
07184-00	Sorensen	ID	037	0.78	0.10	0.10	F	0	0.030	0.029	0.003

Table 4-1

Potentially Developable Hydropower Sites[a]

FERC NO.	PROJECT NAME	LOCATION ST	CO[b]	DEVELOPMENT PROBABILITY RIVER	REGUL	FINAL	TYPE CODE[c]	COST ($/kWa)[d]	INSTALLED CAPACITY (MW)	AVERAGE ENERGY (MWa)	PROBABLE ENERGY (MWa)
07185-00	NG Rock Cr 5	ID	079	1.00	0.10	0.10	F	0	0.150	0.126	0.013
07214-01	Spring Creek	WA	039	1.00	1.00	0.10	C	0	0.006	0.003	0.000
07215-00	South Prairie Creek	WA	053	0.60	0.20	0.20	D	3,258	5.000	2.255	0.451
07217-01	Valsetz	OR	053	0.64	0.87	0.64	D	0	3.900	1.943	1.241
07225-03	Fall Creek	ID	003	1.00	0.85	0.85	F	5,031	1.091	0.298	0.253
07255-01	Stanton Creek	MT	029	0.81	0.10	0.10	F	8,290	0.100	0.080	0.008
07269-00	Jim Boyd	OR	059	1.00	1.00	0.10	F	16,906	1.095	0.483	0.048
07276-02	Fall Creek	ID	077	0.95	0.60	0.60	F	2,563	0.150	0.137	0.082
07286-00	Beulah (Agency Valley)	OR	045	0.94	0.25	0.25	G	6,591	2.000	0.594	0.148
07289-00	Juntura	OR	045	0.93	0.25	0.25	G	6,521	3.000	0.799	0.200
07290-00	Hood River	OR	027	1.00	0.20	0.20	P	0	3.960	2.232	0.446
07294-03	North Fork	OR	029	0.65	0.82	0.65	F	3,288	3.350	2.112	1.373
07311-00	Timberline	OR	005	0.82	0.10	0.10	F	0	0.350	0.314	0.031
07315-01	Curry Ditch	OR	001	1.00	0.60	0.60	P	0	0.420	0.251	0.150
07318-02	Kirtley-York	ID	013	0.76	0.60	0.60	D	0	0.600	0.382	0.229
07322-00	Trail Creek	ID	081	1.00	0.20	0.20	P	4,455	0.450	0.212	0.042
07324-00	Dead Horse Creek	ID	085	1.00	0.60	0.60	F	36,267	0.360	0.148	0.089
07325-00	Rogue River	OR	029	0.69	0.10	0.10	F	0	19.000	12.215	1.221
07368-00	Wagner Enterprises	OR	005	0.72	1.00	0.72	A	0	0.032	0.014	0.010
07390-00	Little Palouse Falls	WA	021	0.55	0.60	0.55	F	6,295	5.000	1.986	1.092
07393-02	Bagley Creek Water	WA	073	1.00	0.60	0.60	F	3,178	2.500	1.199	0.719
07402-00	Dailey Creek	OR	019	1.00	0.60	0.60	F	0	0.300	0.080	0.048
07405-00	Upper Indian Creek	OR	061	1.00	1.00	0.60	F	31,124	0.075	0.065	0.039
07439-00	George 1	ID	043	0.74	0.10	0.10	F	6,168	2.649	1.804	0.180
07440-00	George 2	ID	043	0.74	0.10	0.10	F	5,712	3.098	2.110	0.211
07441-00	George 3	ID	043	0.74	0.10	0.10	F	0	3.547	2.416	0.242
07447-02	Portneuf River	ID	005	0.73	0.99	0.73	I	2,744	0.744	0.445	0.324
07452-01	Clear Creek	OR	001	0.89	0.82	0.82	F	0	0.522	0.459	0.376
07455-00	Triple Creek	WA	061	1.00	0.60	0.60	F	5,080	0.640	0.279	0.167
07533-00	Farmers Irrigation District	OR	027	1.00	0.95	0.95	P	0	2.500	1.484	1.410
07562-00	Tomtit Lake Power Project	WA	061	1.00	0.30	0.30	S	0	0.300	0.228	0.068
07577-00	Burton Creek	WA	041	1.00	1.00	0.30	F	7,175	0.800	0.400	0.120
07589-00	Shingle Creek	ID	049	1.00	0.85	0.85	F	5,790	0.621	0.160	0.136
07491-00	Italian Creek	WA	015	1.00	0.10	0.10	F	0	1.500	0.228	0.023
07598-00	Arrow Creek	WA	057	1.00	0.10	0.10	F	0	0.950	0.380	0.038
07600-00	Iron Creek	WA	057	1.00	0.20	0.20	F	3,309	2.800	1.118	0.224

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Potentially Developable Hydropower Sites[a]

FERC NO.	PROJECT NAME	LOCATION ST	CO[b]	DEVELOPMENT PROBABILITY RIVER	REGUL	FINAL	TYPE CODE[c]	COST ($/kWa)[d]	INSTALLED CAPACITY (MW)	AVERAGE ENERGY (MWa)	PROBABLE ENERGY (MWa)
07601-00	Peek-a-boo Creek	WA	061	1.00	0.10	0.10	F	13,919	0.890	0.356	0.036
07602-01	Loch Katrine	WA	033	1.00	0.20	0.20	F	13,009	1.147	0.459	0.092
07606-00	Harvey Creek	WA	051	1.00	0.10	0.10	F	6,574	0.700	0.490	0.049
07620-00	SMC Lake	WA	033	0.73	0.20	0.20	F	4,579	1.700	0.670	0.134
07627-00	Ashley Creek	MT	029	0.93	0.10	0.10	F	4,318	0.352	0.243	0.024
07640-00	French Cabin Creek	WA	037	1.00	0.20	0.20	N	5,863	2.949	1.180	0.236
07641-00	Black Creek	WA	061	1.00	0.20	0.20	F	3,685	2.040	0.815	0.163
07644-00	Greider Creek Water Power	WA	061	1.00	0.20	0.20	F	6,690	0.860	0.342	0.068
07666-00	Meadow Creek	WA	061	1.00	0.20	0.20	F	0	3.470	1.389	0.278
07668-00	Silver Creek	WA	037	1.00	0.20	0.20	F	0	2.817	1.127	0.225
07672-00	Canyon Creek	WA	053	0.78	0.20	0.20	N	7,221	1.960	0.784	0.157
07675-00	Sloan Peak Water Power Project	WA	061	1.00	0.20	0.20	F	3,996	1.150	0.460	0.092
07684-00	Leishman Irrigation System	WA	037	1.00	1.00	0.20	S	0	0.032	0.007	0.001
07697-00	Chester Dam	ID	043	0.71	0.60	0.60	D	10,222	0.900	0.674	0.404
07719-03	O. J. Power Company	ID	071	1.00	1.00	0.60	F	6,695	0.146	0.152	0.091
07732-00	Mason Dam	OR	001	0.93	0.90	0.90	G	3,267	2.300	0.902	0.812
07741-00	Thorp Creek	WA	037	1.00	0.20	0.20	F	7,583	2.393	0.957	0.191
07786A00	Three Mile Falls 1	OR	059	1.00	0.30	0.30	P	0	5.000	0.463	0.139
07786B00	Three Mile Falls 2	OR	059	1.00	0.30	0.30	P	0	3.700	0.722	0.217
07788-01	Nancy 3 Water Power	WA	051	1.00	0.10	0.10	F	4,945	0.200	0.171	0.017
07806-01	Prospect Creek	MT	089	0.86	0.95	0.86	F	3,535	2.900	0.936	0.807
07817-00	Cummings Hydro Power	ID	059	1.00	0.60	0.60	F	0	0.030	0.012	0.007
07819-01	Lava Creek	ID	023	1.00	0.10	0.10	F	7,384	0.530	0.308	0.031
07829-00	Emigrant Dam	OR	029	0.72	0.90	0.72	M	7,912	1.850	0.628	0.450
07833-00	Gill Creek Hydro Project	WA	007	1.00	0.20	0.20	F	6,380	0.993	0.397	0.079
07834-00	Evans Lake	WA	033	1.00	0.20	0.20	F	8,399	1.005	0.402	0.080
07839-00	Cougar Creek	WA	061	1.00	0.20	0.20	F	6,981	1.334	0.534	0.107
07840-00	Hansen Creek	WA	033	1.00	0.20	0.20	F	5,816	1.340	0.534	0.107
07846-00	Bonneville Fish Attraction	OR	051	0.76	0.20	0.20	B	0	7.600	7.237	1.447
07858-00	Boulder Park	OR	001	1.00	0.60	0.60	F	0	0.600	0.046	0.027
07859-00	Carmen Creek	ID	059	0.88	0.10	0.10	F	8,434	2.300	0.986	0.099
07878-00	Hidden Springs	ID	047	1.00	0.87	0.87	D	10,762	0.073	0.035	0.031
07903-00	Squaw Creek	OR	017	0.66	0.10	0.10	F	0	3.500	2.511	0.251
07926-00	Spread Creek	MT	053	0.89	0.10	0.10	F	7,393	0.700	0.490	0.049
07940-00	Price Creek	WA	073	1.00	0.60	0.60	F	2,020	1.900	1.073	0.644
07978-00	Boulder Creek	MT	039	0.99	0.60	0.60	F	2,406	0.500	0.194	0.116

Table 4-1
Potentially Developable Hydropower Sites[a]

FERC NO.	PROJECT NAME	LOCATION ST	CO[b]	DEVELOPMENT PROBABILITY RIVER	REGUL	FINAL	TYPE CODE[c]	COST ($/kWa)[d]	INSTALLED CAPACITY (MW)	AVERAGE ENERGY (MWa)	PROBABLE ENERGY (MWa)
08040-02	Kinney Lake	OR	063	1.00	0.20	0.20	P	6,104	1.277	0.596	0.119
08043-03	Crow Creek	OR	065	0.74	0.20	0.20	O	8,607	3.350	1.747	0.349
08082-00	Cotten Hydro	WA	041	1.00	0.60	0.60	F	0	0.040	0.020	0.012
08094-02	Pine Creek	OR	001	0.70	0.20	0.20	F	4,338	1.700	1.095	0.219
08120-00	Wallace Creek	ID	059	0.98	0.60	0.60	F	0	0.007	0.007	0.005
08121-00	Deer Creek	ID	015	0.98	0.95	0.95	F	1,414	0.383	0.275	0.261
08128-00	Bob Nydegger Hydro Project	ID	083	0.90	0.20	0.20	J	0	4.702	0.940	0.188
08130-01	Brush Creek	ID	085	1.00	0.20	0.20	F	9,373	2.000	0.571	0.114
08131-00	Box Creek	ID	085	0.98	0.10	0.10	F	10,824	2.000	0.571	0.057
08133-04	East Fork Ditch	ID	003	0.98	0.95	0.95	D	3,145	4.980	1.522	1.446
08151-00	Clearwater Ditch & Chamberlin Pipeline	OR	063	1.00	0.95	0.95	S	0	0.057	0.047	0.045
08183-00	Deer Creek	WA	061	1.00	0.20	0.20	F	1,404	2.600	2.600	0.520
08202-00	Home Project	WA	041	1.00	0.60	0.60	F	0	0.008	0.002	0.001
08229-00	Freeman Creek	ID	059	0.98	0.10	0.10	F	6,066	1.200	0.853	0.085
08250-00	Amy Ranch	ID	023	0.98	0.82	0.82	F	11,389	0.450	0.228	0.187
08251-03	Riser Creek	ID	017	0.88	0.10	0.10	F	7,040	0.500	0.225	0.022
08253-00	Sharrott Creek	MT	081	1.00	0.60	0.60	F	20,255	0.095	0.040	0.024
08279-00	Lincoln Bypass	ID	063	1.00	0.60	0.60	P	2,070	1.960	1.139	0.684
08289-08	Noisy Creek	WA	073	0.98	0.95	0.95	F	2,910	10.700	5.057	4.804
08314-00	Deer Creek	WA	061	1.00	0.10	0.10	F	0	2.600	1.541	0.154
08332-00	1146 Wasteway	WA	037	1.00	0.20	0.20	P	0	3.600	0.792	0.158
08375-01	Blind Canyon	ID	047	1.00	1.00	0.20	P	4,958	1.300	0.646	0.129
08379-01	Louie Creek	ID	085	0.84	0.10	0.10	F	7,608	3.600	1.800	0.180
08479-00	Damfino Creek	WA	073	1.00	0.10	0.10	F	4,156	4.300	2.055	0.205
08481-00	Hill-Hagerman	ID	047	1.00	0.60	0.60	S	12,188	0.050	0.050	0.030
08515-00	Hope Creek	OR	063	1.00	0.60	0.60	F	2,773	0.115	0.040	0.024
08523-01	Jug Creek	ID	085	1.00	0.10	0.10	F	9,733	1.500	0.308	0.031
08524-01	Fall Creek	ID	085	1.00	0.10	0.10	F	7,725	3.900	0.799	0.080
08525-01	Boulder Creek	ID	085	0.95	0.10	0.10	F	8,485	4.500	0.890	0.089
08547-00	North Bend	WA	033	0.77	0.10	0.10	F	2,490	7.700	3.938	0.394
08601-01	Jore	MT	047	1.00	0.85	0.85	F	897	1.000	0.362	0.307
08612-01	Geo-Bon 1	ID	063	0.64	0.85	0.64	F	2,252	1.350	0.799	0.511
08643-00	Lower Patterson Creek	ID	059	0.82	0.20	0.20	F	7,164	1.350	0.675	0.135
08646-06	Mink Creek	ID	041	1.00	1.00	0.20	F	2,497	2.750	1.071	0.214
08667-00	Greenwood	ID	053	1.00	0.60	0.60	P	0	2.400	2.352	1.411
08670-00	Prineville	OR	013	0.90	0.20	0.20	G	0	2.900	1.949	0.390

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FERC NO.	PROJECT NAME	LOCATION ST	LOCATION CO[b]	DEVELOPMENT PROBABILITY RIVER	DEVELOPMENT PROBABILITY REGUL	DEVELOPMENT PROBABILITY FINAL	TYPE CODE[c]	COST ($/kWa)[d]	INSTALLED CAPACITY (MW)	AVERAGE ENERGY (MWa)	PROBABLE ENERGY (MWa)
08706-04	Keechelus to Kachess	WA	037	1.00	0.20	0.20	J	0	3.250	2.477	0.495
08790-00	Wishkah	WA	027	1.00	0.95	0.95	S	0	0.330	0.220	0.209
08795-00	Royal Catfish	ID	053	1.00	0.60	0.60	P	0	3.100	2.800	1.680
08804-01	Strawberry Flats	OR	029	0.93	0.20	0.20	M	0	20.000	7.991	1.598
08860-03	Little Gold	MT	039	1.00	1.00	0.20	F	5,017	0.450	0.217	0.043
08864-03	Calligan Creek	WA	033	0.77	0.45	0.45	F	0	5.050	2.020	0.909
08871-00	Marsh Valley	ID	005	1.00	0.60	0.60	P	3,796	1.700	0.813	0.488
08917-00	Phillips Ditch	OR	001	0.87	0.20	0.20	F	8,674	0.260	0.153	0.031
08946-01	Willow Creek	ID	031	1.00	0.20	0.20	F	10,665	0.740	0.308	0.062
08950-04	Twelve Mile Creek	ID	059	0.76	0.10	0.10	F	0	0.450	0.338	0.034
08971-05	Lincoln Bypass	ID	063	1.00	0.95	0.95	P	2,070	1.900	1.139	1.082
09006-02	Tumalo Creek	OR	017	0.76	0.25	0.25	D	6,186	7.300	3.311	0.828
09025-00	Hancock Creek	WA	033	0.77	0.45	0.45	F	0	5.220	2.599	1.169
09035-00	Clarence Creek	OR	057	0.53	0.95	0.53	F	3,120	0.550	0.258	0.138
09044-01	Bigg's Creek	WA	011	1.00	0.95	0.95	F	0	0.015	0.006	0.005
09060-01	North Boulder Creek	OR	005	1.00	0.10	0.10	F	0	3.100	1.747	0.175
09067-01	Warm Springs Creek	OR	019	0.87	0.20	0.20	F	0	3.000	1.374	0.275
09103-02	Cherry Creek	OR	003	1.00	0.85	0.85	F	1,647	0.015	0.006	0.005
09121A00	Nampa 1	ID	027	0.98	0.25	0.25	G	0	4.000	1.204	0.301
09121B00	Nampa 2	ID	027	0.98	0.25	0.25	G	0	4.000	1.204	0.301
09134-00	Dry Creek	ID	023	1.00	1.00	0.25	S	0	3.600	2.021	0.505
09247-01	Pratt Creek	ID	059	1.00	0.82	0.82	F	8,126	0.305	0.183	0.150
09336-00	Eagle Creek	WA	047	1.00	0.20	0.20	F	0	0.350	0.137	0.027
09364-00	Painted Rocks Dam	MT	081	0.99	0.45	0.45	J	0	5.000	3.500	1.575
09377-02	Big Quilcene	WA	031	0.70	0.25	0.25	G	1,173	1.000	5.708	1.427
09424-04	Cascade Creek	ID	021	0.77	0.95	0.77	F	2,286	0.900	0.405	0.313
09491-00	Fall Creek	OR	039	0.70	0.45	0.45	M	0	1.400	0.719	0.324
09543A00	Rim View Trout Company, Inc.	ID	047	1.00	0.65	0.65	S	9,911	0.215	0.205	0.133
09543B00	Rim View Trout Company, Inc.	ID	047	1.00	0.65	0.65	S	6,861	0.333	0.317	0.206
09587-00	Patterson Creek Associates	ID	059	0.74	0.20	0.20	F	4,448	3.000	1.712	0.342
09633-01	Hawkins Willow Creek	ID	019	0.75	0.20	0.20	F	6,647	0.693	0.428	0.086
09643-00	Tony Creek	MT	089	0.96	0.55	0.55	D	0	0.100	0.040	0.022
09656-02	Marble Creek	ID	079	0.65	0.95	0.65	F	0	3.200	1.142	0.742
09693-00	Challis Canal	ID	037	1.00	0.30	0.30	P	2,871	1.600	1.313	0.394
09867-00	Newman Ranch	ID	059	0.73	0.60	0.60	F	20,859	0.140	0.086	0.052
09883-02	Black Canyon	WA	033	1.00	0.45	0.45	F	0	2.500	13.744	6.185

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09885-03	Falls River	ID	043	1.00	0.95	0.95	P	1,307	7.500	5.274	5.010
09890A02	Upper Mesa Falls	ID	043	0.74	0.10	0.10	F	1,763	8.000	7.203	0.720
09907-00	Sunshine	ID	059	1.00	1.00	0.10	S	5,503	0.110	0.065	0.006
09940-00	Pines Hydro	ID	037	1.00	0.20	0.20	F	11,200	0.900	0.628	0.126
09975-00	Howard Hanson Dam	WA	033	0.68	0.50	0.50	G	0	24.500	12.250	6.125
09986-00	Elk Creek Lake	OR	029	0.71	0.45	0.45	M	0	7.000	4.900	2.205
09998-00	St Anthony Canal	ID	043	1.00	0.20	0.20	P	0	0.800	0.628	0.126
10002-00	Lake Isabel	WA	061	1.00	0.40	0.40	I	0	5.000	2.500	1.000
10019-01	Scoggins Water Power	OR	067	0.69	0.20	0.20	M	0	1.500	0.474	0.095
10027-00	Broughton	WA	059	0.57	0.55	0.55	D	0	4.500	4.326	2.380
10039-00	Riverdale Hydro	ID	041	0.74	0.20	0.20	F	0	5.200	2.215	0.443
10040-01	Dry Creek	ID	041	0.74	0.20	0.20	F	17,776	14.000	2.340	0.468
10069-00	Upper Deer Creek	OR	033	0.55	0.95	0.55	F	0	3.350	1.296	0.713
10100-00	Irene Creek	WA	057	1.00	0.45	0.45	F	0	3.680	1.839	0.828
10101-00	Black Creek	WA	061	1.00	0.45	0.45	F	0	1.230	0.629	0.283
10106-00	South Creek	ID	023	1.00	0.45	0.45	F	0	0.450	0.198	0.089
10115-01	Bull Run Creek	ID	035	0.98	0.20	0.20	O	0	3.950	2.765	0.553
10145-00	Lowe Creek	WA	033	1.00	0.45	0.45	F	0	1.720	0.864	0.389
10146-00	San Juan Creek	WA	061	1.00	0.45	0.45	F	0	2.240	0.896	0.403
10148-00	Bear Creek	WA	061	1.00	0.45	0.45	F	0	2.700	1.080	0.486
10151-00	Howard Creek	WA	061	1.00	0.45	0.45	F	0	3.500	1.727	0.777
10152-00	Excelsior Creek	WA	061	1.00	0.45	0.45	F	0	1.700	0.816	0.367
10164-00	Hazelton A	ID	053	1.00	0.95	0.95	P	0	8.940	2.854	2.711
10178-00	Deadwood Dam	ID	085	0.87	0.20	0.20	J	0	2.600	2.055	0.411
10180-00	Deep Creek	ID	003	0.98	0.45	0.45	F	0	1.646	0.982	0.442
10184-00	Pressentin Creek	WA	057	1.00	0.45	0.45	F	0	3.160	1.264	0.569
10186-00	Sloan Creek	WA	061	1.00	0.45	0.45	F	1,333	3.620	2.174	0.978
10187-00	Salmon Creek	WA	061	1.00	0.45	0.45	F	1,712	2.880	1.438	0.647
10189-00	Burn Creek	WA	033	1.00	0.45	0.45	F	1,357	3.440	1.751	0.788
10193-00	Crystal Creek	WA	061	1.00	0.45	0.45	F	1,457	2.880	1.467	0.660
10194-00	Helena Creek	WA	061	1.00	0.45	0.45	F	1,114	2.200	1.701	0.765
10197-00	Skykomish Tributaries	WA	061	1.00	0.45	0.45	F	0	4.408	2.626	1.182
10206-01	New Prospect	OR	029	0.82	0.20	0.20	I	2,176	16.000	11.073	2.215
10208-00	Enterprise Hydro	ID	043	1.00	0.65	0.65	P	0	1.200	0.600	0.390
10210-00	Harlan Creek	WA	033	1.00	0.40	0.40	I	0	2.330	1.164	0.466
10213-00	Boulder Creek 1	WA	061	1.00	0.45	0.45	F	0	1.362	0.680	0.306

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10214-00	Evergreen Creek	WA	061	1.00	0.45	0.45	F	0	1.701	0.850	0.383
10215-00	Fourth of July Creek	WA	061	1.00	0.45	0.45	F	0	1.696	0.848	0.382
10216-00	Bullbucker Creek	WA	061	1.00	0.45	0.45	F	0	1.548	0.774	0.348
10217-00	Johnson Creek	WA	061	1.00	0.40	0.40	I	0	2.515	1.258	0.503
10222-00	Barometer Creek 2	WA	073	1.00	0.45	0.45	F	0	10.700	5.365	2.414
10236-00	Lower Cedar Creek	ID	037	1.00	0.40	0.40	C	0	2.660	1.330	0.532
10237-00	Low Head 1	WA	001	1.00	0.95	0.95	P	2,524	0.200	0.080	0.076
10238-00	Low Head 2	WA	001	1.00	0.95	0.95	P	2,524	0.200	0.080	0.076
10239-00	Low Head 3	WA	001	1.00	0.95	0.95	P	2,524	0.200	0.080	0.076
10256-00	Hood Street Reservoir	WA	053	1.00	1.00	0.95	U	0	0.800	0.548	0.521
10258-00	Sonny Boy Creek	WA	057	1.00	0.45	0.45	F	0	3.510	1.791	0.806
10266-00	Found Creek 2	WA	057	0.90	0.45	0.45	F	0	4.120	2.079	0.935
10272-00	Thunder Creek	WA	057	0.90	0.45	0.45	F	0	2.494	1.244	0.560
10273-00	Shannon Creek	WA	073	1.00	0.45	0.45	F	0	2.430	1.215	0.547
10274-00	Sibley Creek	WA	057	1.00	0.45	0.45	F	0	2.980	1.493	0.672
10277-00	Wells Creek	WA	073	1.00	0.20	0.20	F	0	6.514	3.257	0.651
10287A00	Grandy Creek Tributary 1	WA	057	1.00	0.45	0.45	F	0	2.524	1.261	0.568
10287B00	Grandy Creek Tributary 2	WA	057	1.00	0.45	0.45	F	0	0.680	0.548	0.247
10290-00	Sandy + Dillard Creek	WA	073	1.00	0.45	0.45	F	0	3.787	1.894	0.852
10299-00	Nooksack River Tributary	WA	073	1.00	0.45	0.45	F	0	5.467	2.734	1.230
10305-00	Hidden Creek	WA	073	1.00	0.45	0.45	F	0	4.805	2.402	1.081
10326-00	Hazelton B	ID	053	1.00	0.95	0.95	P	0	7.500	2.580	2.451
10328-00	Alma/Copper Creek	WA	057	1.00	0.45	0.45	F	0	10.478	5.239	2.357
10356E00	Middle Fork Snoqualmie River	WA	033	1.00	0.45	0.45	F	0	1.397	0.699	0.314
10356G00	Middle Fork Snoqualmie River	WA	033	1.00	0.45	0.45	F	0	2.072	1.037	0.466
10360-00	Upper South Fork Snoqualmie River	WA	033	0.63	0.40	0.40	I	7,379	1.838	0.919	0.368
10371-00	Bear Creek Power	WA	057	0.97	0.50	0.50	G	1,988	2.000	1.370	0.685
10382C00	North Fork Snoqualmie (Calligan)	WA	033	0.77	0.20	0.20	F	1,448	3.583	1.791	0.358
10382D00	North Fork Snoqualmie (Hancock)	WA	033	0.77	0.20	0.20	F	2,848	4.328	2.164	0.433
10392-00	Falls Creek	WA	061	1.00	0.45	0.45	F	7,021	3.460	1.764	0.794
10396B00	North Fork Payette	ID	015	0.43	0.40	0.40	C	0	320.000	114.808	45.923
10398-00	Goblin Creek	WA	061	1.00	0.45	0.45	F	0	0.759	0.377	0.170
10416-00	Anderson Creek	WA	073	1.00	0.45	0.45	F	2,052	3.094	1.705	0.767
10420-00	Tye River	WA	033	1.00	0.60	0.60	I	0	8.000	3.984	2.390
10421-00	Howard Creek	WA	057	0.90	0.40	0.40	C	1,213	4.230	2.115	0.846
10424-00	Anderson Creek	WA	073	1.00	0.20	0.20	F	3,558	3.500	1.370	0.274

Table 4-1
Potentially Developable Hydropower Sites[a]

FERC NO.	PROJECT NAME	LOCATION ST	LOCATION CO[b]	DEVELOPMENT PROBABILITY RIVER	DEVELOPMENT PROBABILITY REGUL	DEVELOPMENT PROBABILITY FINAL	TYPE CODE[c]	COST ($/kWa)[d]	INSTALLED CAPACITY (MW)	AVERAGE ENERGY (MWa)	PROBABLE ENERGY (MWa)
10428-00	Ebey Hill	WA	061	1.00	1.00	0.20	M	4,051	0.100	0.070	0.014
10432-00	Lookout-Fossil Creek	WA	073	1.00	0.40	0.40	I	0	1.500	0.582	0.233
10433-00	Ririe	ID	019	0.96	0.20	0.20	G	2,365	3.400	2.283	0.457
10468-00	Dike	ID	005	0.80	0.85	0.80	F	0	1.700	0.850	0.677
10496-00	Big Creek	WA	033	1.00	0.45	0.45	F	2,675	1.183	0.591	0.266
10536-00	Enloe Dam	WA	047	0.70	0.50	0.50	G	0	4.500	3.425	1.712
10540-00	Harry Nelson	ID	087	0.79	0.35	0.35	L	1,401	4.500	2.333	0.817
10552-00	Mile-28 Water Power	ID	053	1.00	0.65	0.65	P	0	1.500	0.750	0.487
10558-00	McCoy Creek	WA	061	0.73	0.20	0.20	M	3,541	0.230	0.228	0.046
10568-00	Cispus River 3	WA	041	0.77	0.45	0.45	F	0	13.100	9.804	4.412
10574-00	Freeway Drop	ID	039	1.00	0.65	0.65	P	0	1.400	0.685	0.445
10607-00	Reeds Creek	ID	035	0.88	0.45	0.45	F	10,556	4.800	1.735	0.781
10610-00	Trout Creek	ID	029	0.95	0.60	0.60	D	5,466	0.640	0.274	0.164
10611-00	Whiskey Creek	ID	029	0.91	0.60	0.60	D	2,353	0.640	0.584	0.351
10625-00	Taneum Chute	WA	037	1.00	0.65	0.65	P	0	0.760	0.212	0.138
10671-00	Silver Creek	WA	041	0.81	0.10	0.10	F	0	6.000	4.566	0.457

[a] This table was compiled using the best information available to the Council at the time the final supplement was prepared. Hydropower site information changes over time and is constantly being refined. Therefore, the inclusion of a specific project on this list does not imply that there are no institutional constraints on the development of the project. In particular, it should be noted that possible constraints presented by the Oregon Wild and Scenic Rivers Act and the Oregon Rivers Measure may apply to certain projects included on this list. Information pertaining to these measures was not available at the time the final supplement was prepared.

[b] Federal General Data Standard county code (key follows).

[c] Type code key:

Status of Waterway Structure	Run-of River	Diversion	Run-of River Reservoir with Diversion	Storage Reservoir	Storage Reservior with Diversion	Canal	Conduit	Pumped Storage
Existing	A	D	G	J	M	P	S	V
Existing with power	B	E	H	K	N	Q	T	W
Undeveloped	C	F	I	L	O	R	U	X

[d] Note that capital cost is in terms of dollars per average kilowatt energy production.

Table 4-1
Potentially Developable Hydropower Sites[a]

FEDERAL GENERAL DATA STANDARD COUNTY CODE

STATE	CODE	COUNTY NAME	STATE	CODE	COUNTY NAME	STATE	CODE	COUNTY NAME	STATE	CODE	COUNTY NAME
ID	001	Ada	ID	071	Oneida	MT	051	Liberty	OR	005	Clackamas
ID	003	Adams	ID	073	Owyhee	MT	053	Lincoln	OR	007	Clatsop
ID	005	Bannock	ID	075	Payette	MT	055	McConde	OR	009	Columbia
ID	007	Bear Lake	ID	077	Power	MT	057	Madison	OR	011	Coos
ID	009	Benewah	ID	079	Shoshone	MT	059	Meagher	OR	013	Crook
ID	011	Bingham	ID	081	Teton	MT	061	Mineral	OR	015	Curry
ID	013	Blaine	ID	083	Twin Falls	MT	063	Missoula	OR	017	Deschutes
ID	015	Boise	ID	085	Valley	MT	065	Musselshell	OR	019	Douglas
ID	017	Bonner	ID	087	Washington	MT	067	Park	OR	021	Gilliam
ID	019	Bonneville	ID	093	Silver Bow	MT	069	Petroleum	OR	023	Grant
ID	021	Boundary				MT	071	Phillips	OR	025	Harney
ID	023	Deer Lodge	MT	001	Beaverhead	MT	073	Pondera	OR	027	Hood River
ID	025	Camas	MT	003	Big Horn	MT	075	Powder River	OR	029	Jackson
ID	027	Canyon	MT	005	Blaine	MT	077	Powell	OR	033	Josephine
ID	029	Caribou	MT	007	Broadwater	MT	079	Prairie	OR	035	Klamath
ID	031	Cassia	MT	009	Carbon	MT	081	Ravalli	OR	037	Lake
ID	033	Clark	MT	011	Carter	MT	083	Richland	OR	039	Lane
ID	035	Clearwater	MT	013	Cascade	MT	085	Roosevelt	OR	041	Lincoln
ID	037	Custer	MT	015	Chouteau	MT	087	Rosebud	OR	043	Linn
ID	039	Elmore	MT	017	Custer	MT	089	Sanders	OR	045	Malheur
ID	041	Franklin	MT	019	Daniels	MT	091	Sheridan	OR	047	Marion
ID	043	Fremont	MT	021	Dawson	MT	093	Silver Bow	OR	049	Morrow
ID	045	Gem	MT	025	Fallon	MT	095	Stillwater	OR	051	Multnomah
ID	047	Gooding	MT	027	Fergus	MT	097	Sweet Grass	OR	053	Polk
ID	049	Idaho	MT	029	Flathead	MT	099	Teton	OR	055	Sherman
ID	051	Jefferson	MT	031	Gallatin	MT	101	Toole	OR	057	Tillamook
ID	053	Jerome	MT	033	Garfield	MT	103	Treasure	OR	059	Umatilla
ID	055	Kootenai	MT	035	Glacier	MT	105	Valley	OR	061	Union
ID	057	Latah	MT	037	Golden Valley	MT	107	Wheatland	OR	063	Wallowa
ID	059	Lemhi	MT	039	Granite	MT	109	Wibaux	OR	065	Wasco
ID	061	Lewis	MT	041	Hill	MT	111	Yellowstone	OR	067	Washington
ID	063	Lincoln	MT	043	Jefferson	MT	113	Yellowstone Nat'l Park	OR	069	Wheeler
ID	065	Madison	MT	045	Judith Basin				OR	071	Yamhill
ID	067	Minidoka	MT	047	Lake	OR	001	Baker			
ID	069	Nez Perce	MT	049	Lewis & Clark	OR	003	Benton			

Table 4-1
Potentially Developable Hydropower Sites[a]

FEDERAL GENERAL DATA STANDARD COUNTY CODE

STATE	CODE	COUNTY NAME	STATE	CODE	COUNTY NAME	STATE	CODE	COUNTY NAME	STATE	CODE	COUNTY NAME
WA	001	Adams	WA	041	Lewis						
WA	003	Asotin	WA	043	Lincoln						
WA	005	Benton	WA	045	Mason						
WA	007	Chelan	WA	047	Okanogan						
WA	009	Clallam	WA	049	Pacific						
WA	011	Clark	WA	051	Pend Oreille						
WA	013	Columbia	WA	053	Pierce						
WA	015	Cowlitz	WA	055	San Juan						
WA	017	Douglas	WA	057	Skagit						
WA	019	Ferry	WA	059	Skamania						
WA	021	Franklin	WA	061	Snohomish						
WA	023	Garfield	WA	063	Spokane						
WA	025	Grant	WA	065	Stevens						
WA	027	Grays Harbor	WA	067	Thurston						
WA	029	Island	WA	069	Wahkiakum						
WA	031	Jefferson	WA	071	Walla Walla						
WA	033	King	WA	073	Whatcom						
WA	035	Kitsap	WA	075	Whitman						
WA	037	Kittitas	WA	077	Yakima						
WA	039	Klickitat									

Table 4-1
Potentially Developable Hydropower Sites[a]

ELECTRIC UTILITY FOSSIL FUEL PRICE AND AVAILABILITY

The Council prepares estimates of non-electricity fuel prices for the residential, commercial and industrial sectors for use in developing the load growth forecasts. Because of the large quantities of fuel used by electric generating plants and the reliability requirements of these plants, the fuel prices for these plants may differ from those of other industrial sectors. For this reason, separate estimates of fossil fuel prices for electricity generation are prepared by the Council.

In the 1986 Power Plan, separate utility fuel price estimates were prepared only for coal. In this supplement, utility fuel price estimates have been prepared for distillate fuel oil, residual fuel oil and natural gas, in addition to coal. Natural gas prices are forecast for firm, interruptible and "hybrid" contracts. The fuel price forecasts described in this section are based on work conducted by the Council and Bonneville since the 1986 Power Plan, and on discussions with fuel suppliers.

Distillate Fuel Oil

Distillate (No. 2) fuel oil may be used to fire boilers, simple-cycle and combined-cycle combustion turbines, and diesel generators. It may substitute for natural gas in these applications, but generally commands a premium price relative to natural gas under equilibrium price conditions, because it can be transported and stored more easily. For this reason, in the Pacific Northwest, distillate fuel oil use is limited to back-up fuel for combustion turbines, unless natural gas is not available at the plant site. It is expected that use of distillate as a utility fuel will continue to be limited to those uses.

If used as a back-up fuel, distillate purchases by utilities would be relatively small scale, and prices should be similar to those for other industrial sectors. The proposed utility distillate fuel price series is therefore based on the industrial oil price series prepared for the load growth forecasts. The distillate series is obtained by adding an estimated distillate premium to the crude price series underlying the regional average industrial oil price forecasts.

Distillate prices are forecast to begin at $3.66 per million Btu[3] in 1988. This is much lower than the $5.70 per million Btu (1985 dollars) used in the 1986 plan, due to the drop in crude oil prices in 1986. Following a slight decline through 1990, as shown in Figure 4-1 and Table 4-6, distillate prices are forecast to escalate through the balance of the planning period. The average rate of escalation over the 20-year period is 2.5 percent, compared to 1.9 percent used in the 1986 plan.

Residual Fuel Oil

Residual (No. 6) fuel oil is used to fire boilers in the utility sector. Because it can substitute for natural gas in boiler applications, it is the principal link between natural gas prices and fuel oil prices. There are few natural gas or oil-fired utility boilers in the Pacific Northwest.

3./ Btu - British thermal unit--a measure of thermal energy.

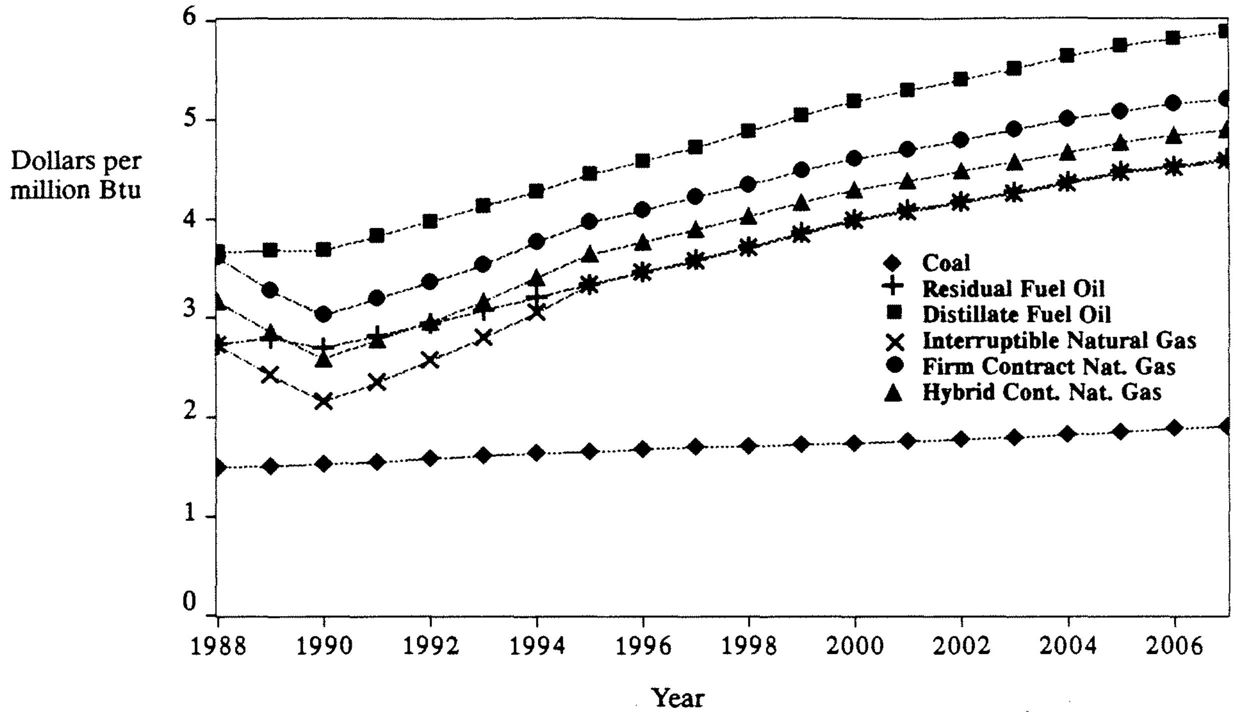

Figure 4-1
Electric Utility Fossil Fuel Prices

Table 4-6
Coal and Fuel Oil Prices

		COAL	RESIDUAL FUEL OIL	DISTILLATE FUEL OIL
Fuel Type		Subbituminous	Fuel Oil No. 6	Fuel Oil No. 2
Heat Value		8,550 Btu/lb.	18,994 Btu/lb. (HHV)[a]	19,161 Btu/lb (HHV)[a]
Source		Powder River Basin	Not Specified	Not Specified
Delivery		Boardman, OR	PNW Site	PNW Site
Transport		Unit Train	Rail or Barge	Rail or Barge
Purchase		Spot/Contract	Spot	Spot
Fixed Delivery Cost (1988$/kW)		$8.60	$0.00	$0.00
Variable Cost (1988$/MMBtu)	1988	$1.49	$2.73	$3.66
	1989	$1.50	$2.79	$3.67
	1990	$1.52	$2.69	$3.68
	1991	$1.54	$2.81	$3.82
	1992	$1.57	$2.94	$3.97
	1993	$1.60	$3.07	$4.12
	1994	$1.63	$3.20	$4.27
	1995	$1.64	$3.34	$4.44
	1996	$1.67	$3.46	$4.58
	1997	$1.69	$3.59	$4.72
	1998	$1.70	$3.71	$4.87
	1999	$1.72	$3.86	$5.03
	2000	$1.73	$3.99	$5.18
	2001	$1.75	$4.09	$5.29
	2002	$1.77	$4.17	$5.40
	2003	$1.79	$4.27	$5.51
	2004	$1.82	$4.37	$5.63
	2005	$1.85	$4.48	$5.74
	2006	$1.88	$4.53	$5.82
	2007	$1.90	$4.60	$5.88
Average Escalation (1988-2007)		1.3%	2.8%	2.5%

a HHV - High Heating Value

Because of limited future use, utility residual fuel oil prices are likely to be similar to those for other industrial sectors. The proposed series of residual fuel prices is therefore the same as the regional average industrial residual fuel price series. Prices begin at $2.72 per million Btu, and hold relatively steady through 1990 (Table 4-6 and Figure 4-1). Beginning in 1991, real prices begin to escalate through the end of the study period. The average rate of escalation through the 20-year study period is 2.8 percent. This escalation rate is greater than that of distillate fuel oil, because it is anticipated that improved refining technology and increasing demand for lighter petroleum products will, over time, reduce the availability of heavy products such as residual oil. Also, the near-term price of residual oil is lower than that of distillate, so an equivalent price increase results in a greater rate of escalation.

Natural Gas

Natural gas is used in the electric utility industry to fire boilers, combustion turbines, combined-cycle plants and diesel generators. Utility use of natural gas in the Pacific Northwest has been less than elsewhere in the nation because of historically limited gas availability and the abundance of hydropower and coal resources. Natural gas may enjoy an expanded role in future electricity generation for several reasons, including:

- declining natural gas prices;
- abundant long-term reserves;
- improvements in combustion turbine technology;
- the advent of packaged natural gas-fired cogeneration units;
- the lesser environmental impacts of natural gas as compared to coal; and
- the cost-effectiveness of gas-based technologies for firming nonfirm hydropower.

Natural gas may be purchased under either firm or interruptible delivery contracts, or purchased on the spot market. Delivery of firm ("contract") gas is guaranteed, but at a premium price compared to interruptible gas. The price differential is attributable to the cost of constructing, operating and maintaining the natural gas transmission and distribution system, and the cost of providing peak period service.

Under equilibrium conditions, the price of natural gas is set through the interaction of interruptible natural gas and residual fuel oil in the industrial boiler fuel market. The two fuels are generally interchangeable, and industrial users can purchase the least costly option. Therefore, the price of residual fuel oil caps the price of interruptible natural gas. Under conditions like the current natural gas surplus, the price of interruptible gas may drop well below that of residual fuel oil. Firm gas prices are based on the same commodity charge as interruptible gas, but incorporate the additional fixed costs associated with guaranteed delivery. Firm gas prices therefore follow interruptible gas price movements, but at a higher level.

Either firm or interruptible natural gas contracts could be used to supply a gas-fired electric generating plant used primarily for baseload service. If interruptible contracts were employed, the plant would require a back-up fuel oil supply for use during periods of interruption. Gas sold as interruptible in the Pacific Northwest is, nonetheless, rarely interrupted because of the surplus capacity of the natural gas transmission and distribution system. But, as the surplus in gas transmission capacity declines, delivery of interruptible gas might be suspended for as many as 100 days per year.

Use of natural gas for backing up nonfirm hydropower presents an unusual gas supply problem. Because these generating plants might operate only one year out of four or five, there would be many years during which no delivery is taken. On the other hand, when the plant is needed, it might have to run at nearly full capacity for much of the year. (Because energy, not capacity, is the reason for operating these plants, short shutdowns could be tolerated.) Representatives of the gas industry have suggested that these plants would require the reserved pipeline delivery capacity of firm service. But it should be possible to market some of this reserved delivery capacity during those years when plant operation is not required, thereby offsetting part of the fixed delivery costs. Moreover, since these generating plants could be shut down for short periods of time, even during poor water years, some of the peaking service costs associated with firm gas contracts could be avoided. The resulting cost of gas would be between the costs of conventional firm and interruptible contracts. The Council has chosen the average of the firm and interruptible natural gas price forecasts to represent this hybrid price.

Interruptible gas prices follow residual fuel oil prices through the study period, with the exception of the early years during which the current gas surplus is worked off. Prices begin at $2.72 per million Btu in 1986, and decline through 1990 because of the current gas surplus (Table 4-7 and Figure 4-1). Escalation is rapid in the early 1990s as the surplus is exhausted. As equilibrium with oil is re-established in the mid-1990s, the rate of natural gas escalation declines to a rate close to that of fuel oil. The overall rate of escalation of natural gas over the planning period is 2.8 percent, compared to 1.8 percent in the 1986 plan.

Table 4-7
Natural Gas Prices[a]

Heat Value		1,021 Btu/SCF (HHV)	1,021 Btu/SCF (HHV)	1,021 Btu/SCF (HHV)
Source		Not Specified	Not Specified	Not Specified
Delivery		PNW Site	PNW Site	PNW Site
Transport		Pipeline	Pipeline	Pipeline
Purchase		Interruptible	Firm Contract	Hybrid Contract (50/50)
Fixed Delivery Cost (1988$/kW)		$2.70	$2.70	$2.70
Variable Cost (1988$/MMBtu)	1988	$2.72	$3.61	$3.16
	1989	$2.42	$3.27	$2.85
	1990	$2.15	$3.02	$2.58
	1991	$2.34	$3.19	$2.77
	1992	$2.56	$3.35	$2.95
	1993	$2.79	$3.53	$3.16
	1994	$3.05	$3.76	$3.40
	1995	$3.33	$3.96	$3.64
	1996	$3.45	$4.08	$3.76
	1997	$3.57	$4.22	$3.89
	1998	$3.70	$4.33	$4.02
	1999	$3.83	$4.48	$4.16
	2000	$3.98	$4.60	$4.29
	2001	$4.06	$4.69	$4.38
	2002	$4.16	$4.79	$4.48
	2003	$4.25	$4.90	$4.57
	2004	$4.35	$5.00	$4.67
	2005	$4.46	$5.08	$4.77
	2006	$4.51	$5.16	$4.84
	2007	$4.58	$5.20	$4.89
Average Escalation (1988-2007)		2.8%	1.9%	2.3%

a 1,021 Btu/SCF (Higher Heat Value)

Firm gas prices follow interruptible prices, but at a higher level, reflecting the additional costs of firm service. Prices begin at $3.61 per million Btu in 1988, with an overall rate of escalation over the 20-year planning period of 1.9 percent.

The hybrid gas price series used for plants operated to back up nonfirm hydropower is the average of the firm and interruptible natural gas price series. Prices begin at $3.16 in 1988 and escalate at an average rate of 2.3 percent over the 20-year planning period.

If the nationwide movement to increased use of natural gas for thermal and electrical applications continues, natural gas prices may increase more rapidly than forecast. Because coal gasification technology is now commercially available, the cost of coal-derived synthetic gas may set a ceiling on natural gas prices for utility applications.

Coal

Coal is used as a boiler fuel in the utility and industrial sectors. Most coal use in the Pacific Northwest is associated with the electric power industry.

The reference utility coal is a Powder River Basin subbituminous coal delivered by unit train to Boardman, Oregon. The price estimates for this coal are the composite of a series of prices for minemouth Powder River Basin coal and a price series for rail transportation to Boardman. Purchase and maintenance of rail cars to transport the coal (rolling stock) are treated separately, as an annual fixed fuel delivery cost of $8.60 per kilowatt per year.

Delivered coal prices begin at $1.49 per million Btu ($29.60 per ton) in 1988. This is less than the $2.00 per million Btu used in the 1986 plan (about $2.15 in 1988 dollars) and reflects the surplus mining capacity in the Powder River Basin. The difference between the 1988 and 1986 estimates is not as great as it appears, since rolling stock purchase and maintenance costs were included in the 1986 estimate. Delivered coal prices escalate at a moderate rate throughout the planning period (Figure 4-1 and Table 4-6), reaching $1.90 by 2007. The average rate of escalation over the 20-year planning period is 1.3 percent, somewhat higher than the 0.9 percent used in the 1986 plan. Components of the long-term escalation rate include a steady, but slow increase in rail transportation rates and a fairly rapid run-up in minemouth coal prices as surplus mining capacity is exhausted. Because the minemouth cost represents only about 14 percent of delivered coal costs, escalation of minemouth coal prices has relatively little effect on the escalation rates of delivered coal.

Fossil Fuel Issues

Declining natural gas costs and improvements in the performance of combustion turbines have reduced the cost of electrical energy produced by base-loaded, combined-cycle plants. It is possible that these plants, operating either in cogeneration or stand-alone configuration, could comprise a substantial portion of future electrical generation, not only in the Pacific Northwest, but nationwide. The resulting increase in natural gas demand could cause a significant run-up in natural gas prices, and consequent electricity price escalation.

It is widely agreed that there is an abundance of natural gas available for the long-term at the producer level. However, because natural gas is generally considered to be a depletable resource, is obtained outside the region, and is subject to transportation constraints, it may be unwise to rely too heavily on natural gas as the basis for expanding the region's electric generating capacity.

The long-term availability of natural gas to the Pacific Northwest will be explored in a future Council issue paper. Several proposals to reduce risks associated with increased use of natural gas have been advanced. These include use of combined-cycle generating plants that could be converted to coal gasification; purchase of long-term contracts with gas producers; and limiting new gas-fired capacity to some proportion of new resource requirements (similar to California's resource diversity policies).

Increasing concerns regarding the environmental effects of fossil fuel use, particularly global warming, have focused interest on the advisability of continued development of fossil-fuel-fired generating resources. The environmental implications of additional fossil fuel usage will be considered by the Council following the release of this supplement. Natural gas releases less carbon dioxide per unit energy than other fossil fuels, and is generally cleaner with respect to other combustion products of concern. Because more reliance may be placed on natural gas, it is important to understand the long-term availability of this resource.

References

BPA, 1988: Utility Fuel Supply and Cost Study, Prepared for the Bonneville Power Administration, by Fluor Technology, Inc., January 1988.

THE COST AND PERFORMANCE OF ELECTRIC GENERATION TECHNOLOGIES USING NATURAL GAS

Natural gas has not played a substantial role in meeting the region's electrical loads. About 1,190 megawatts of gas-fired capacity, including a combined-cycle plant and several simple-cycle combustion turbines, are located in the region. But because of the relatively high cost of natural gas in the past, the use of these plants has been limited to meeting peaking loads, providing emergency capacity and firming secondary hydropower.

Attractive characteristics of gas-fired generating equipment include short lead times, small module sizes, low capital costs and modest environmental effects. In addition, combustion turbine equipment has the flexibility to adapt to changing load conditions and fuel prices. Simple-cycle combustion turbines may be converted to combined-cycle plants of higher capacity and efficiency by addition of heat recovery steam generators and steam turbine generators. Combined-cycle plants may be retrofitted with coal gasification facilities to use coal if natural gas prices increase.

These factors suggest that natural gas could play a greater regional role for electricity generation in the future. Promising applications include expanded use of combustion turbines for firming secondary hydropower and for meeting unexpected high rates of load growth. Declining natural gas prices, relaxed federal restrictions on the use of natural gas for electric power generation and improved plant efficiency may make combined-cycle plants cost-effective for baseload generation of electricity.

Constraints to Development

This discussion focuses on the cost and technical performance characteristics of natural gas-fired combustion turbines. Important questions remain regarding the extent to which natural gas-fired power plants should be counted on for future regional applications, such as cogeneration, backing up nonfirm hydropower and meeting unexpected load growth. Natural gas-fired power plants may be constrained by the availability of suitable sites, environmental considerations, including emission of nitrogen oxides and carbon dioxide, and the assurance of a long-term supply of natural gas at forecasted prices. These questions will be addressed by the Council when preparing its next power plan.

Generation Technologies

Natural gas is a very flexible fuel and can be used to generate electricity by several technologies. Conventional natural gas generating technologies include direct-fired steam-electric plants, simple-cycle combustion turbines, combined-cycle combustion turbine plants and internal combustion engines. All are commercially available and mature technologies, and may be used either in a stand alone or cogeneration configuration. Advanced conversion technologies using natural gas include fuel cells and hybrid solar-natural gas systems. This assessment focuses upon combustion turbine technology. The Council will review advanced natural gas conversion technologies when preparing its next power plan.

A simple-cycle combustion turbine consists of an air compressor, a fuel combustor, a gas turbine and an electrical generator. For electricity generation applications, the compressor, turbine and generator are generally mounted on a common shaft. Air is compressed in the compressor section, heated in the combustor section, and expanded through the gas turbine. The turbine drives both the compressor and the generator.

Either aircraft-derivative or heavy-duty combustion turbines are available for electric power generation. Aircraft-derivative machines are based on the lightweight, high efficiency units used as jet aircraft engines. They are characterized by high pressure ratios (ratio of compressor discharge pressure to compressor inlet pressure) that optimize the performance of these machines in simple-cycle configurations. High power-to-weight ratios are less important in heavy-duty (industrial grade) units, designed specifically for stationary applications. Heavy-duty units are characterized by lower pressure ratios that sacrifice efficiency in simple-cycle configuration but produce better efficiency in combined-cycle configuration. Heavy duty designs, therefore, may be a better choice where the machine will operate (or is expected to be later converted) to combined-cycle configuration. Industrial grade machines are available in a wider range of sizes than aircraft-derivative units, and have had a better reliability record for utility applications. (Properly maintained, aircraft-derivative units are now reported to be as reliable as heavy-duty machines in comparable service.)

Combustion turbines may be installed in simple-cycle, regenerative-cycle, steam-injected and combined-cycle configurations. Simple-cycle machines consist of compressor, combustor and turbine sections, as described earlier. Regenerative-cycle machines are provided with a heat exchanger in which the heat of the turbine exhaust is used to preheat the combustor inlet air, thereby improving efficiency. Steam injected units are provided with a heat-recovery steam generator on the turbine exhaust. Steam produced in this steam generator is injected into the combustor. The increased mass of the gas passing through the turbine augments both the power and the efficiency of the unit.

A combined-cycle combustion turbine consists of one or more combustion turbine generators, a heat-recovery steam generator and a steam-turbine generator. The hot combustion turbine exhaust is directed to the steam generator where it is used to raise steam. The steam drives the steam turbine generator. This use of the otherwise wasted exhaust gas of the combustion turbines increases the capacity and efficiency of the combined-cycle unit. Additional capacity may be obtained (at some sacrifice in efficiency) by supplemental firing of the steam generator with natural gas.

A new generation of heavy-duty combustion turbine designs, offering improved reliability and fuel use efficiency is now being introduced. These machines are in the 135 - 150 megawatt size range, and feature improved efficiency, achieved by increased air flow and higher firing temperatures. Machines of this type will be offered by ASEA Brown Bovari, General Electric, Siemens-Kraftwerk Union and Westinghouse-Mitsubishi. (EPRI, 1988.)

Typical performance characteristics of various types of gas turbines are shown in Table 4-8.

Table 4-8
Typical Combustion Turbine Performance Characteristics[a]

TYPE	SIZE (MW)	HEAT RATE (Btu/kWh)[b]	EFFICIENCY (%)[b]
Heavy-Duty, Simple Cycle	10-150	14,600-10,900	23-31%
Aircraft-Derivative, Simple Cycle	21-33	10,800-10,700	32%
Aircraft-Derivative, Steam Injected	26-50	9,800-8,700	35-38%
Heavy-Duty, Combined Cycle	57-446	8,100-7,300	42-47%
Aircraft-Derivative, Combined Cycle	58-178	8,000-7,800	43-44%

a From General Electric, 1988.

b Based on higher heating value of natural gas.

Simple-Cycle Combustion Turbine

The superior performance record for heavy duty units and their potential for conversion to more efficient combined-cycle configuration lead the Council to choose heavy-duty units as its representative combustion-turbine technology. However, other designs might be better suited for specific applications. For example, an aircraft-derivative, steam-injected unit might be the choice when later conversion to combined-cycle configuration was not expected. Aircraft-derivative units will be assessed in the next power plan.

The General Electric MS7001F combustion turbine is the basis for the Council's revised estimates of representative combustion turbine cost and performance. This machine operates at higher combustion temperatures and therefore greater efficiency than previous machines. The first MS7001F will be delivered to Virginia Power as the first phase of a possible gasification, combined-cycle power plant. Orders for four additional units have been placed.

The representative plant consists of twin combustion turbines installed near Hermiston, in eastern Oregon. The plant includes site improvements, weather enclosure with overhead crane, a switchyard, a two-mile gas pipeline spur and 10 miles of transmission line linking the unit with the grid. The weather enclosure and crane might be deleted for a western Washington or Oregon location. The lengths of gas pipeline and transmission line required for an actual installation, would, of course, depend on the site selected.

The representative combustion turbine cost, performance and other planning assumptions are compared in Table 4-9 to the assumptions of the 1986 plan. The primary source of information for the revised assumptions was a July 1988 study prepared by Fluor-Daniel for the Bonneville Power Administration (Fluor-Daniel, 1988). The figures for plant operating availability have not been re-examined since the 1986 plan, but are believed to be conservative because of generally increasing combustion turbine plant availability.

	SIMPLE-CYCLE GAS TURBINE GENERATORS		COMBINED-CYCLE GAS TURBINE GENERATORS	
	1986 PLAN	1989 SUPPLEMENT	1986 PLAN	1989 SUPPLEMENT
Design	Westinghouse W501D Note 1A	General Electric MS7001F Note 1B	Westinghouse PACE Note 1C	General Electric STAG 207F Note 1D
No. of Units	2	2	2	1
Unit Size (MW)	105 net	139.3 (net @ ISO[a])	286 (nominal)	419.6 (net @ ISO[a])
Site	Hermiston, OR	Hermiston, OR	Hermiston, OR	Hermiston, OR
Primary Fuel	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Heat Value (Btu/scf, HHV)	1,021	1,021	1,021	1,021
Primary Fuel Delivery	HP[b] pipeline	HP[b] pipeline	HP[b] pipeline	HP[b] pipeline
Alternate Fuel	Fuel Oil No. 2	Fuel Oil No. 2	Fuel Oil No. 2	Fuel Oil No. 2
Heat Value (Btu/lb, HHV)	19,430	19,430	19,430	19,430
Alternate Fuel Delivery	Truck, Barge or Rail	Truck, Barge or Rail	Truck, Barge or Rail	Truck, Barge or Rail
Fuel Inventory	14 day FO[c] @ 208MW	14 day FO[c] @ 279MW	14 day FO[c] @ 572MW	14 day FO[c] @ 420MW
Heat Rejection	Atmosphere	Atmosphere	Mech. Draft Towers	Mech. Draft Towers
Particulates	None required	None required	None required	None required
SOX Control	Low-sulfur FO[c]	Low-sulfur FO[c]	Low-sulfur FO[c]	Low-sulfur FO[c]
NOX Control	Water injection	Water injection	Water injection	Water injection
Transmission - Configuration	230kV single circuit	230kV single circuit	500kV single circuit	230kV double circuit
Transmission - Length (miles)	10	10	10	10
		NET CAPACITY AND HEAT RATE		
Max. Sust. Cap. @ 35F (MW)	124/unit	152.4/unit	n/a	452.2
ISO[a] Rated Cap. (MW)	104/unit	139.3/unit	586	419.6
Minimum Sustainable Capacity (MW)	5/unit	n/a	n/a	n/a
Net Heat Rate @ Max. Sus. (Btu/kWh)	10,530 Note 2A	11,130 Note 2B	n/a	7,500 Note 2B
Net Heat Rate @ Rated (Btu/kWh)	10,710 Note 2A	11,480 Note 2B	9,810 Note 2A	7,620 Note 2B
Net Heat Rate @ Min. Sus. (Btu/kWh)	62,000 Note 2A	n/a	n/a	n/a

Table 4-9
Simple-cycle and Combined-cycle Gas Turbine Generator Power Plants

	SIMPLE-CYCLE GAS TURBINE GENERATORS		COMBINED-CYCLE GAS TURBINE GENERATORS	
	1986 PLAN	1989 SUPPLEMENT	1986 PLAN	1989 SUPPLEMENT
OPERATING AVAILABILITY				
Equivalent Annual Availability	85%	85%	83%	83%
Routine Annual Insp. & Maintenance	30 days	30 days	30 days	30 days
Major Inspection & Overhaul	90 days	90 days	90 days	90 days
Freq. of Major Insp. & Overhaul	5 years	5 years	5 years	5 years
Average Maintenance Outage	42 days	42 days	42 days	42 days
Other Planned & Unplanned Outages	4%	4%	6%	6%
SEASONALITY				
Monthly Capacity Potential (percent of rated capacity, exclusive of outages):				
Jan	100.0% Note 4A	114.0% Note 4B	100.0% Note 4A	110.0% Note 4C
Feb	100.0%	112.0%	100.0%	108.0%
Mar	100.0%	109.0%	100.0%	106.0%
Apr	100.0%	106.0%	100.0%	104.0%
May	100.0%	103.0%	100.0%	101.0%
Jun	100.0%	100.0%	100.0%	99.0%
Jul	100.0%	97.0%	100.0%	97.0%
Aug	100.0%	98.0%	100.0%	97.0%
Sep	100.0%	101.0%	100.0%	100.0%
Oct	100.0%	106.0%	100.0%	104.0%
Nov	100.0%	111.0%	100.0%	107.0%
Dec	100.0%	113.0%	100.0%	109.0%

Table 4-9
Simple-cycle and Combined-cycle Gas Turbine Generator Power Plants

		SIMPLE-CYCLE GAS TURBINE GENERATORS 1986 PLAN	SIMPLE-CYCLE GAS TURBINE GENERATORS 1989 SUPPLEMENT	COMBINED-CYCLE GAS TURBINE GENERATORS 1986 PLAN	COMBINED-CYCLE GAS TURBINE GENERATORS 1989 SUPPLEMENT
PROJECT DEVELOPMENT - SITING AND LICENSING (January 1988 dollars)					
Siting & Licensing Lead Time (mos)		24	24	24	24
Siting & Licensing Cost ($/kW)		$4.00 Note 5A	$5.00 Note 5B	$13.00 Note 5A	$6.00 Note 5C
Siting & Licensing Shelf Life (yrs)		5	5	5	5
Siting & Licensing Hold Cost ($/kW/yr)		$0.50 Note 5D	$0.50 Note 5E	$0.50 Note 5D	$0.40 Note 5E
Prob. of S&L Success (%)		60.0%	60.0%	60.0%	60.0%
Prob. of S&L Hold Success (%)		n/a Note 5E	90.0%	n/a Note 5E	90.0%
PROJECT DEVELOPMENT - ENGINEERING & CONSTRUCTION (January 1988 dollars)					
Construction Lead Time (mos)		30	24 Note 6A	45	36 Note 6B
Lag Between Units (mos)		none	none	3 months	n/app
Cash Flows (%/yr)	Year 1	35.0%	48.0% Note 6C	4.0%	7.9% Note 6C
	Year 2	60.0%	52.0%	32.0%	40.8%
	Year 3	5.0%		43.0%	51.2%
	Year 4			21.0%	
Construction Cost ($/kW) (Excl. of siting, licensing & AFUDC)		$281 Note 6D	$530 Note 6E1	$714 Note 6D	$620 Note 6E2
Fuel Inventory ($/kW)		n/a Note 6G	$14	n/a Note 6G	$9
OPERATION					
Fixed Primary Fuel ($/kW/yr)		$2.70 Note 7A1	$0.00 Note 7A2	$2.70 Note 7A1	$0.00 Note 7A2
Fixed Alternate Fuel ($/kW/yr)		$2.70 Note 7B1	$0.00 Note 7B2	$2.70 Note 7B1	$0.00 Note 7B2
Fixed O&M ($/kW/yr)		$1.40 Note 7C	$2.00 Note 7D	$10.20 Note 7C	$5.40 Note 7D
Capital Replacement ($/kW/yr)		$1.40 Note 7E	$0.00 Note 7E1	$12.60 Note 7E	$0.00 Note 7E1

Table 4-9
Simple-cycle and Combined-cycle Gas Turbine Generator Power Plants

	SIMPLE-CYCLE GAS TURBINE GENERATORS 1986 PLAN	SIMPLE-CYCLE GAS TURBINE GENERATORS 1989 SUPPLEMENT	COMBINED-CYCLE GAS TURBINE GENERATORS 1986 PLAN	COMBINED-CYCLE GAS TURBINE GENERATORS 1989 SUPPLEMENT
		OPERATION (cont.)		
Variable primary fuel ($/MMBtu)	$5.10 Note 7F	$3.16 Note 7G	$5.10 Note 7F	$3.16 Note 7G
Variable alternate fuel ($/MMBtu)	$5.70 Note 7F	$3.66 Note 7G	$5.70 Note 7F	$3.66 Note 7G
Variable O&M (mills/kWh)	2.2 Note 7C	0.1 Note 7H	0.32 Note 7C	0.3 Note 7H
Byproduct Credit	0.0	0.0	0.0	0.0
Physical life (yrs)	30	30	30	30

a ISO - International Standards Organization Conditions
b HP - High Pressure
c FO - Fuel Oil

Notes

1A. Plant design based on Westinghouse W501D units used at the Fredonia Plant of Puget Sound Power and Light Company. Derivation of planning assumptions is described in Appendix 6G of Volume II of the 1986 Power Plan.

1B. Plant design based on twin General Electric MS7001F gas turbines, as described in BPA/Fluor, 1988.

1C. Two combined-cycle units of 286 megawatts nominal capacity each, based on Westinghouse PACE design. Each unit consists of two single-shaft, industrial-grade, open-cycle, gas turbine generators of 105 megawatts of nominal capacity (Westinghouse W501D), two heat-recovery steam generators and one steam turbine-generator of 84 megawatts of gross capacity. Steam conditions are 1,210 pounds per square inch guage pressure (psig) and 950°F.

1D. General Electric STAG 207F packaged combined-cycle units of 419.6 megwatt capacity (net at ISO[a] conditions). Enclosed gas turbo-generators. Each unit consists of two single-shaft, industrial-grade gas, turbine generators of 138.8 megawatts gross capacity at ISO[a] conditions (GE MS7001F), one heat recovery steam generator and one steam turbine generator of 151 megawatts (gross). Steam conditions are 1,465 psig and 1,000°F (throttle) and 1,000°F reheat.

2A. 1986 heat rates are based on lower heat value of fuel.

Table 4-9
Simple-cycle and Combined-cycle Gas Turbine Generator Power Plants

2B. 1988 heat rates are based on higher heat value of fuel.

4A. Seasonal constraints on energy capability not considered.

4B. Seasonal constraints on capacity are significant due to ambient temperature effects on combustion turbine output. From Figure 3.1 of BPA/Fluor, 1986, using mean monthly temperatures for Arlington, OR (NOAA, 82).

4C. Seasonal constraints on capacity are significant due to ambient temperature effects on combustion turbine output. From Figure 3.4 of BPA/Fluor, 1986, using mean monthly temperatures for Arlington, OR (NOAA, 82).

5A. 1986 estimates, escalated to January 1988 using gross national product (GNP) deflators.

5B. Siting and Licensing cost components are as follows:
- Securing option on land (8A) - 15 percent of fair market value (Battelle, 1982)
- Conceptualization, preliminary engineering, select site, secure licenses - 1 percent of total plant cost (Battelle, 1982)

5C. Siting and Licensing cost components are as follows:
- Securing option on land (20A) - 15 percent of fair market value (Battelle, 1982).
- Conceptualization, preliminary engineering, select site, secure licenses - 1.7 percent of total plant cost (Battelle, 1982).

5D. 1986 estimates, escalated to January 1988 using GNP deflators.

5E. Option Hold cost components are as follows:
- Project management - 1 Engineer (COTF, 1985).
- Siting Council fees - $0.05 kilowatt-hours per year (WWP, 1984).
- Environmental baseline - $0.16 kilowatt-hours per year (WWP, 1984).
- Maintenance of land option - 15 percent of fair market value per year (Battelle, 1982).
- Owner's indirect costs - 11 percent (WWP, 1984).

Rounded to nearest $0.10 kilowatt-hour per year.

6A. Construction schedule is from BPA/Fluor, 1986 Figure 5.1, rounded to the nearest year. (It is assumed that the second unit could be installed in parallel with the first unit.)

6B. Construction schedule is from BPA/Fluor, 1988 Figure 5.3, rounded to the nearest year. (It is assumed that gas turbines can be installed in parallel with HSRG and steam T/G.)

6C. Annual cash flows are derived from Table 5-4 of BPA/Fluor, 1988, adjusted to nearest year.

Table 4-9
Simple-cycle and Combined-cycle Gas Turbine Generator Power Plants

6D. 1986 estimates, escalated by appropriate indices from Handy-Whitman, 1988.

6E1. Construction cost components are as follows:

- Land purchase - 20 Acres @ $2,000 per acre (1986 dollars).
- Direct construction costs (Including Plant Facilities Investment, BPA/Fluor(88) T.5-2 ($115.7MM) and Fuel Oil Storage (Scaled from Kaiser(85) $5.0MM)).
- Contingency - 10 percent of direct and indirect costs (BPA/Fluor(88)).
- Owner's costs during construction - 4 percent of direct and indirect costs, including contingency (PNUCC, 1984).
- Transmission interconnect - Bonneville estimates.
- Spare parts inventory - BPA/Fluor, 1986, Table 6-4.
- Socioeconomic impact mitigation - 1 percent of total direct and indirect plant costs (COTF, 1985).
- Natural gas pipeline - Two miles at $500,000 per mile (Bonneville).
- Startup costs as noted in Note 6F.

All costs escalated to January 1988, using Handy-Whitman, 1988 where appropriate, GNP deflator otherwise. Rounded to the nearest $10 per kilowatt.

6E2. Construction cost components are as follows:

- Land purchase - 20 Acres @ $2,000 per acre (1986 dollars).
- Direct construction costs (Including Total Plant Investment from BPA/Fluor(88) T.5-3 ($208.7MM) and Fuel Oil Storage (Scaled from Kaiser(85) $5.0MM)).
- Contingency - 10 percent of direct and indirect costs (BPA/Fluor(88)).
- Owner's costs during construction - 4 percent of direct and indirect costs, including contingency (PNUCC, 1984).
- Transmission interconnect - Bonneville estimates.
- Spare parts inventory - BPA/Fluor, 1986, Table 6-4.
- Socioeconomic impact mitigation - 1 percent of total direct and indirect plant costs (COTF, 1985).
- Natural gas pipeline - Two miles at $500,000 per mile (Bonneville).
- Startup costs as noted in Note 6F.

All costs escalated to January 1988, using Handy-Whitman, 1988 where appropriate, GNP deflator otherwise. Rounded to the nearest $10 per kilowatt.

6F. Startup cost components are as follows:

- One month of fixed O&M costs.
- One month of variable O&M costs.
- One week at full capacity primary fuel cost.
- Two percent of total construction cost.

6G. Fuel inventory costs and startup costs were not broken out of the 1986 estimates.

7A1. 1986 estimate escalated to January 1988 using GNP deflator.

Table 4-9

Simple-cycle and Combined-cycle Gas Turbine Generator Power Plants

7A2. The 1986 fixed primary-fuel cost was the cost of the gas pipeline to plant. The capital cost of this pipeline is now included in plant capital costs.

7B1. 1986 estimate escalated to January 1988 using GNP deflator.

7B2. The 1986 fixed secondary-fuel cost was the cost of an oil pipeline to the plant. The current representative plant would use rail, truck or barge delivery of fuel oil.

7C. 1986 estimate escalated to January 1988 using BPA "JEFOM" steam plant O&M deflator.

7D. Fixed O&M costs include:

- Standby maintenance material costs - BPA/Flour(88) T.6-3.
- Operating, maintenance and support labor (BPA/Fluor T.6-4).
- General and administrative costs (17 percent, PNL(85))

Rounded to nearest $0.10 kilowatt-hour per year.

7E. 1986 estimate escalated to January 1988 using Handy-Whitman, 1988, Gas Turbogenerator index.

7E1. Interim capital replacement is included in O&M estimates.

7F. 1986 base year fuel prices, unescalated.

7G. 1989 supplement, Chapter 4, section on utility fuel prices.

7H. Variable O&M costs include the following:

- "Fixed" maintenance materials (BPA/Fluor T.6-4) less standby maintenance materials (BPA/Fluor T.6-3).
- Consumables (BPA/Fluor(88) T.6-6).
- General and administrative costs of 17 percent (PNL(85)).

Rounded to nearest 0.1 mills per kilowatt-hour.

References

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BPA/Fluor, 1988: Fluor Daniel, Inc., Technical and Economic Evaluation of New and Conventional Generation Technologies Development of Combustion Turbine Capital and Operating Costs, July 1988.

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COTF, 1985: Northwest Power Planning Council Coal Options Task Force, convened for preparation of the 1986 Plan.

Handy-Whitman, 1988: Whitman, Requardt and Associates. Handy-Whitman Index of Public Utility Construction Costs, Preliminary Numbers Bulletin 127, January 1988.

NOAA, 1982: National Oceanaic and Atmospheric Administration. Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1951-1980.

PNL, 1985: Pacific Northwest Laboratory. Electric Energy Supply Systems: Description of Available Technologies, February 1985.

PNUCC, 1984: Pacific Northwest Utilities Conference Committee. Working Paper Development of Generic Resource Data, October 1984.

WWP, 1984: Washington Water Power Company. Creston Generating Station Status Report, July 1984.

Table 4-9
Simple-cycle and Combined-cycle Gas Turbine Generator Power Plants

Combined-Cycle Combustion Turbine

The General Electric STAG 207F combined-cycle plant is the basis for the Council's revised estimates of representative combined-cycle combustion turbine cost and performance. This plant uses two MS7001F combustion turbines, one heat-recovery steam generator and one steam turbine generator.

The representative power plant consists of twin combined-cycle plants installed near Hermiston, Oregon. The plant includes site improvements, weather enclosure with overhead crane for the combustion turbines, water supply, cooling towers, a switchyard, a 2-mile gas pipeline spur and 10 miles of transmission line linking the plant with the grid.

The cost, performance and other planning assumptions for the representative combined-cycle combustion turbine are compared in Table 4-9 to the assumptions of the 1986 plan. The primary basis for the revised combined-cycle planning assumptions was a July 1988 study completed by Fluor-Daniel for the Bonneville Power Administration (Fluor-Daniel, 1988). Availability estimates have not been re-examined since the 1986 plan, but are believed to be conservative.

References

EPRI, 1987: Electric Power Research Institute. Evaluation of Alternative Steam Generator Designs for Atmospheric Fluidized Bed Combustion Plants (EPRI CS-5296). Prepared by Bechtel Group, Inc. July 1987.

Fluor-Daniel, 1988: Technical and Economic Evaluation of New and Conventional Generation Technologies. Development of Combustion Turbine Capital and Operating Costs. Prepared for the Bonneville Power Administration, Portland, Oregon, July 1988.

General Electric, 1988: General Electric Company, 1988. Turbine State-of-the-Art Technology Seminar. October 1988.

THE COST AND PERFORMANCE OF ELECTRIC GENERATION TECHNOLOGIES USING COAL

The Pacific Northwest power system receives output from 13 coal-fired units totaling 6,702 megawatts of nameplate capacity. The regional shares of these plants supply 3,957 megawatts of peak capacity and 3,154 megawatts of energy (Appendix 6-A of Volume II of the 1986 Power Plan).[4]

Except for mines supplying the Centralia Generating Station in western Washington, little coal is mined within the region. However, proven reserves of low sulfur coal far in excess of those required to meet electricity needs for the foreseeable future are available from sources near the region. Because of the abundance of low-cost coal available for regional use, and proven technology for generating electricity from coal, coal-fired power plants were used as the basis for long-term marginal electricity costs in the 1983 and 1986 plans.

Constraints to Development

This discussion focuses on the cost and technical performance of coal-fired power plants. Future use of coal on the scale suggested by high load growth forecasts presents important questions associated with air-quality impacts (including emissions of sulfur dioxide, nitrogen oxides and carbon dioxide), solid waste disposal, site availability, coal transportation and electric power transmission. The Council will examine these questions during the development of its next power plan.

Generation Technologies

The pulverized-coal-fired steam-electric power plant is an established technology for producing electricity from coal. Advanced coal-based generating technologies include fluidized bed combustion, gasification-combined-cycle plants and magnetohydrodynamics.

A pulverized-coal-fired power plant consists of a coal-handling and preparation section, a boiler and a steam turbine generator. Coal is pulverized in the preparation section and burned in the boiler, generating steam. The steam operates the steam turbine generator, producing electricity. A cooling system transfers reject heat from the steam turbine to the atmosphere and an emission control system removes particulates and sulfur oxides from the combustion gasses.

Pulverized-coal-fired plants are tested, reliable designs. Flue-gas desulfurization and particulate control equipment permits these plants to meet current U.S. New Source Performance Standards promulgated under the Clean Air Act. Although a mature technology, enhancements in plant control, efficiency and reliability have improved the cost and performance of new pulverized-coal-fired plants compared with earlier designs. A wide range of unit sizes is available, allowing capacity additions to be matched to load growth. Smaller plant sizes have somewhat shorter construction lead times and greater reliability, but are generally more costly (per unit capacity) to build and operate than larger units.

An atmospheric, fluidized-bed coal-fired (AFBC) power plant is similar in overall configuration to a pulverized-coal-fired plant but uses a different type of furnace to combust the coal. A fluidized-bed plant

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4./ Not included in these figures is the J.E. Corette plant of Montana Power Company, or the Montana Power Company shares of the Colstrip units. About 30 percent of the capability of these resources (excluding Colstrip 4) is available to the region. This fraction (which may change through time) represents the portion of total Montana Power Company load located within the Pacific Northwest. By Pacific Northwest planning conventions, the regional shares of Montana Power Company resources are treated as imports to the region.

burns coarsely ground coal in a bed of limestone particles suspended by continuous injection of air from below. The limestone scavanges sulfur directly from the burning coal. With certain coals, this design can meet current federal New Source Performance Standards without use of flue-gas desulfurization equipment. Elimination of flue-gas desulfurization saves capital and operating costs, and improves plant efficiency. Also, the lower combustion temperatures of AFBC plants reduce formation of nitrogen oxides. AFBC plants eliminate the need for coal pulverizers and produce a dry solid waste instead of a wet flue gas desulfurization sludge.

AFBC technology has been employed in the non-utility industry for many years, but utility use is recent in the United States. Three utility AFBC units, ranging in size from 20 megawatts to 125 megawatts, are in service in the United States. A fourth unit of 160 megawatts is scheduled for service this year. Tacoma Light and Power's 38-megawatt Steam Plant No. 2 is being repowered with fluidized bed furnaces that will be capable of burning coal, wood refuse and municipal solid waste. Many in the utility industry believe that the next generation of central-station coal plants will be largely of AFBC design.

In pressurized fluidized-bed combustion (PFBC) designs, fuel is burned in a pressurized chamber. The hot combustion gases power a gas turbine prior to final heat recovery in a steam boiler. This combined-cycle design results in higher energy conversion efficiencies. The first U.S. demonstration of PFBC technology for utility application has been announced recently. This will be a 330-megawatt repowering of two units of the American Electric Power Sporn plant. (Electrical World, 1988.)

A gasification-combined-cycle (GCC) plant consists of a coal gasification section and a combined-cycle combustion turbine power plant. The gasification section produces low or medium-Btu synthetic gas that is used to fuel the combined-cycle combustion turbine plants. GCC plants feature a high degree of modularity, significantly improved control of atmospheric emissions and high energy conversion efficiencies. The combustion turbine and combined-cycle sections can be installed prior to the gasification plant, and operated on natural gas until fuel prices or load conditions warrant installation of the gasification section. The gasifier therefore imparts fuel flexibility to the highly efficient combined-cycle plant (a description of combustion turbines and combined-cycle plants is provided earlier in this chapter).

Coal gasification technology has been available for many years and was once widely used to produce "town gas" in cities (including several in the Northwest) where natural gas was not locally available. The technology fell into disuse as the long-distance natural gas transmission system was constructed, but was resurrected as interest in substitutes for natural gas rose in the 1970s. Improved versions of the technology have since been developed. Utility-scale application of the coal-gasification, combined-cycle plant concept has been successfully demonstrated since 1984 at the 100-megawatt Coolwater plant.

Magnetohydrodynamics (MHD) is a process for converting heat energy directly into electricity. High combustion temperatures, combined-cycle operation and direct conversion of thermal to electrical energy could offer the advantages of high energy conversion efficiency. The MHD concept also promises improved control of atmospheric emissions.

An MHD power plant would consist of a combustor, an MHD "channel," a heat-recovery boiler and a steam turbine generator. Pulverized coal would be burned at high temperature and pressure in the combustor. Potassium "seed," injected to ionize the hot gas, would create electrically conductive plasma. Passing through the MHD channel, where a strong magnetic field would be established by use of superconducting magnets, the ionized gasses of the plasma would create an electrical potential across electrodes installed in the channel. The plasma would discharge from the channel to a heat-recovery boiler. Steam from this boiler would drive a conventional steam turbine generator, augmenting the power production of the MHD channel. The MHD process is in the research and development stage and is not expected to be commercially available in the near future.

Conventional pulverized-coal-fired power plants, atmospheric, fluidized-bed power plants and gasification combined-cycle power plants offer at present, the greatest potential for meeting future regional electricity needs using coal. The Council adopted revised planning assumptions for pulverized coal plants and adopted new planning assumptions for atmospheric, fluidized-bed plants, and a coal-gasification combined-cycle plant.

Pulverized-Coal-Fired Power Plants

Two representative pulverized-coal-fired power plants are considered. One is a twin-unit design of 603 megawatts net capacity per unit. This size is typical of the larger plants constructed in recent years. The second generic plant is a twin-unit design of 250 megawatts net capacity per unit. This plant is typical of the smaller units completed in recent years and offers the advantages of shorter lead time and smaller module size. Because of economics of scale, the larger units retain cost advantages.

The planning characteristics of these plants are derived from Bonneville's Comparative Generation Study (BPA, 1987). Each plant includes coal receiving, storage, handling and preparation facilities, a pulverized-coal-fired boiler, a steam turbine generator, wet limestone scrubbers and electrostatic precipitators for emissions control, and a mechanical draft heat rejection system. The projects also include site improvements, water supply, switchyards and transmission linkage to the grid. A listing of the cost components is provided in this chapter, in the next section.

The planning assumptions for the twin 603-megawatt unit plant and the twin 250-megawatt unit plant are shown in Table 4-10, compared to the 1986 equivalents. The 1986 plants were based on an earlier version of the Bonneville Comparative Generation Study, hence the similarity of the current assumptions with the 1986 plan. Note that the 1988 plants are shown as having lower efficiency than the 1986 plants. This is due to an error in computing the heat rates of the 1986 plants. The unit capital cost of the twin 250-megawatt unit plant has declined, but is still more expensive than the plant comprised of larger units. The results of a study of siting and licensing costs completed since the 1986 plan (BPA, 1986a), suggest that the siting and licensing costs used in the 1986 plan were too high. The proposed siting and licensing cost estimates have been reduced to the mid-range estimates of BPA, 1986a.

	TWO 270-MEGAWATT UNITS		TWO 650-MEGAWATT UNITS	
	1986 PLAN	1989 SUPPLEMENT	1986 PLAN	1989 SUPPLEMENT
Design	Pulverized firing 2,400 psig steam 1,000°F/1,000°F reheat 3.5Hga backpressure Note 1A	Pulverized firing 2,400 psig steam 1,000°F/1,000°F reheat 2.95Hga backpressure Notes 1B and 1F	Pulverized firing 2,400 psig steam 1,000°F/1,000°F reheat 3.5Hga backpressure Note 1C	Pulverized firing 2,400 psig steam 1,000°F/1,000°F reheat 2.95Hga backpressure Notes 1D and 1F
Number of Units	2	2	2	2
Unit Size (MW)	270 (gr)/250 (net)	270 (gr)/250 (net)	650 (gr)/603 (net)	650 (gr)/603 (net)
Site	Hermiston, OR	Hermiston, OR	Hermiston, OR	Hermiston, OR
Primary Fuel	WY subbituminous	WY subbituminous	WY subbituminous	WY subbituminous
Heat Value (Btu/lb)	8,445	8,445	8,445	8,445
Fuel Delivery	Unit train	Unit train	Unit train	Unit train
Fuel Inventory	90 day @ 500MW	90 day @ 500MW	90 day @ 500MW	90 day @ 500MW
Heat Rejection	Mech. draft towers	Mech. draft towers	Mech. draft towers	Mech. draft towers
Flash Control	Precipitators	Precipitators	Precipitators	Precipitators
SOX Control	Wet scrubbers	Wet scrubbers	Wet scrubbers	Wet scrubbers
NOX Control	Comb. control	Comb. control	Comb. control	Comb. control
Transmission - Configuration	500kV single circuit	230kV dbl cir. Note 1G1	500kV double circuit	500kV double circuit Note 1G2
Transmission - Length (miles)	10	10	10	10
		CAPACITY AND HEAT RATES		
Max. Sust. Cap. (MW/unit)	262	262	633	633
Rated Capacity (MW/unit)	250	250	603	603
Minimum Sustainable Cap. (MW/unit)	63	63	151	151
Net Heat Rate @ Max. Sus. (Btu/kWh)	10,320	11,145 Note 2A	10,210	10,970 Note 2A
Net Heat Rate @ Rated (Btu/kWh)	10,190	11,005	10,080	10,856
Net heat Rate at Min. Sus. (Btu/kWh)	11,670	n/a	11,940	n/a

Table 4-10
Pulverized-Coal-Fired Power Plants

	TWO 270-MEGAWATT UNITS		TWO 650-MEGAWATT UNITS	
	1986 PLAN	1989 SUPPLEMENT	1986 PLAN	1989 SUPPLEMENT
OPERATING AVAILABILITY				
Equivalent Annual Availability	77.0%	77.0%	75.0%	75.0%
Routine Annual Insp. & Maintenance	30 days	30 days	30 days	30 days
Major Inspection & Overhaul	60 days	60 days	60 days	60 days
Freq. of Major Insp. & Overhaul	5 years	5 years	5 years	5 years
Average Maintenance Outage	36 days	36 days	36 days	36 days
Other Planned & Unplanned Outages	17%	17%	15%	15%
ENERGY PRODUCTION PROFILE				
Monthly Capacity Potential (percent of rated capacity, exclusive of outages):				
Jan	100.0% Note 4A	100.0%	100.0% Note 4A	100.0%
Feb	100.0%	100.0%	100.0%	100.0%
Mar	100.0%	100.0%	100.0%	100.0%
Apr	100.0%	100.0%	100.0%	100.0%
May	100.0%	100.0%	100.0%	100.0%
Jun	100.0%	100.0%	100.0%	100.0%
Jul	100.0%	100.0%	100.0%	100.0%
Aug	100.0%	100.0%	100.0%	100.0%
Sep	100.0%	100.0%	100.0%	100.0%
Oct	100.0%	100.0%	100.0%	100.0%
Nov	100.0%	100.0%	100.0%	100.0%
Dec	100.0%	100.0%	100.0%	100.0%

Table 4-10
Pulverized-Coal-Fired Power Plants

	TWO 270-MEGAWATT UNITS 1986 PLAN	TWO 270-MEGAWATT UNITS 1989 SUPPLEMENT	TWO 650-MEGAWATT UNITS 1986 PLAN	TWO 650-MEGAWATT UNITS 1989 SUPPLEMENT
PROJECT DEVELOPMENT - SITING AND LICENSING (January 1988 dollars)				
Siting & Licensing Lead Time (mos)	48	48	48	48
Siting & Licensing Cost ($/kW)	$57	$32 Note 5A	$40	$23 Note 5A
Siting & Licensing Shelf Life (yrs)	5	5	5	5
Siting & Licensing Hold Cost ($/kW/yr)	$0.60	$0.90 Note 5B	$0.30	$0.80 Note 5B
Prob. of S&L Success (%)	70.0%	70.0%	70.0%	70.0%
Prob. of S&L Hold Success (%)	n/est.	90.0%	n/est.	90.0%
PROJECT DEVELOPMENT - ENGINEERING & CONSTRUCTION (January 1988 dollars)				
Const. Lead Time (to first unit)(mos)	60	60	72	72
Lag Between Units (mos)	12	12	12	12
Cash Flows (%/yr): Year 1	2.0%	2.0%	4.0%	4.0% Note 6A
Year 2	8.0%	8.0%	11.0%	11.0%
Year 3	24.0%	24.0%	17.0%	17.0%
Year 4	40.0%	40.0%	27.0%	27.0%
Year 5	23.0%	23.0%	28.0%	28.0%
Year 6	3.0%	3.0%	12.0%	12.0%
Year 7			1.0%	1.0%
Construction Cost ($/kW) (Excl. of siting, licensing & AFUDC)	$1,749	$1,670 Notes 6B and 6E	$1,227	$1,210 Notes 6C and 6E
Fuel Inventory ($/kW)	$44	$35	$44	$35
OPERATION (January 1988 dollars)				
Fixed Primary Fuel ($/kW/yr)	$0.00	$8.60 Note 7A	$0.00	$8.60 Note 7A
Fixed Alternate Fuel ($/kW/yr)	n/app.	n/app.	n/app.	n/app.
Fixed O&M ($/kW/yr)	$20.10	$32.80 Note 7B	$10.10	$20.50 Note 7B
Capital Replacement ($/kW/yr)	$12.60	Inc. in FXOM	$12.60	Inc. in FXOM

Table 4-10
Pulverized-Coal-Fired Power Plants

	TWO 270-MEGAWATT UNITS		TWO 650-MEGAWATT UNITS	
	1986 PLAN	1989 SUPPLEMENT	1986 PLAN	1989 SUPPLEMENT
		OPERATION (January 1988 dollars) (cont.)		
Variable Primary Fuel ($/MMBtu)	$2.00	$1.49	$2.00	$1.49
Variable Alternate Fuel ($/MMBtu)	n/app.	n/app.	n/app.	n/app.
Variable O&M (mills/kWh)	2.1	2.3 Note 7D	1.2	1.4 Note 7D
Consumables (mills/kWh)	Inc. in VROM	0.7 Note 7E	Inc. in VROM	0.5 Note 7E
Physical Life (yrs)	40	same	40	same

Notes

1A. Details regarding planning assumptions are provided in Volume II, Appendix 6C of the 1986 Power Plan.

1B. Plant design based on Case Study 2 (two 270-megawatt (gross) coal-fired units) appearing in Kaiser(87).

1C. Details regarding planning assumptions are provided in Volume II, Appendix 6C of the 1986 Power Plan.

1D. Plant design based on Case Study 1 (two 650-megawatt (gross) coal-fired units) appearing in Kaiser(87).

1F. 1986 turbine backpressure was incorrect.

1G1. Transmission voltage changed to 230kV to agree with case study switchyard assumptions.

1G2. Kaiser estimates used a 230kV switchyard. 1988 update estimates were adjusted to represent a 500kV switchyard.

2A. 1986 heat rates were gross; 1989 proposal corrects to net.

4A. Seasonal constraints on energy capability judged insignificant.

Table 4-10
Pulverized-Coal-Fired Power Plants

5A. 1986 assumes purchase of site; 1989 assumes optioning of land. Estimated cost of miscellaneous easements and ROWs, owner's preconstruction administrative costs, permits amd licenses, geotechnical investigation and environmental impact statement from Kaiser(86).

5B. Annual land option fee (15 percent of market value) added to 1986 estimate. Rounded to nearest $0.10.

6A. Cashflow adjusted to correspond with Kaiser(87).

6B. Construction cost based on Kaiser(87), escalated to 1988 dollars and adjusted to include transmission link and owner's costs during construction; and to exclude fuel inventory costs. (Land costs retained i.a.w. Note 5A.) Rounded to the nearest $10 per kilowatt.

6C. Construction cost based on Kaiser(87), escalated to 1988 dollars and adjusted to include 500kV switchyard, transmission link and owner's costs during construction; and to exclude 230kV swithyard and fuel inventory costs. (Land costs retained i.a.w. Note 5A.) Rounded to the nearest $10 per kilowatt.

6E. Startup (preproduction) costs calculated i.a.w. EPRI(86).

7A. Annual fixed costs of purchase and maintenance of unit train rolling stock.

7B. Annual fixed O&M costs calculated as 70 percent of the total of annual labor costs (from Kaiser(87) and 1.8 percent of total construction cost (excluding startup costs). Rounded to the nearest $0.10 kilowatt-hour per year.

7D. Variable O&M costs calculated as 30 percent of the total of annual labor costs (from Kaiser(87) and 1.8 percent of total capital costs (excluding fuel inventory, working capital and startup costs). 70 percent capacity factor used. Rounded to the nearest 0.1 mill per kilowatt-hour.

7E. Consumables include costs of materials and chemicals, utilities and sludge and ash disposal from Kaiser(87). Rounded to the nearest 0.1 mill per kilowatt-hour.

References

EPRI(86): Electric Power Research Institute. Technical Assessment Guide (EPRI P-4463-SR) Volume I, December 1986.

Kaiser(86): Kaiser Engineers. Preconstruction Costs and Schedules for Comparative Generation Study Coal-fired Powerplants. Prepared for Bonneville Power Administration. November 1986.

Kaiser(87): Kaiser Engineers. Comparative Generation Study Coal-fired Powerplants. Prepared for Bonneville Power Administration. October 1987.

Atmospheric Fluidized-Bed Plants

Two representative atmospheric fluidized-bed power plants are considered. One is a single-unit plant of 200 megawatts nominal capacity; the second a twin-unit plant of 500 megawatts nominal capacity per unit. Both use a subcritical, reheat steam cycle, similar to the representative pulverized coal plants. The AFBC plant characteristics are based on an evaluation of alternative AFBC designs recently prepared for the Electric Power Research Institute (EPRI) by Bechtel Group, Inc. (EPRI, 1987). EPRI supplied the Council with additional details of the "Hermiston, Oregon - Wyoming Subbituminous" cases of the Bechtel study for use in developing these planning assumptions.

The 200-megawatt plant is similar in scale to recent AFBC demonstration projects. This plant is an overbed feed design, more suitable for smaller furnace sizes. The conceptual design includes coal storage, handling and preparation facilities, an AFBC boiler, baghouse particulate removal, turbine generator and mechanical draft waste heat removal systems. Also included is a switchyard and a 10-mile transmission link to the grid.

The proposed planning characteristics for the 200-megawatt plant are shown in Table 4-11, compared with the smaller 110-megawatt generic AFBC plant appearing in the 1986 Power Plan. The lower heat rate of the 200-megawatt unit results from the use of a more efficient reheat steam cycle. Unit capital costs are somewhat lower, as might be expected for a larger unit, and are comparable with the capital costs of the generic 250-megawatt pulverized-coal-fired power plant. Plant life is 30 years in lieu of 40 years used for the 1986 case. This is believed to be more reasonable in view of the limited utility experience with AFBC designs, and resulting potential for early design obsolescence. Because of the experience gained with demonstration plants, the figures for the 200-megawatt plant should be more certain than those used in 1986.

The twin 500-megawatt unit plant is much larger than recent AFBC demonstration projects, and is an extrapolation of experience gained with smaller designs. This plant is an underbed feed design, better suited for larger furnace sizes. The conceptual design includes the same features as the 200-megawatt plant.

The planning assumptions for the twin 500-megawatt unit plant are also shown in Table 4-11. Unit capital costs are considerably lower than the 200-megawatt unit, as might be expected for larger, replicate units. The capital costs are comparable to those of the representative twin 603-megawatt pulverized-coal-fired plant (Table 4-10). Because of the lack of experience with AFBC units of this size, the figures for the 500-megawatt units should be considered less certain than those for the 200-megawatt unit.

	SINGLE SMALL UNIT		TWO LARGE UNITS	
	1986 PLAN	1989 SUPPLEMENT	1986 PLAN	1989 SUPPLEMENT
Design	Atm. fluidized-bed 1,500 psig steam 1,000°F, no reheat 2.0Hga bkpress Note 1A1	Overbed feed AFBC 2,400 psig steam 1,000/1,000°F reheat Note 1A2	No equivalent	Underbed feed AFBC 2,400 psig steam 1,000/1,000°F reheat Note 1A3
Number of Units	1	1		2
Unit Size (MW)	113 (gr)/110 (net)	210 (gr)/197 (net)		544 (gr)/509 (net)
Site	Hermiston, OR	Hermiston, OR		Hermiston, OR
Primary Fuel	WY Subbituminous	WY Subbituminous		WY Subbituminous
Heat Value (Btu/lb)	8,445	8,445		8,445
Fuel Delivery	Unit train	Same		Unit train
Fuel Inventory	90 day @ 110MW	90 day @ 197MW		90 day @ 1,018MW
Heat Rejection	Mech. draft towers	Mech. draft towers		Mech. draft towers
Flash Control	Cyclones & baghouse	Baghouse		Baghouse
SOX Control	Limestone injection	Limestone injection		Limestone injection
NOX Control	Comb. temp control	Comb. temp control		Comb. temp control
Transmission Interconnect	Not specified	10mi 230kV dbl ckt		10mi 500kV dbl ckt
		CAPACITY AND HEAT RATES		
Max. Sust. Cap. (MW/unit)	n/a	n/a		n/a
Rated Capacity (MW/unit)	110	197		509
Minimum Sustainable Cap. (MW/unit)	39	n/a		n/a
Net Heat Rate @ Max. Sus. (Btu/kWh)	n/a	n/a		n/a
Net Heat Rate @ Rated (Btu/kWh)	11,200	9,885 Note 2A		9,851
Net Heat Rate at Min. Sus. (Btu/kWh)	n/a	n/a		n/a

Table 4-11
Atmospheric Fluidized-Bed Combustion Coal-fired Power Plants

	SINGLE SMALL UNIT		TWO LARGE UNITS	
	1986 PLAN	1989 SUPPLEMENT	1986 PLAN	1989 SUPPLEMENT
OPERATING AVAILABILITY				
Equivalent Annual Availability	75%	81% Note 3A		74% Note 3B
Routine Annual Insp. & Maintenance	35 days	n/a		n/a
Major Inspection & Overhaul	n/a	n/a		n/a
Freq. of Major Insp. & Overhaul	n/a	n/a		n/a
Average Maintenance Outage	35 days	34 days Note 3C		42 days Note 3D
Other Planned & Unplanned Outages	17%	10% Note 3A		16% Note 3B
ENERGY PRODUCTION PROFILE				
Monthly Energy Production Potential, (Percent of average annual potential, exclusive of outages):				
Jan	100.0% Note 4A	100.0% Note 4A		100.0%
Feb	100.0%	100.0%		100.0%
Mar	100.0%	100.0%		100.0%
Apr	100.0%	100.0%		100.0%
May	100.0%	100.0%		100.0%
Jun	100.0%	100.0%		100.0%
Jul	100.0%	100.0%		100.0%
Aug	100.0%	100.0%		100.0%
Sep	100.0%	100.0%		100.0%
Oct	100.0%	100.0%		100.0%
Nov	100.0%	100.0%		100.0%
Dec	100.0%	100.0%		100.0%

Table 4-11
Atmospheric Fluidized-Bed Combustion Coal-fired Power Plants

	SINGLE SMALL UNIT		TWO LARGE UNITS	
	1986 PLAN	1989 SUPPLEMENT	1986 PLAN	1989 SUPPLEMENT
PROJECT DEVELOPMENT - SITING AND LICENSING (January 1988 dollars)				
Siting & Licensing Lead Time (mos)	48	48		48
Siting & Licensing Cost ($/kW)	$43 Note 5A	$41 Note 5B		$23 Note 5C
Siting & Licensing Shelf Life (yrs)	5	5		5
Siting & Licensing Hold Cost ($/kW/yr)	$1.00 Note 5A	$1.40 Note 5D		$0.50 Note 5D
Prob. of S&L Success (%)	70.0%	70.0%		70.0%
Prob. of S&L Hold Success (%)	n/est.	90.0%		90.0%
PROJECT DEVELOPMENT - ENGINEERING & CONSTRUCTION (January 1988 dollars)				
Const. Lead Time (to first unit) (mos)	72	64 Note 6A		76 Note 6B
Lag Between Units (mos)	n/app	n/app		12 Note 6C
Cash Flows (%/yr): Year 1	1.0%	4.0% Note 6D		4.0% Note 6E
Year 2	7.0%	11.0%		11.0%
Year 3	18.0%	39.0%		17.0%
Year 4	47.0%	45.0%		27.0%
Year 5	22.0%	5.0%		28.0%
Year 6	5.0%			12.0%
Year 7				10.0%
Construction cost ($/kW) (Excl. of siting, licensing & AFUDC)	$1,823 Note 6F	$1,760 Note 6G		$1,270 Note 6G
Fuel Inventory ($/kW)	$48 Note 6H1	$0 Note 6H2		$0 Note 6H2
OPERATION (January 1988 dollars)				
Fixed primary fuel ($/kW/yr)	$0.00	$8.60 Note 7A		$8.60 Note 7A
Fixed alternate fuel ($/kW/yr)	n/app.	n/app.		n/app.
Fixed O&M ($/kW/yr)	$36.20 Note 7B	$37.10 Note 7C		$20.70 Note 7C
Capital replacement ($/kW/yr)	$12.60	Inc. in FXOM		Inc. in FXOM

Table 4-11
Atmospheric Fluidized-Bed Combustion Coal-fired Power Plants

	SINGLE SMALL UNIT		TWO LARGE UNITS	
	1986 PLAN	1989 SUPPLEMENT	1986 PLAN	1989 SUPPLEMENT
OPERATION (January 1988 dollars)				
Variable Primary Fuel ($/MMBtu)	$2.00 Note 7A	$1.49 Note 7A		$1.49 Note 7A
Variable Alternate Fuel ($/MMBtu)	n/app.	n/app.		n/app.
Variable O&M (mills/kWh)	1.1 Note 7B	4.8 Note 7D		3.1 Note 7D
Consumables (mills/kWh)	Inc. in VROM	Inc. in VROM		Inc. in VROM
Physical Life (yrs)	40	30		30

Notes

1A1. Plant design based on 1x110-megawatts (net) AFBC coal-fired power plant case appearing in BPA/Kaiser, 1985. Derivation of planning assumptions is described in Volume II, Appendix 6D of the 1986 Power Plan.

1A2. Plant design based on 1x200-megawatt overbed-fired AFBC coal-fired power plant case, Hermiston, Oregon, location, appearing in EPRI, 1987.

1A3. Plant design based on 2x500-megawatt overbed-fired AFBC plant, Hermiston, Oregon, location, appearing in EPRI, 1987.

2A. Heat rate is from McGowin, 1988.

3A. From EPRI, 1986 Exhibit B.5-10B, Technology 10.2.

3B. From EPRI, 1986 Exhibit B.5-10B, Technology 10.1.

3C. Planned outages are from EPRI, 1986 Exhibit B.5-10B, Technology 10.2, converted to days.

3D. Planned outages are from EPRI, 1986 Exhibit B.5-10B, Technology 10.1, converted to days.

4A. Seasonal constraints on energy capability judged insignificant.

Table 4-11
Atmospheric Fluidized-Bed Combustion Coal-fired Power Plants

5A. 1986 estimates, escalated to January 1988 using GNP deflators.

5B. Siting and Licensing cost components are as follows:
- Securing option on land (500 Acres @ 15 percent of market value ($2,000 per acre) (Battelle, 1982).
- Conceptualization, preliminary engineering site selection, secure licenses - 3 percent of total plant cost (from BPA/Kaiser, 1986, rounded to nearest percentage).

5C. Siting and Licensing cost components are as follows:
- Securing option on land (750 Acres @ 15 percent of market value ($2,000 per acre) (Battelle, 1982).
- Conceptualization, preliminary engineering site selection, secure licenses - 3 percent of total plant cost (from BPA/Kaiser, 1986, rounded to nearest percentage).

5D. Option Hold cost components are as follows:
- Project management - 1 Engineer (COTF, 1985).
- Siting Council fees - $0.05 kilowatts per year (WWP, 1984).
- Environmental baseline - $0.16 kilowatts per year (WWP, 1984).
- Maintenance of land option - 15 percent of fair market value per year (Battelle, 1982).
- Owner's indirect costs - 11 percent (WWP, 1984).

6A. Construction leadtimes are from EPRI, 1987, Figure 4-13, plus 24 months for detailed engineering.

6B. Construction leadtimes are from EPRI, 1987, Figure 4-14, plus 24 months for detailed engineering.

6C. Unit 2 lag is from EPRI, 1987, Figure 4-14.

6D. From Kaiser, 1987, one 270-megawatt pulverized-coal unit.

6E. From Kaiser, 1987, two 650-megawatt pulverized-coal units (cash flows for years 1 and 2 combined).

6F. 1986 estimates, escalated to January 1988, using Handy-Whitman indices.

6G. Overnight construction costs include the following:
- Land.
- Direct plant construction costs.
- Contractor overhead and profit.
- Engineering.

- Construction management.
- Contingency.
- Owner's costs during construction.
- Transmission interconnect.
- Spare parts.
- Prepaid royalties.
- Socioeconomic impact mitigation.
- Startup costs.

Construction costs are derived from McGowin, 1988, adjusted as follows:
- Land cost component adjusted to $2,000 per acre from $6,500 per acre (page C-32 of EPRI, 1987).
- Cost of transmission interconnect added (Bonneville estimates).
- Owner's costs during construction added (4 percent of direct and indirect costs).
- Startup (preproduction) costs excluded.
- Socioeconomic impact mitigation costs added (1 percent of total direct and indirect plant costs, COTF, 1985).
- Costs escalated from January 1983 to January 1988, using Handy-Whitman indices.

Startup cost components are as follows:
- One month of fixed O&M costs.
- One month of variable O&M costs.
- One week at rated capacity primary-fuel cost.
- Two percent of total construction cost.

1986 fuel costs currently used.

6H1. 1986 estimates, escalated to January 1988, using GNP deflators.

6H2. Fuel inventory cost is based on 90 days operation at rated capacity.

7A. Annual capital and maintenance cost of railroad rolling stock.

7B. 1986 estimate escalated to January 1988, using Bonneville "JEFOM" escalation series.

7C. Fixed O&M cost components are as follows:
- Operating labor.
- Maintenance costs.
- Overhead charges.

Fixed O&M costs are derived from McGowin, 1988, escalated to January 1988, using the Bonneville "JEFOM" steam plant O&M deflator.

7D. Variable O&M costs components are as follows:

- Utilities.
- Raw materials and chemicals (Consumables).

Variable O&M costs are derived from McGowin, 1988, escalated to January 1988, using the Bonneville "JEFOM" steam plant O&M deflator.

References

Battelle, 1982: Battelle, Pacific Northwest Laboratories. Development and Characterization of Electric Power Conservation and Supply Resource Planning Options. August 1982.

BPA/Kaiser, 1985: Kaiser Engineers Power Corporation. Bonneville Power Administration Comparative Electric Generation Study (Supplemental Studies). February 1985.

BPA/Kaiser, 1986: Kaiser Engineers. Preconstruction Costs and Schedules for Comparative Electric Generation Study Coal-Fired Power Plants. November 1986.

BPA/Kaiser, 1987: Kaiser Engineers. Comparative Electric Generation Study, Coal-fired Power Plants. October 1987.

COTF, 1985: Northwest Power Planning Council Coal Options Task Force, convened for preparation of the 1986 Power Plan.

EPRI, 1986: Electric Power Research Institute. TAG - Technical Assessment Guide (EPRI P-4463-SR).

EPRI, 1987: Electric Power Research Institute. Evaluation of Alternative Steam Generator Designs for Atmospheric Fluidized-bed Combustion Plants (EPRI CS-5296). July 1987.

Handy-Whitman, 1988: Whitman, Requardt and Associates. Handy-Whitman Index of Public Utility Construction Costs, Preliminary Numbers, Bulletin 127. January 1988.

McGowin, 1988: Letter from C.R. McGowin (EPRI) to Kevin Watkins (BPA) of March 23, 1988, regarding cost breakouts and additional background information on EPRI CS-5296 Hermiston, Oregon cases.

PNUCC, 1984: Pacific Northwest Utilities Conference Committee. Working Paper Development of Generic Resource Data. October 1984.

WWP, 1984: Washington Water Power Company. Creston Generating Station Status Report. July 1984.

Table 4-11
Atmospheric Fluidized-Bed Combustion Coal-fired Power Plants

Coal-Gasification Combined-Cycle Power Plant

The representative gasification combined-cycle power plant will have 419-megawatts capacity when completed. The plant could be constructed as a complete entity, or could be constructed in phases. If phased, the first phase would consist of a twin-unit combustion turbine plant fired by natural gas. In the Pacific Northwest, this plant could be used for firming secondary hydropower or meeting unexpected rates of load growth. As loads increase, the second, combined-cycle phase of the project could be constructed. This would require addition of heat-recovery steam generators, a steam turbine generator and a heat rejection system. The resulting natural gas-fired, combined-cycle plant would operate at high efficiency and could be base loaded while natural gas prices remain low. If natural gas prices rose, the third and final phase, a coal-gasification plant, could be added to allow the plant to operate on coal.

Combustion Turbine Phase

Because it is expected that the plant would be converted to combined cycle configuration, heavy-duty combustion turbines offering design characteristics suitable for combined-cycle conversion are used for the first phase. The combustion turbine phase consists of twin General Electric MS7001F machines installed at a site near Hermiston, Oregon. (Additional discussion of these machines is provided earlier in the natural gas section.) The plant includes site improvements, a weather enclosure with overhead crane, a switchyard, a 2-mile gas pipeline spur and a single-circuit 230-kV transmission line linking the site to the transmission grid. Sufficient land for the entire GCC plant is included in this phase. The water supply system, administrative building and site improvements are also sized for the complete GCC plant.

The Bonneville Power Administration prepared an engineering scoping study of a phased construction gasification combined-cycle plant in 1986 (BPA, 1986b). However, since the 1986 study, General Electric announced significant changes in the prices and performance characteristics of the MS7001F gas turbines used for the combustion turbine section in the 1986 study. These charges are reflected in a 1988 study of stand-alone combustion turbines and combined-cycle plants prepared by Fluor-Daniel, Inc. for Bonneville (Fluor-Daniel, 1988). In order to incorporate the revised information of the 1988 study, the capital costs of the first (combustion turbine) phase are based on the power generation equipment costs of Fluor-Daniel, 1988, and the general facilities costs of BPA, 1986. Performance characteristics and operating and maintenance costs are based on the 1988 Fluor study. Costs include sufficient land for the entire GCC plant, permits for the final GCC plant and a natural gas supply pipeline, transmission interconnection, owner's construction-related costs and socio-economic impact mitigation. The capital costs, performance characteristics and operating costs for the combustion turbine phase are shown in Table 4-12.

Combined-Cycle Phase

The combined-cycle phase includes addition of heat recovery steam generators, a steam turbine generator, and a reject-heat-removal system to the combustion turbines of the first phase. These additions are sized to the completed GCC plant. Also included is a second single-circuit 230-kV transmission line to accommodate the additional generating capacity.

Costs and schedules for both an incremental second phase, and a complete "gasifier-ready" combined-cycle plant are shown in Table 4-12. Because review of the original licenses and permits would likely be required, some preconstruction costs and a preconstruction lead time are shown for incremental construction. Construction costs are derived from BPA, 1986b, and Fluor-Daniel, 1988, as described above. Construction costs include transmission, impact mitigation and owner's construction costs.

Performance characteristics and operating costs for the combined-cycle phase are also shown in Table 4-12. These are derived from Fluor-Daniel, 1988.

Gasification Phase

The gasification section, addition of which comprises the third phase, includes coal handling, storage and preparation facilities, oxygen plant, Shell gasifiers, gas cleanup and sulfur recovery facilities.

Costs and schedules for both an incremental gasification addition, and a complete gasifier combined-cycle plant are shown in Table 4-12. The preconstruction cost and schedule for the incremental addition allows for review of the project licenses and permits prior to proceeding with construction. Capital costs of the gasifier section and general facilities are based on BPA, 1986b, escalated to 1988 and include owner's construction costs and socio-economic impact mitigation. Combined-cycle power plant costs are taken from Fluor-Daniel, 1988.

Operating costs and performance characteristics of Table 4-12 are from BPA, 1986b. The fuel use efficiency of the GCC plant (38 percent) is less than that of the combined-cycle plant alone (43 percent) because of inefficiencies of the gasification process. The net efficiency of the GCC plant is, however, better than that of either the pulverized coal and AFBC coal plants (31 percent and 35 percent respectively).

	SIMPLE-CYCLE COMBUSTION TURBINES (TOTAL PLANT)	COMBINED-CYCLE COMBUSTION TURBINES (INCREMENTAL/PLANT)	COAL GASIFICATION COMBINED-CYCLE (INCREMENTAL/PLANT)
Design	GE MS7001F Enclosed	GE STAG 207F Enclosed CTs Note 1A1	Shell gasifier w/GE STAG 207F Note 1A2
Configuration: CT Section	2 x 139MW (ISO)	2 x 139MW (ISO)	2 x 139MW (ISO)
HRSG/TG Section	n/a	1 x 142MW (ISO)	1 x 141MW (ISO)
Site	Hermiston, OR	Hermiston, OR	Hermiston, OR
Primary Fuel	Natural Gas	Natural Gas	Wyoming sub. PRB coal
Heat Value	1,021 Btu/scf (HHV)	1,021 Btu/scf (HHV)	8,445 Btu/lb
Primary Fuel Delivery	High Pressure Pipeline	High Pressure Pipeline	Unit Train
Alternate Fuel	Fuel Oil No. 2	Fuel Oil No. 2	Natural Gas
Heat Value	19,430 Btu/lb (HHV)	19,430 Btu/lb (HHV)	1,021 Btu/scf (HHV)
Alternate Fuel Delivery	Truck, Barge or Rail	Truck, Barge or Rail	High Pressure Pipeline
Fuel Inventory	14 day FO @ 270MW	14 day FO @ 410MW	90 days coal @ 419MW
Heat Rejection	Atmosphere	Mech. Draft Towers	Mech. Draft Towers
Particulates	None required	None required	Pre-comb. gas treatment
SOX Control	Low-sulfur fuel oil	Low-sulfur fuel oil	"Selexol" acid gas removal
NOX Control	Water injection	Water injection	Vapor injection
Transmission Interconnect	10 mi 230kV single circuit	10 mi 230kV double circuit	10 mi 230kV double circuit
	CAPACITY AND HEAT RATES		
Max. Sust. Cap. @ 35F (MW)	152.4/unit Note 2A	452.2 Note 2A	451 Note 2B
Rated Capacity @ ISO (MW)	139.3/unit Note 2A	419.6 Note 2A	419 Note 2B
Minimum Sustainable Capacity (MW)	n/a	n/a	n/a
Net Heat Rate @ Max. Sus. (Btu/kWh)	11,130 Note 2A	7,500 Note 2A	9,160 Note 2B
Net Heat Rate @ Rated (Btu/kWh)	11,480 Note 2A	7,620 Note 2A	9,270 Note 2B
Net Heat Rate at Min. Sus. (Btu/kWh)	n/a	n/a	n/a

Table 4-12
Coal Gasification Combined-Cycle Power Plant

	SIMPLE-CYCLE COMBUSTION TURBINES (TOTAL PLANT)	COMBINED-CYCLE COMBUSTION TURBINES (INCREMENTAL/PLANT)	COAL GASIFICATION COMBINED-CYCLE (INCREMENTAL/PLANT)
OPERATING AVAILABILITY			
Equivalent Annual Availability	85.0%	83.0%	80%
Routine Annual insp. & Maintenance	30 days	30 days	30 days
Major Inspection & Overhaul	90 days	90 days	90 days
Freq. of Major Insp. & Overhaul	5 years	5 years	5 years
Average Maintenance Outage	42 days	42 days	42 days
Other Planned & Unplanned Outages	4.0%	6.0%	9%
SEASONALITY			
Monthly Energy Production Potential (Percent of average annual, exclusive of outages):			
Jan	114.0% Note 4A1	110.0% Note 4A2	108.2% Note 4A3
Feb	112.0%	108.0%	106.0%
Mar	109.0%	106.0%	104.3%
Apr	106.0%	104.0%	102.0%
May	103.0%	101.0%	99.2%
Jun	100.0%	99.0%	96.8%
Jul	97.0%	97.0%	94.5%
Aug	98.0%	97.0%	95.0%
Sep	101.0%	100.0%	97.7%
Oct	106.0%	104.0%	101.6%
Nov	111.0%	107.0%	105.5%
Dec	113.0%	109.0%	107.2%

Table 4-12
Coal Gasification Combined-Cycle Power Plant

	SIMPLE-CYCLE COMBUSTION TURBINES (TOTAL PLANT)		COMBINED-CYCLE COMBUSTION TURBINES (INCREMENTAL/PLANT)	COAL GASIFICATION COMBINED-CYCLE (INCREMENTAL/PLANT)
PROJECT DEVELOPMENT - SITING AND LICENSING (January 1988 dollars)				
Siting & Licensing Lead Time (mos)		48 Note 5A1	12/48 Note 5A2	12/48 Note 5A3
Siting & Licensing Cost ($/kW)		$49 Note 5B1	$8/33 Note 5B2	$16/$38 Note 5B3
Siting & Licensing Shelf Life (yrs)		5	5	5
Siting & Licensing Hold Cost ($/kW/yr)		$0.60 Note 5D1	n/a/$0.50	n/a/$0.50
Prob. of S&L Success (%)		75.0%	90%/75%	75.0%
Prob. of S&L Hold Success (%)		90.0%	90.0%	90.0%
PROJECT DEVELOPMENT - ENGINEERING & CONSTRUCTION (January 1988 dollars)				
Const. Lead Time (to first unit) (mos)		24	38/38	39/39
Lag Between Units (mos)		none	none	none
Cash Flows (%/yr):	Year 1	48.0%	8.0%	12.0%
	Year 2	52.0%	41.0%	48.0%
	Year 3		51.0%	40.0%
Construction Cost ($/kW) (Excl. of siting, licensing & AFUDC)		$530 Note 6D1	$280/620 Note 6D2	$1,230/1820 Note 6D3
Fuel inventory ($/kW)		$14	$3/9	$30/30
OPERATION (January 1988 dollars)				
Fixed Primary Fuel ($/kW/yr)		$0.00	$0.00	$8.60 Note 7A3
Fixed Alternate Fuel ($/kW/yr)		$0.00	$0.00	$0.00
Fixed O&M ($/kW/yr)		$2.00 Note 7C1	$5.40 Note 7C2	$61.22 Note 7C3
Capital Replacement ($/kW/yr)		Inc. in FXOM	Inc. in FXOM	Inc. in FXOM

Table 4-12
Coal Gasification Combined-Cycle Power Plant

	SIMPLE-CYCLE COMBUSTION TURBINES (TOTAL PLANT)	COMBINED-CYCLE COMBUSTION TURBINES (INCREMENTAL/PLANT)	COAL GASIFICATION COMBINED-CYCLE (INCREMENTAL/PLANT)
	OPERATION (January 1988 dollars)		
Variable Primary Fuel ($/MMBtu)	$3.16	$3.16	$1.49
Variable Alternate Fuel ($/MMBtu)	$3.66	$3.66	$3.16
Variable O&M (mills/kWh)	0.1 Note 7G1	0.2 Note 7G2	0.2 Note 7G3
Consumables (mills/kWh)	0.0 Note 7G1	0.1 Note 7G2	0.8 Note 7H3
Byproduct Credit (mills/kWh)	none	none	0.2 Note 7I3
Physical Life (yrs)	30	30	30

Notes

1A1. One General Electric 207F STAG combined-cycle plant. This plant consists of two single-shaft, heavy-duty, combustion turbines, (General Electric MS7001S), one heat-recovery steam generator and one steam turbine generator. Steam conditions are 905 psig 998°F/1,000°F reheat. Plant design based on case study Phase 3 appearing in BPA, 1986.

1A2. Shell entrained gasifier supplying medium-Btu gas to one General Electric 207F STAG combined-cycle plant (see Note 1B). Plant design based on case study Phase 4 appearing in BPA, 1986.

2A. From Table 3-2, BPA, 1988 (more recent data regarding the MS7001F than BPA, 1986).

2B. From Table 2-3, BPA, 1986.

4A1. Seasonal effects on capacity are significant due to ambient temperature effects on combustion turbine output. From Figure 3.1 of BPA, 1986, using mean monthly temperatures for Arlington, Oregon (NOAA, 82).

4A2. Seasonal effects on capacity are significant due to ambient temperature effects on combustin turbine output. From Figure 3.4 of BPA, 1986, using mean monthly temperatures for Arlington, Oregon (NOAA, 82).

4A3. Seasonal effects on capacity are significant due to ambient temperature effects on combustion turbine output. From least squares regression on power vs. ambient temperature data of Table 2-3 of BPA, 1986, using mean monthly temperatures for Arlington, Oregon (NOAA, 82).

Table 4-12
Coal Gasification Combined-Cycle Power Plant

5A1. The siting and licensing lead time for a "gasifier-ready" combustion turbine plant is assumed to be the same as for a pulverized-coal-fired power plant.

5A2. A permit review lead time of 12 months is assumed to be required for conversion of "gasifier-ready" combustion turbines to combined cycle. The siting and licensing lead time for a complete "gasifier-ready" combined-cycle plant is assumed to be the same as for a pulverized-coal-fired power plant.

5A3. A permit review lead time of 12 months is assumed to be required for addition of a coal gasification plant to the "gasifier-ready" combined-cycle plant. The siting and licensing lead time for a complete gasification plant is assumed to be the same as for a pulverized-coal-fired power plant.

5B1. Siting and licensing costs include:
- Securing option on land at 15 percent fair market value - Battelle (1982).
- Easements & ROW, owner's costs, permits & licenses, geotechnical studies and EIS - BPA(1986) T.1-1.

5B2. Siting and licensing costs for complete plant include:
- Securing option on land at 15 percent fair market value - Battelle (1982).
- Easements & ROW, owner's costs, permits & licenses, geotechnical studies and EIS - BPA(1986) T.1-1.

Siting and licensing costs for combined-cycle increment include estimated review costs of 25 percent of the estimated total costs of BPA(1986) T.1-1 for owner's costs, permits & licenses and EIS.

5B3. Siting and licensing costs for complete plant include:
- Securing option on land at 15 percent fair market value - Battelle (1982).
- Easements & ROW, owner's costs, permits & licenses, geotechnical studies and EIS - BPA(1986) T.1-1.

Siting and licensing costs for gasifier increment include estimated review costs of 50 percent of the estimated total costs of BPA (1986) T.1-1 for owner's costs, permits & licenses and EIS.

5D1. Hold cost rounded to nearest $0.10 kilowatt-hour per year.

6D1. Construction cost components are as follows:
- Land purchase - BPA(1986) T.6-4.
- Direct construction costs, General Facilities - BPA (1986) T.5-1,-2.
- Direct construction costs, Power Generation - BPA (1988) T.5-1,-2.
- Direct construction costs, Catalysts & Chemicals - BPA (1988) T.5-1,-2.
- Contingency - 10 percent of direct and indirect costs - BPA (1988).
- Owner's costs during construction - 4 percent of direct and indirect costs, inc. contingency (PNUCC, 1984).
- Transmission interconnect - Bonneville estimates.
- Spare parts inventory - BPA (1986) T.6-4.
- Royalties - BPA (1986) T.6-4.
- Socioeconomic impact mitigation - 1 percent of total direct and indirect plant costs (COTF, 1985).
- Natural gas pipeline - Two miles at $500,000 per mile (Bonneville).
- Startup costs as noted below.

Table 4-12

Coal Gasification Combined-Cycle Power Plant

All costs escalated to January 1988, using Handy-Whitman, 1988 where appropriate, GNP deflator otherwise. Based on rated capacity. Rounded to the nearest $10 per kilowatt.

Startup cost components are as follows:
- One month of fixed O&M costs.
- One month of variable O&M costs.
- One week at full capacity primary fuel cost.
- Two percent of total construction cost.

6D2. Construction cost components for incremental addition of combined-cycle plant are as follows:
- Direct construction costs, General Facilities - BPA (1986) T.5-3.
- Direct construction costs, Power Generation - BPA (1988) T.5-3.
- Direct construction costs, Catalysts & Chemicals - BPA (1988) T.5-3.
- Contingency - 10 percent of direct and indirect costs - BPA (1988).
- Owner's costs during construction - 4 percent of direct and indirect costs, including contingency (PNUCC, 1984).
- Second 10 mile, 230kV transmission interconnect - Bonneville estimates.
- Spare parts inventory - BPA (1986) T.6-4.
- Royalties - BPA (1986) T.6-4.
- Socioeconomic impact mitigation - 1 percent of total direct and indirect plant costs (COTF, 1985).
- Startup costs as noted below.

All costs escalated to January 1988, using Handy-Whitman, 1988 where appropriate, GNP deflator otherwise. Based on total rated capacity. Rounded to the nearest $10 per kilowatt.

Startup cost components are as follows:
- One month of fixed O&M costs.
- One month of variable O&M costs.
- One week at full capacity primary fuel cost.
- Two percent of total construction cost.

Construction cost components for the complete combined cycle phase are as follows:
- Land purchase - BPA (1986) T.6-4.
- Direct construction costs, General Facilities - BPA (1986) T.5-1,-2,-3.
- Direct construction costs, Power Generation - BPA (1988) T.5-1,-2,-3.
- Direct construction costs, Catalysts & Chemicals - BPA (1986) T.5-1,-2,-3.
- Contingency - 10 percent of direct and indirect costs - BPA (1988).
- Owner's costs during construction - 4 percent of direct and indirect costs, including contingency (PNUCC, 1984).
- Transmission interconnect - Bonneville estimates.
- Spare parts inventory - BPA (1986) T.6-4.
- Royalties - BPA (1986) T.6-4.

Table 4-12
Coal Gasification Combined-Cycle Power Plant

- Socioeconomic impact mitigation - 1 percent of total direct and indirect plant costs (COTF, 1985).
- Natural gas pipeline - Two miles at $500,000 per mile (Bonneville).
- Startup costs as noted above.

All costs escalated to January 1988, using Handy-Whitman, 1988 where appropriate, GNP deflator otherwise. Based on rated capacity. Rounded to the nearest $10 per kilowatt.

6D3. Construction cost components for incremental addition of the gasification plant are as follows:

- Direct construction costs, incremental - BPA (1986) T.5-2.
- Construction management - 5 percent of direct costs (BPA/Kaiser(1987)).
- Contingency - 14.9 percent of direct and indirect costs - BPA (1988).
- Owner's costs during construction - 4 percent of direct and indirect costs, including contingency (PNUCC, 1984).
- Spare parts inventory - BPA (1986) T.6-4.
- Royalties - BPA (1986) T.6-4.
- Socioeconomic impact mitigation - 1 percent of total direct and indirect plant costs (COTF, 1985).
- Startup costs as noted below.

All costs escalated to January 1988, using Handy-Whitman, 1988 where appropriate, GNP deflator otherwise. Based on total rated capacity. Rounded to the nearest $10 per kilowatt.

Startup cost components are as follows:

- One month of fixed O&M costs.
- One month of variable O&M costs.
- One week at full capacity primary fuel cost.
- Two percent of total construction cost.

Construction cost components for the complete gasification-combined cycle plant are as follows:

- Land purchase - BPA (1986) T.6-4.
- Direct construction costs, complete - BPA (1986) T.5-2.
- Construction management - 5 percent of direct costs (BPA/Kaiser(1987)).
- Contingency - 13.3 percent of direct and indirect costs - BPA (1988).
- Owner's costs during construction - 4 percent of direct and indirect costs, including contingency (PNUCC, 1984).
- Transmission interconnect - Bonneville estimates.
- Spare parts inventory - BPA (1986) T.6-4.
- Royalties - BPA (1986) T.6-4.
- Socioeconomic impact mitigation - 1 percent of total direct and indirect plant costs (COTF, 1985).
- Natural gas pipeline - Two miles at $500,000 per mile (Bonneville).
- Startup costs as noted above.

All costs escalated to January 1988, using Handy-Whitman, 1988 where appropriate, GNP deflator otherwise. Based on rated capacity. Rounded to the nearest $10 per kilowatt.

Table 4-12
Coal Gasification Combined-Cycle Power Plant

7A3. Annual fixed costs of purchase and maintenance of unit train rolling stock.

7C1. See SCCT datasheet for derivation of fixed O&M costs. Rounded to the nearest $0.10 kilowatts per year.

7C2. See CCCT datasheet for derivation of fixed O&M costs. Rounded to the nearest $0.10 kilowatts per year.

7C3. Fixed O&M costs include:
- Fixed operating costs - BPA (1986) T.6-3, escalated to 1988 using Bonneville "JEFOM" index.
- General and administrative costs of 17 percent - PNL (1985).

Rounded to the nearest $0.10 kilowatts per year.

7G1. See SCCT datasheet for derivation of variable O&M costs. Rounded to the nearest 0.1 mills per kilowatt-hour.

7G2. See CCCT datasheet for derivation of variable O&M costs. Rounded to the nearest 0.1 mills per kilowatt-hour.

7G3. Variable O&M costs include:
- Variable operating costs - BPA (1986) T.6-3, escalated to 1988 using Bonneville's "JEFOM" index.
- General and administrative costs of 17 percent - PNL (1985).

Rounded to the nearest 0.1 mills per kilowatt-hour.

7H3. Consumable costs include:
- Consumables - BPA (1986) T.6-3, escalated to 1988 using Bonneville's "JEFOM" index.
- General and administrative costs of 17 percent - PNL (1985).

Rounded to the nearest 0.1 mills per kilowatt-hour.

7I3. Credit for elemental sulfur byproduct of Selexol sulfur removal process. Sulfur valued at $78.00 per long ton (1988 dollars).

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Table 4-12
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COST COMPONENTS

The estimates of resource costs that appear in this plan are intended to include the full monetary costs of constructing and operating the resources. These include, as appropriate, the following components:

1. Acquisition program administration costs

2. Siting and licensing costs, including:

   - Land options
   - Easements and right-of-way acquisition
   - Owners costs during siting and licensing
   - Permits and licenses
   - Geotechnical surveys
   - Environmental impact statement

3. Construction costs, including:

   - Land acquisition
   - Site utilities and services
   - Direct construction costs
   - Construction management and engineering
   - Contingency allowance
   - Owner's costs during construction
   - Switchyard
   - Transmission interconnect to grid
   - Spare parts inventory
   - Royalties
   - Socioeconomic impact mitigation
   - Preproduction (start-up) costs
   - Sales tax (where applicable)

4. Fuel costs, including:

   - Fixed fuel delivery costs
   - Fuel inventory
   - Fuel commodity costs

5. Operating and maintenance costs, including:[5]

   - Fixed operating and maintenance costs
   - Variable operating and maintenance costs
   - Consumables
   - By-product credit
   - Interim capital replacement (for operation through the expected operating life)

5./ Property taxes, insurance, generating taxes and gross revenue taxes are excluded from the estimated operation and maintenance costs. These taxes and fees are calculated by the Council's Decision Model and other models used in the development of the resource portfolio.