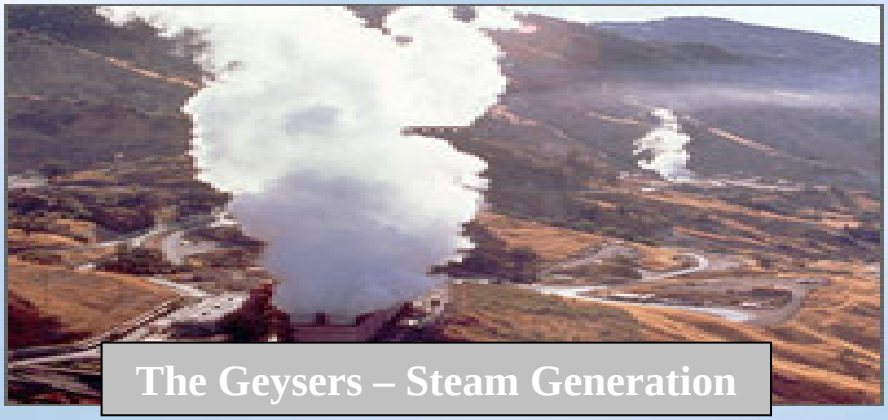
Oregon Geothermal Working Group

Joe Eberhardt

Geothermal Energy – *Meeting Changing Demands & Power Supply*

- PGE customer demands for renewable energy are high relative to the National
  - This is true of residential and commercial & industrial customers too
  - Over 7% of residential customers pay a premium to “green up” their energy
- Many premium wind energy sites are being developed throughout the Northwest
  - PGE is building Biglow Canyon Wind Farm (size = 400 to 450 MW)
  - The availability of these choice sites is sure to diminish in the coming years
- Oregon legislature recently passed the Renewable Energy Standard mandating renewable energy in utility power supply portfolios



The Geysers – Steam Generation

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Geothermal Energy – *Native Oregon Resources*

- Newberry Crater, Oregon:
  - Best known potential project site in Oregon is in late stage development
  - A developer recently sold 120 MW of the project under a PPA to PG&E, with intention to serve California load
  - 240 MW expected production at the site, thus 120 MW still available
- Other prominent native Oregon resources:

Top Known Oregon Locations	Expected Production	Recommended Generation Type	Development Stage
Newberry Crater	240 MW	Flash	Phase 3 (PPA executed)
Crump's Hot Springs	20 MW	Flash	Phase 1 (identified)
Mickey Hot Springs	25 MW	Flash	Unconfirmed
Neal Hot Springs	25 MW	Flash	Unconfirmed
Other Sites<=20 MW	70MW	Flash	Unconfirmed

- Total expected Oregon potential is 380 MW (including Newberry Crater)

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Geothermal Energy – *Prominent Sites Locations*

- Prominent native Oregon resources:
  - **<u>Significant Production (>=20 MW):</u> OR-7=Newberry Crater, OR-1=Crump's Hot Springs, OR-3=Mickey Hot Springs, OR-6=Neal Hot Springs**
  - **<u>Lesser Production (<=20 MW):</u> OR-9=Three Creek Butte, OR-11=Trout Creek Area, OR-2=Lakeview/Hot Lake Area, OR-8=Summer Lake**

Oregon Native Resources

OR-4=Mt Hood is the closest site to the PGE service territory, but is not currently considered a prominent site

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Geothermal Energy – *Utility Quality Reliability*

- High Supply Reliability
  - Bulk of plant mechanics are well known and widely implemented turbines as used in natural gas fired plants, and well field equipment used in oil fields
  - Base load generation resource;
  - Expected 85% mechanical availability factor including planned maintenance

Sierra Nevada Hydrothermal Reservoir

Drilling Rig

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Geothermal Energy – *Project Economic Drivers*

- Plant-related fixed capital costs ("CAPEX") versus fuel-related variable costs
  - CAPEX allocated to turbines and plant comparable to a conventional natural gas turbine (low fixed cost compared to wind- or coal-based energy)
  - Substantial CAPEX may exist in the form of transmission costs to move the energy from a location that is remote to the main transmission grid
  - Virtually no fuel-related variable costs (possible small residual waste disposal cost); though may require "make-up water" to preserve aquifer
- Exploration and production costs typically up to 50% of total CAPEX
  - Finding (est. 5-10% of CAPEX), test drilling (est. 5-10% of CAPEX) and well field production development (est. 20-30% of CAPEX) of hydrothermal reservoirs are comparable in nominal dollars to oil and natural gas E&P
  - Best exploration technology can still result in unsuccessful test wells that will not produce economic energy (potential cost of $2MM per well at risk)
  - Permitting poses challenges as many of the best resources are on federal land (US Forest, BLM or National Park lands) and involve long government permitting queues, restrictions and royalties

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Geothermal Energy – *Expected Project Economics*

- Low Cost per MWh
  - Current subsidies (*federal* = Production Tax Credit, ("PTC"); *state* = ETO) make some projects a close comparison to avoided costs
  - Real-levelized avoided costs are forecasted at $55.70/MWh (2006$) over the 30 year expected life of a typical project brought online by the end of 2007; whereas the PGE base case estimated project cost is projected to be $66.55/MWh (2006$) with the current PTC; a $10.85/MWh difference
  - Actual project costs can vary drastically based on the hydrothermal reservoir quality, potential total output and remoteness of the project from the main transmission grid

Imperial Valley – Flash Generation

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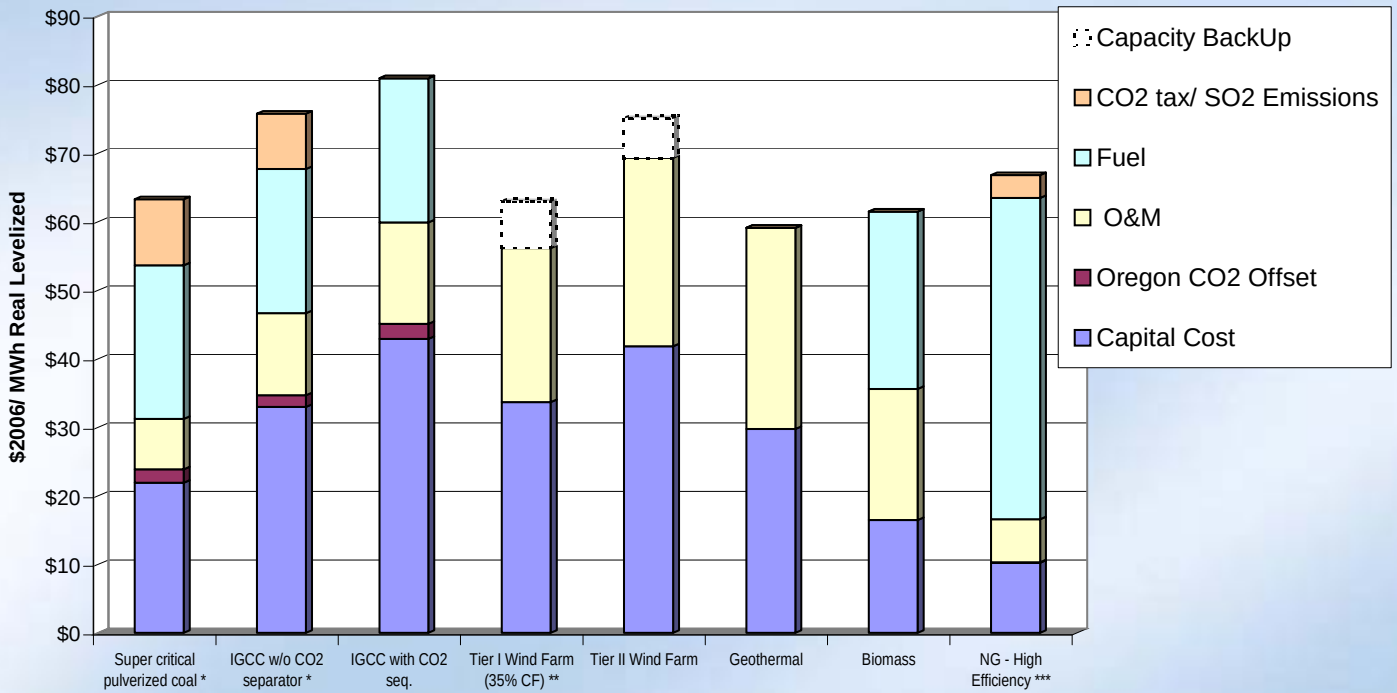
Geothermal Energy – *Resource Comparison*

- Data available to PGE indicate that geothermal resources may be second only to premium wind resources

Reference Case - Life Cycle Cost of New Resources
(Assumes no additional investment for new transmission)



* Coal by Rail, Boardman location (Brownfield)
** Max 350 MW available (Biglow Canyon characteristics)
*** Base Load, assumes a CF >65%

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Geothermal Energy – *Pros/Cons and Next Steps*

- Pros
  - Clean energy: green tags, little risk of carbon tax, little to no pollution
  - Stable energy cost: helps stabilizes customer rates, no volatile fuel costs
  - PTC available: current 10 year credit equal to about a real-levelized $16/MWh over the 30 year expected life of a project online by end of 2007
  - ETO funds available: helps buy-down a smaller project to avoided costs
- Cons
  - Technology risk: hydrothermal reservoir production and generator life span
  - Resource development risk: exploration and production costs are high
- Next Steps for PGE
  - Identify: 1) all potential Oregon resources and degree of development, 2) permitting and transmission hurdles for each resource, 3) costs to complete development and best technology to maximize production of each resource
  - Screen based on: 1) probability of completing all development aspects, 2) lowest real-levelized cost

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Geothermal Energy – *PGE's Interest*

- PPAs
  - PGE's initial foray into new power supply technology typically has been in the form of small PPAs (PGE had contracts for Condon, Vansycle Ridge and Klondike 2 before acquiring the Biglow Canyon Wind Farm)
  - PPAs that overcome transmission obstacles would be more attractive
- Turnkey Project
  - Fully developed geothermal projects that can be acquired or projects that are developed for PGE by others are an alternative, however often high developer fees often do not make this the least expensive path
- Self-build Project
  - As comfort with new power supply technology progresses, PGE often finds the least expensive path is a self-build project
  - Given complicated permitting (BLM, et al) related to geothermal development assets, a mid-development hand-off from a geothermal energy development company may be desirable (PGE pursued this model with Biglow Canyon Wind Farm, acquiring the project rights after permitting was completed)

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