

**Northwest Power and Conservation Council
Generating Resources Advisory Committee
January 7, 2020**

Gillian Charles, NWPPC, began the meeting at 9:30 with a call for introductions and a review of the agenda.

**Proposed reference plant for conventional geothermal
Gillian Charles, NWPPC**

Fred Heutte, NW Energy Coalition, asked what “engineered” means [Slide 3.] Charles explained that “enhanced” and “engineered” both mean manmade in some way. Terra Rogers, AltaRock Energy, added that “manmade” focuses on making the inground fractures to interconnect wells.

Heutte recalled hearing about more potential at Neal Hot Springs [Operating Geothermal in PNW] but didn’t know about plans to add operations. Charles stated that Neal and Raft River are both owned by Ormat Technologies and offered to double check on plans to enhance and expand existing resources.

Heutte asked about the production costs at Neal Hot Springs and Raft River [Slide 8.] Mike Starrett, NWPPC, said the PPA with IPC is \$100. Heutte noted that there were no environmental issues or constraints that would hold up expansion at the Neal site. Charles offered to give an update at the February meeting.

Heutte spoke about dispatch at The Geysers [Slide 14.] He added that there were issues with re-injection equipment and the effluent is treated wastewater.

Heutte joked that southern California is a really HOT place for Geothermal [Slide 20.] Charles called for more puns. Starrett strongly disagreed.

Heutte noted that the top three states for EGS are Nevada, Idaho and Oregon [Slide 22] while other geothermal opportunities are more dispersed.

Rogers pointed to industry-wide efforts to make geothermal plants more flexible [Slide 28] but cautioned that flexibility may look more like storage or a slipstream. She said it will never be 100 to zero but may be more like 100 to 80.

Dhruv Bhatnagar, PNNL, added that Puna Geothermal in Hawaii is not currently operating after the recent volcanic eruption.

Rogers discussed using blended flash over binary for the geothermal 2021 Plan reference plant [Slide 36] based on temperature. David Nightingale, WA UTC, noted that the resource maximum buildout is based on the 95-percentile number. He agreed that the technology is complex but called this overly conservative. Charles said that the very limited development and

activity over the last decade leads to a lot of uncertainty over the 20-year life of the Plan. She said this pointed her to a more conservative estimate but was open to suggestions.

Nightingale said policy shifts of the last decade, including big swings for renewable and non-emitting resources, may push innovation. Charles agreed but stated that 475MW represents a substantial number of geothermal plants.

Heutte stated that The Geysers is extensive with 900 MW currently on-line. Rogers argued that price points are not competitive and investors will probably not risk exploratory drilling to build out that many plants in the region. She was okay with identifying the resource by percentile, and encouraged Staff to make sure the plant is market competitive.

Heutte suggested the region could buy some Imperial Geothermal. He then said a geothermal group at UC Davis is optimistic about the resource in that area but agreed with Charles's reference plant estimate for the Council's footprint.

Nightingale argued that the market will take care of economics, calling it a secondary question over technical potential. Charles said the slide represents feasible potential installed. Nightingale asked if she took market conditions into account. Charles said market conditions mostly come into play during the modeling.

Mike Starrett, NWPC, said there will be some sites with lower risk where developers will be more comfortable drilling. He then stated that as they move away from the median to the tail the risks and the costs will get higher. Starrett said this is the argument against setting to the technical maximum potential. Rogers added that transmission is also a constraint.

Super Hot EGS

Terra Rogers, AltaRock Energy

Starrett asked if they expect to find homogeneous rock at a certain depth globally. Rogers answered yes, cautioning that there will be some variances that she will address further in the presentation.

Starrett asked for further description of the water circulation and source [EGS can meet the market....] Rogers admitted that much is still unknown but the first step would require understanding how to create a reservoir. She anticipated a closed-loop approach with liquid brought in adding that the amount of liquid loss is still unknown but models predict that it may be limited.

Starrett asked if fresh water must be used or if the plant would work with salt water. Rogers said this is still unknown.

Heutte called the decline on [Economic Advantage] striking and asked why such a steep curve is predicted. Rogers pointed to very big bands of estimates, adding that completing the well is one of the biggest cost drivers. She said standardized metallurgy is predicted to alleviate 25-

30% of costs and an off-the-shelf model would also greatly reduce costs. Rogers cautioned that these costs represent Plant #46 while Plant #1 would be astronomically higher. Heutte agreed that above and below ground equipment costs should be treated separately and asked about drilling. Rogers pointed to innovations like the millimeter wave drill.

Starrett asked for more information about Super Hot, noting that other geothermal applications run at around the same temperature [Super Hot EGS is the ideal energy source.] Rogers agreed that above ground technology exists but off-the-shelf models don't exist yet. She said the three major hurdles are getting to the required depth, creating the reservoir and then harnessing the steam.

Starrett asked about borrowing drilling technology from offshore oil and gas wells as they are about the same depth. Rogers answered that getting to the correct depth is less of an issue than the required thermal cycling which complicates getting the metallurgy right. Starrett asked if any oil and gas major players are considering leveraging their expertise and investing in EGS. Rogers said she is not seeing anything significant but is hearing rumors of interest.

Heutte asked about induced micro-seismicity issues when deep drilling in urban locations. Rogers agreed that induced micro-seismicity is a large concern, particularly in areas like The Geysers. She said the theory is the depth and consistency of the rock will cause the rock to act like a plastic and thermal shock will create the reservoir. Rogers cautioned that much is still unknown.

Carbon Capture Utilization and Storage

Mike Starrett, NWPCC

Heutte questioned why no performance data is available for the NET Power Plant with the new Allam Cycle even though it is in operation [Slide 11.] Starrett confirmed that he didn't have any but agreed that the technology could possibly be a game changer.

Heutte noted that this region has a fair amount of basalt to create rock through CCS [Slide 14] but wondered about legal issues if something escapes.

Rogers asked about capturing and using CO2 in concrete production [Slide 16.] Starrett said staff has not yet fleshed out the deep decarbonization study where that would be examined but was not sure if it would fall within the Council's scope of work. He added that there doesn't seem to be economic incentive for the process but offered to double check.

Charles spoke about next steps. She pointed to the next GRAC meeting on February 27 and a SIF meeting on March 10. She adjourned the meeting at 12:15.

Attendees

Gillian Charles	NWPCC
Mike Starrett	NWPCC

Terra Rogers
Dhruv Bhatnagar
Fred Heutte

AltaRock Energy
PNNL
NW Energy Coalition

Attendees via Webinar

Alain Bonneville	PNNL
Angela Tanghetti	CA Energy Commission
Bryan Neff	CA Energy Commission
Christopher Allen	Cowlitz PUD
Cindy Wright	Seattle City Light
Dave LeVee	PwrCast
Elizabeth Osborne	NWPCC
Frank Brown	BPA
Shamus Gamache	Cen Coast
Greg Nothstein	WA Dept of Commerce
Holly Taylor	Western Energy Board
Ian Bledsoe	Clatskanie PUD
James Vanden Bos	BPA
Jim Woodward	WA UTC
Tom Kaisersky	Montana Dept of Commerce
Leann Bleakney	NWPCC
John Lyons	Avista Corp
Jennifer Magat	Puget Sound Energy
Mike Hoffman	PNNL
Will Price	EWEB
Paul Nissley	Seattle City Light
Rick Williams	PSU
Sibyl Geiselman	Avangrid
Steve Andersen	EES Consulting
Terry Toland	Clark PUD
Tyler Tobin	
Torsten Kieper	BPA
Usha Mohan	BPA