

Utility Scale Solar PV Cost

Steven Simmons

Northwest Power and Conservation Council

June 20 2013

1. Headlines
2. Recent Report Summaries
3. Cost Review
4. Proposed Capital Cost Forecast
5. Levelized Costs



1

SOLAR POWER SYSTEM HAS BRIGHT FUTURE

1. Modest environmental impacts
2. Avoid reliance on risky fuel
3. Coincidence with peak electricity demand – at least in some areas
4. Technological breakthroughs
5. State Renewable Portfolio Standards
6. Federal and State grants and tax incentives
7. Numerous projects completed and in the works – both large (Agua Caliente 280 MW in AZ) and small (Outback Solar in Southern Oregon 5 MW)



2

SUNNY HEADLINES

DOE SunShot Initiative – reduce Solar PV cost by 75% from 2010 to 2020 (DOE)

Energy Department Announces \$12 million to Accelerate Record-Breaking Solar Cell Efficiency (DOE) The new initiative—the Foundational Program to Advance Cell Efficiency II (FPACEII)—aims to accelerate record-breaking conversion efficiencies that will close the gap with this theoretical limit for a variety of PV cells including silicon-based technologies and thin-film materials such as cadmium telluride (CdTe) and copper indium gallium diselenide (CIGS).

Solar Energy Blazes New Path

Oil and Gas Developers Seek Same Fast Track Preferences (EnergyBiz August 2012) Solar energy projects will be blazing through the regulatory process now that the Obama administration has put the finishing touches on a plan to fast track those deals on public lands. As such, 17 sites in six southwestern states may become home to new green energy plants



3

MORE SUNNY HEADLINES

Power from solar nears amount lost from San Onofre

(Jun 2010)

The Orange County Register) Solar power generation on California's electricity grid reached an all-time high Friday, totaling enough to power more than 1.5 million homes, state officials said Sunday. The record of 2,071 megawatts hit at 12:59 p.m. Friday, said Steven Greenlee with the California Independent System Operator, which operates the state's electricity grid. That nearly equals the 2,250 megawatts of nuclear-powered electricity generation lost in January 2012, when small amounts of radiation began leaking from Southern California Edison's San Onofre Nuclear Generating Station.



4

EVEN MORE SUNNY HEADLINES

New solar panels glisten in the high desert sun

January 09, 2013 – from the BPA website

The clear, high-desert skies over Christmas Valley, Ore., are providing a new source of energy, powering the largest solar array in the Northwest. When it was connected to BPA's transmission system this fall, the 5-megawatt Outback Solar Project became the first commercial-scale solar project in BPA's territory.

The 20,000 solar modules at the 40-acre project track the sun, tilting from east to west. Located about 300 miles southeast of Portland, the array can soak up enough rays to serve 3,000 homes at peak capacity.

"This could be the start of a new journey," says Larry Bekkedahl, Transmission Services senior vice president. "We might look back on this project one day the same way we now think about our first commercial-scale wind farm."

Solar and wind could be the perfect pair. Solar generation peaks during the day, while wind in the Columbia River Gorge – home to many of the region's wind farms – tends to peak at night.

But the Northwest is just beginning to take advantage of solar power. Christmas Valley in particular has attracted a number of developers. "It's a good resource, one of the best in the Northwest," says Eric Taylor, Transmission Services account executive.

The output of the Outback project, on the other hand, is wheeled across BPA's transmission network and marketed to other utilities. Portland General Electric has purchased the full output of the plant under a 25-year contract.

BPA could have more than 150 MW of solar connected to its system by 2016, much of it in the Christmas Valley area.



5

Outback Solar – Christmas Valley, OR



Courtesy of Constellation Energy

- PNW largest solar project to date – 5.7 MW DC installed capacity
- ~ 23,000 polycrystalline ground-mount single-axis tracker solar pv panels
- \$15 million in financing through tax incentives from Oregon's Business Energy Tax Credit and a grant Energy Trust of Oregon
- Four years to complete – from conception to commercial service



6

NOT SO SUNNY HEADLINES

Abound Solar files to liquidate in bankruptcy (Reuters 2012) - Abound Solar filed for bankruptcy on Monday and will liquidate, becoming the latest U.S. solar panel company to fold despite government support.

Micron Owned Transform Solar Received \$1.68 M In State Training Grants Before Announcing Layoffs (NPR/Boise Public Radio June 2012). Earlier this week, Micron-owned Transform Solar, a maker of high-tech solar cells, announced it's closing and laying-off at least 250 people over the next three months.

SoloPower sheds jobs, auctions equipment in California in struggle to survive (Oregonian May 2013) SoloPower's struggle to survive intensified Thursday as it sold off thousands of dollars' worth of equipment from its California headquarters and prepared for more layoffs there to coincide with dozens of others at its Portland plant.

Chinese Solar Imports Continue Decline – effects of trade case felt (renewablebiz.com August 2012)



7

RECENT REPORT SUMMARIES

1. SEPA Utility Solar Rankings from June 2013
2. Energy Environmental Economics (E3) Cost and Performance Review of Generation Technologies – Recommendations for WECC 10 and 20 Year Study Process (October 2012)
3. US Energy Information Administration Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants AEO2013 (April 2013)
4. Lawrence Berkeley National Laboratory Tracking the Sun V – An Historical Summary of the Installed Price of PV in the US 1998-2011
5. SEPA Centralized Solar Projects Update Bulletin – Q1 2013



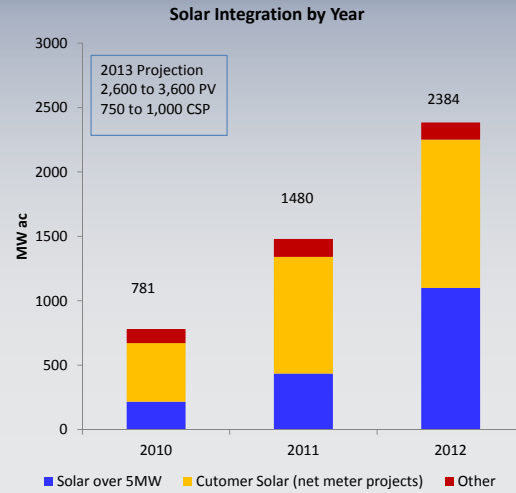
8

SEPA Utility Solar Rankings June 2013

Projects integrated to the grid as reported by utilities, reported in AC units – data reported by SEPA, charts by Council

2012 installations

- 87 % IOU
- 11 % Muni
- 2 % COOPS



9

E3 Cost and Performance Review of Generation Technologies

Prepared for WECC – October 2012

Capital Cost Estimates for plants installed in 2012 and forecast

- Costs in 2010 dollars, all-in include EPC, IDC, Owners Costs
- Single Axis Tracking System
 - 1 to 20 MW Plant – 3,800 \$/kW ac
 - 100 MW Plant – 3,300 \$/kW ac
- Fixed Tilt System
 - 1 to 20 MW Plant – 3,325 \$/kW ac
 - 100 MW Plant – 2,850 \$/kW ac
- Costs expected to continue to decline



10

E3 Cost and Performance Review of Generation Technologies

- Cost decline is proposed to follow a learning curve
- Learning Curves are often used for projecting future costs in high volume manufacturing – assumes a learning rate which drives efficiencies to a process, for each doubling of units produced, costs are reduced by x %. Costs for emerging technologies drop as manufacturing is scaled up, while costs level off for maturing technologies.
- To make a projection, you need historic cost declines and a forecast for future volume
- E3 proposes combining a two separate learning rates for the modules and balance of system (BOS) into a weighted learning curve
- Assumes cost allocation of 60% BOS and 40% Module and learning rates of 10% BOS and 20 % for modules
- In terms of 2012 cost – by 2017 costs are expected to be 82% of the base cost and by 2032 66%



11

EIA Updated Cost Estimates

Developed capital and O&M costs for two reference plants

- Ground mounted single axis tracking PV systems 20 MW and 150 MW in size (includes EPC & Owners costs)
- 2012 Overnight Capital Costs
 - 20 MW plant – 4,183 \$/kW ac
 - 150 MW plant – 3,873 \$/kW ac
 - In 2010 7 MW plant 6,289 \$/kW ac and 150 MW plant 4,943 \$/kW ac
- O&M – only fixed, includes periodic inverter maintenance and water washing
 - 20 MW plant – 27.75 \$/kW ac per year
 - 150 MW plant – 24.69 \$/kW ac per year



12

LBL Tracking the Sun V

Study of Utility Scale Solar PV projects through 2011 (ground mounted and >2 MW)

- Installation price of utility scale PV project may reflect component pricing of one to two years in the past and so not catch recent module price declines
- 49 Utility Scale Projects were completed in 2011 range from 2.4 \$/W to 6.3 \$/k dc in 2011 dollars
- Capacity Weighted project costs
 - 2009/2010 – 3.9 \$/w dc
 - 2011 – 3.4 \$/w dc
- Thin film and crystalline projects did not have a discernible price difference



13

SEPA Solar Projects Bulletin Q1 2013

Update of activity of Utility Scale PV Projects in early 2013

- 9 projects completed in Q1 2013
- 15 projects began construction
- With declining prices, module manufactures are continuing to drop out – which may lead to a stabilization of prices
- Module costs are composing less and less of the overall system cost
- Utilities may be reaching RPS goals or expect to soon



14

Proposed Reference Plant for Central-Station PV Plant

- **Description same as 6th Plan**
 - 20 MW ac using flat plate single crystalline modules mounted on single-axis trackers
 - Inverter, cabling and transformer losses from dc to ac
 - Individual Plants at scattered locations within the better solar resource areas



15

Central-Station PV Key Assumptions

Item	6 th Plan	Proposed 7 th Plan
Total Plant Cost (2012 construction, 2013 operation)	\$ 7,484 /kW ac	\$ 4,270 /kW ac
Fixed O&M	\$ 29.79 /kW ac yr	\$ 27.75 /kW ac yr
Development Phases	Month- % of TTL Cost	Month- % of TTL Cost
Development (site acquisition, permitting)	12 month – 1%	12 month – 1%
Early construction (procurement, site prep)	12 month – 14 %	12 month – 14 %
Construction	12 month – 85 %	12 month – 85 %
Financing	IOU 25 year	IOU 25 year
Incentives	Accelerated depreciation recovery period and 30% investment tax credit	Accelerated depreciation recovery period and 30% investment tax credit
Base \$ - Technology Base	2006 - 2008	2012 - 2012
Economic Life – Years	25	25



16

Utility Scale Solar PV Costing Methodology

- Collected individual project data and normalized to overnight cost in \$/kW ac using the Council's MicroFin Cost Model
- Collected compiled data and forecasts from a variety of sources including – E3, EIA, SEPA, LBL – including small and large projects, tracking and fixed, thin film and crystalline
- Converted all into \$/kW ac 2012 \$ if needed
- Calculated a base cost for 2012 based on the median point
- Assumed a mixture of Council 6th Plan and learning curve cost de-escalation through time



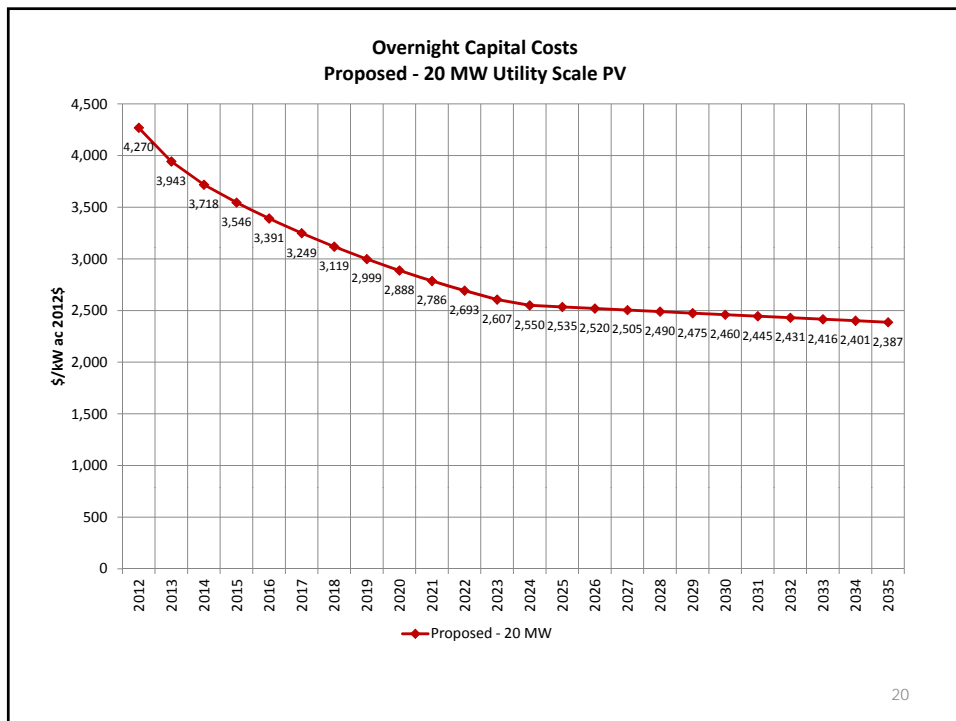
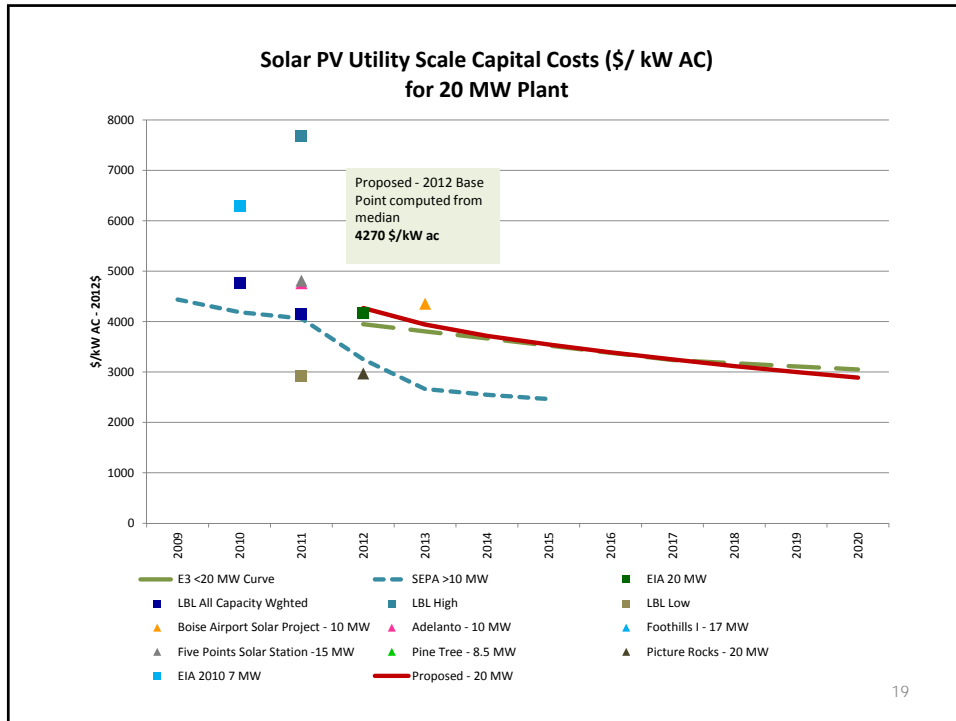
17

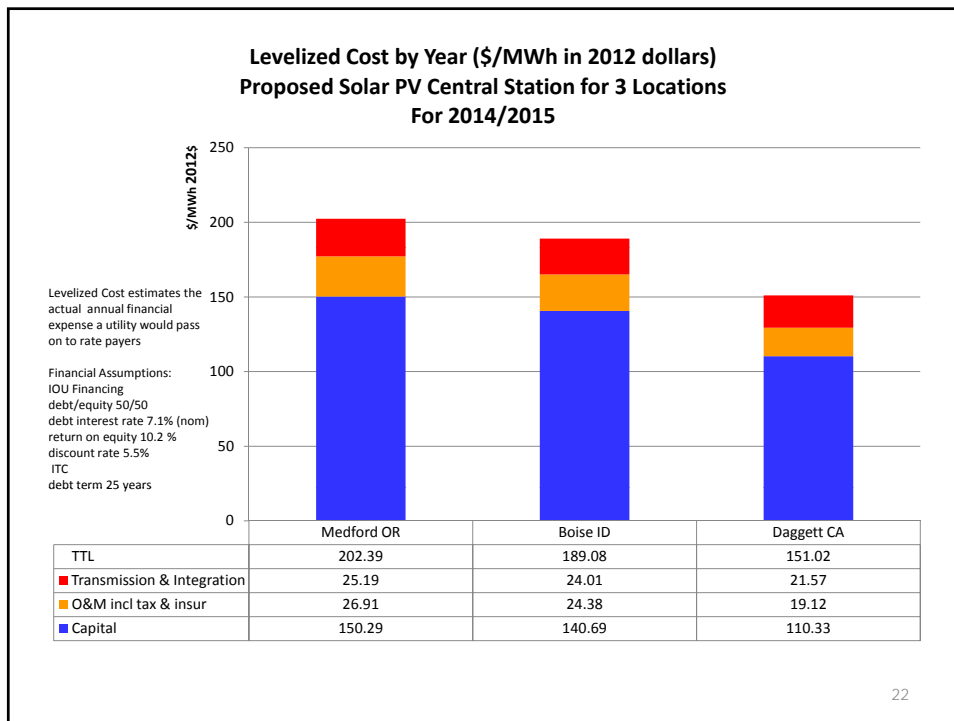
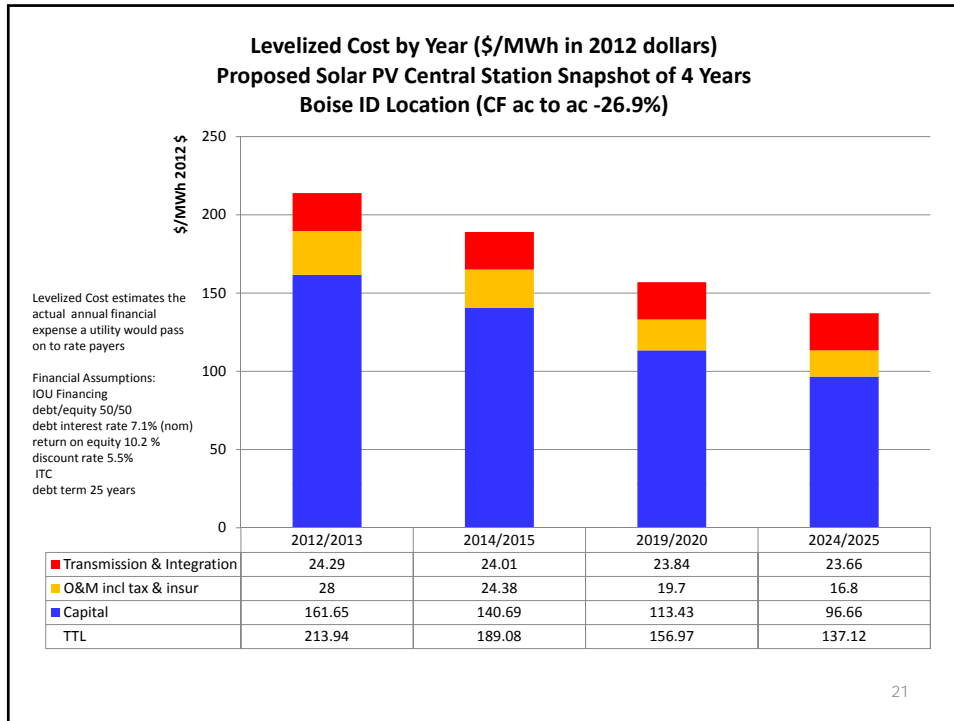
Individual Projects

Name	Developer	Utility	State	Type	Capacity MW ac	Completion	\$/kW ac overnight
Antelope Valley Solar Ranch One	Exelon Power	PGE	CA	Tracker	230	2013	5,792
California Valley Solar Ranch	NRP Energy	PGE	CA	Crystalline Tracker	130	2013	4,832
Centinela	LS Power Group	SDG&E	CA	PV	170	2014	4,034
Boise Airport Solar Project	Sunergy		ID	thin film	10	2014	4,356
Adelanto	SolarWorld	LADWP	CA	crystalline fixed	10	2012	4,763
Foothills I	AZ Public Service	AZ Public Service	AZ	ground mount	17	2013	5,497
Five Points Solar Station	SOLOON	PGE	CA	ground mount	15	2012	4,814
Pine Tree		LADWP	CA	Fixed	8.5	2013	5,531
Picture Rocks	Sun Edison	Tucson Electric Power	AZ	Crystalline Tracker	20	2012	2,972



18





Next Steps

- Will finalize a base capital cost for the reference plant as of 2012
- Will finalize forecasts for capital costs and O & M costs across the Seventh Plan horizon (2015 – 2035)
- Discuss at a later GRAC meeting