Northwest Power and Conservation Council

December 3, 2008

MEMORANDUM

TO: Power Committee

FROM: Jeff King, Senior Resource Analyst

SUBJECT: Assessment of solar-thermal generating resource potential

Increasingly aggressive state renewable portfolio standards and greenhouse gas control policies may lead to the need for new large-scale sources of renewable energy in addition to wind power. One source could be electricity from central-station concentrating solar thermal power (CSP) plants. Of several feasible CSP technologies, parabolic trough technology is commercially available. Over 430 megawatts of parabolic trough CSP capacity is operating in California and Nevada with the latest, the 64 megawatt Nevada Solar One project, having been brought into service in 2007.

CSP attributes include low lifecycle emissions of criteria air pollutants and carbon dioxide (CSP plants are often provided with natural gas backup), short construction lead time, low fuel price risk and favorable public perception. Though CSP output is diurnally intermittent and seasonally variable, inherent operational stability plus optional storage and natural gas backup can reduce or eliminate the need for regulation or load-following resources for system integration and can increase the capacity value and capacity factor of these plants. Unfortunately, CSP technology requires high direct normal solar radiation for best performance, limiting optimal sites to the desert Southwest. Central Nevada locations may be the most feasible for serving Northwest loads. This would require new transmission, adding to the already high capital cost of CSP technology. While parabolic trough CSP technology is commercially available, the new transmission needed to access the resource is unlikely to be available in the near-term. Finally, power from CSP development in central Nevada would likely be priced on the basis of the value of the power to California and other southwestern utilities seeking renewable resources.

Staff will describe an assessment of the potential cost and performance of parabolic trough CSP plant, located in central Nevada for serving Northwest loads. A PowerPoint presentation will be provided prior to the meeting.

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Sixth Northwest Conservation & Electric Power Plan

Concentrating Solar Power (CSP) Resource Assessment

Jeff King
Northwest Power and Conservation Council

Portland, OR
November 20, 2008

CSP considerations and issues I

- Potentially available in very large quantity
- Little direct production of carbon dioxide or criteria air pollutants (SOx, NOx, etc.)
  - Power tower and parabolic-trough technologies may employ gas backup for stabilization of output and for providing peaking capacity value
- Potential ecological impacts from habitat preemption
  - Large land area required
- Public perception:
  - Power plants - cautiously supportive (concerns regarding land use, aesthetics and ecological impacts)
  - New transmission needed from remote resource areas - possible public resistance

CSP considerations and issues II

Investment risk:

- High capital cost (currently $4000 - 5000/kW)
- Short development and construction lead time
- Advanced development of longer-lead time transmission will be needed to access suitable resource areas

Low fuel price risk

Diurnally intermittent and seasonally variable output

- Probably less forecast error than windpower
- Parabolic trough and power tower systems can include thermal storage and gas backup to stabilize output
- Reduces or eliminates regulation and load-following costs

Northwest perspective:

- Poor seasonal load-resource coincidence for most of region
- New transmission in new corridors needed to access resource
- Price competition from California & SW utilities

Parabolic-trough

Mirrored parabolic troughs or linear Fresnel lenses focus radiation on a linear oil-filled receiver

Oil heat transfer fluid transfers energy in an oil/water boiler; steam drives conventional steam turbine generator

Oil thermal storage and supplemental natural gas boiler firing may be provided.

1 - 200 MW unit capacity

North American Development:

- SEGS I - X (354 MW total) in service in California since late 1980s
- 64 MW Nevada Solar One in service in 2007
- 5 MW Kimberlina Linear Fresnel Reflector plant in service 2008 (CA)
- Power sales agreements for 4 projects totaling 1180 MW in CA & AZ
- Power sales agreements for 177 MW Carrizo Plains Fresnel Reflector project

Power Tower

Field of heliostats (tracking mirrors) focus radiation on central tower-mounted receiver

Molten salt heat transfer fluid transfers energy to salt/water boiler; steam drives conventional steam turbine generator

Molten salt thermal storage and supplemental natural gas boiler firing may be provided.

~ 20 MW unit capacity

North American Development

- 10 MW Solar One pilot project (1982 -1988), Barstow, CA
- 10 MW Solar Two pilot project (molten salt heat transfer fluid & thermal storage) (1998 - 1999), Barstow, CA.
- Power sales agreements for 6 projects totaling 1145 MW in CA

Dish/Engine

Heat-driven engine/generator (usually Stirling) at focal point of mirrored dish.

Highly modular (25kW/unit); opportunities for economies of production.

Scalable to arrays of several hundred megawatts, or more.

North American Development

- 150 kW (6 dish) pilot plant in operation
- Power sales contract w/SDGE for 300 MW (12,000 dish) plant in the Imperial Valley, CA
- Power sales contract w/ SCE for 500 MW (20,000) dish plant in the Mojave Desert, CA

Parabolic trough selected for further analysis

Each technology is likely ultimately to play a commercial role

Parabolic-trough technology is commercially proven with an extensive operating record

Cost:

- Dish Stirling cost estimates somewhat higher than Power Tower or Parabolic Trough, but are very preliminary and may benefit from economies of production
- Power Tower and Parabolic trough costs are roughly in the same range, but parabolic trough costs are firmer, based on commercial-scale construction and extended (20 years) of operation.

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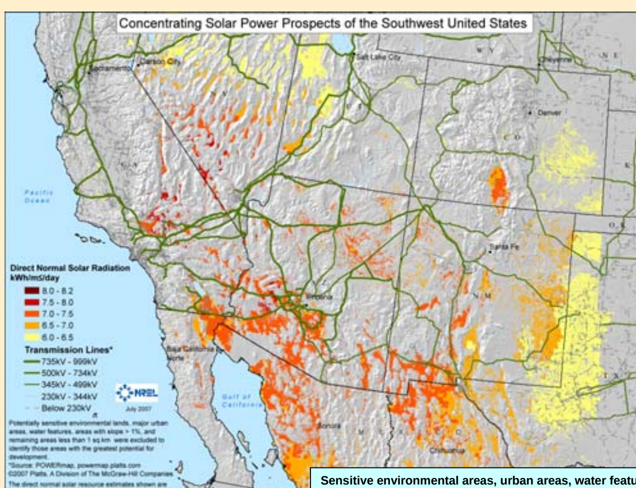
CSP technologies use direct normal radiation Best sites are in the desert Southwest.



Sensitive environmental areas, urban areas, water features and sloping sites screened

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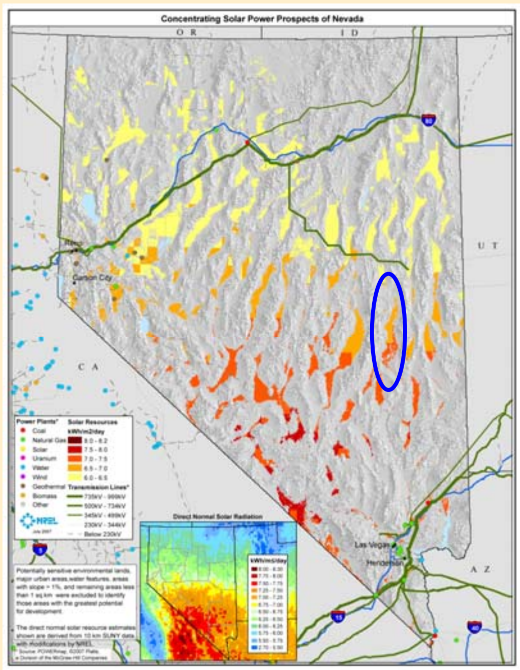
We assumed development in the White River Valley of Nevada

6.5 - 7.5 kWh/m/day

~ 100 mi south of Thirtymile substation of proposed Southwest Intertie Project



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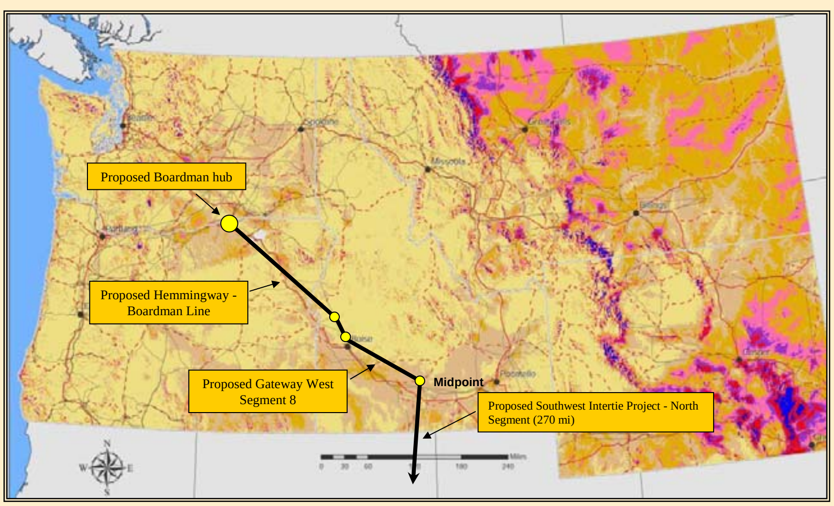
Central NV CSP to S. Idaho, Oregon & Washington



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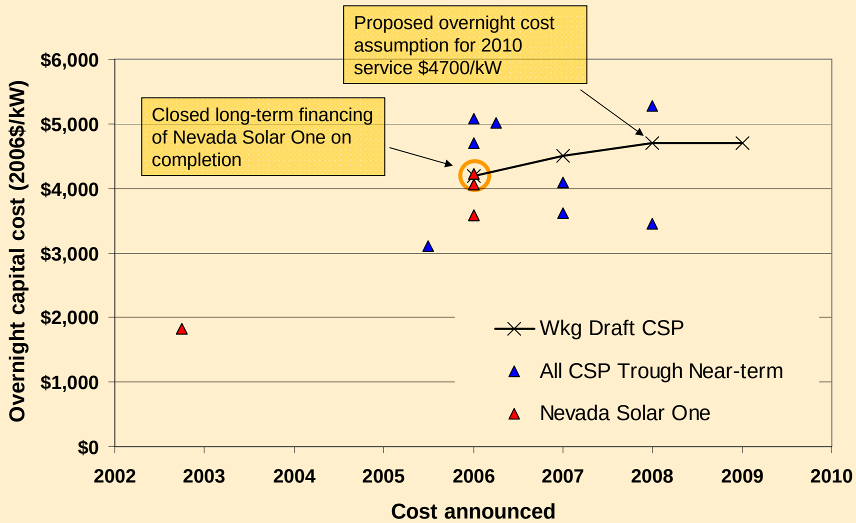
Derivation of CSP capital cost assumption



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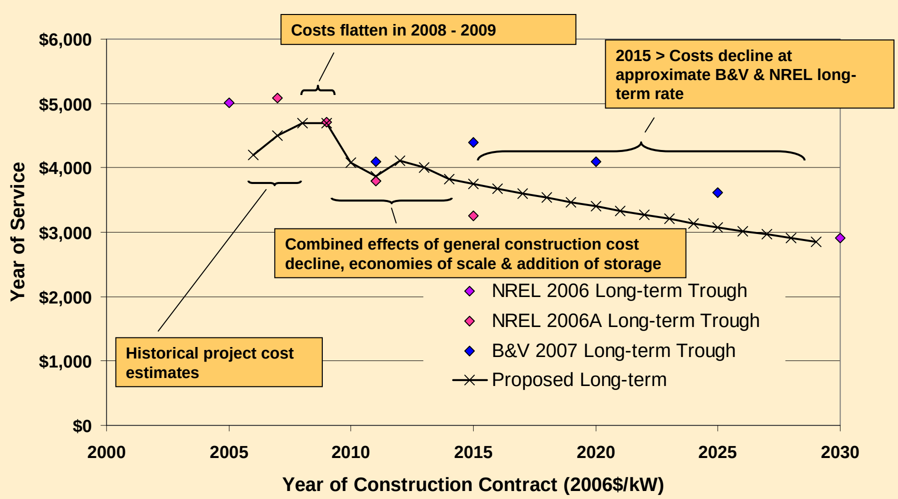
Construction costs over the long-term



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CSP Plant assumptions

Configuration:

- 200 MW parabolic trough power plant
- Natural gas backup (10,000 Btu/kWh HR) and 6 hours storage
- 40% capacity factor

Development and construction cost (overnight):

- $4700/kW (2010 service)
- $4100/kW (2015 service)

Operating costs:

- Fixed O&M - $60.00/kW/yr
- Variable O&M - $1.00/MWh
- System Integration - None (Storage & backup NG used for stabilization)

Schedule and cash flow

- Development - 24 mo; 2% of overnight cost
- Preparation - 8 mo (4 mo overlap w/development); 20% of overnight cost
- Construction - 24 mo; 78% of overnight cost

Earliest service for project available to the Northwest ~ 2015

- Prerequisite: Construction of transmission

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Transmission assumptions

- Incremental transmission system cost fully allocated to CSP energy transfer (no network reliability credit).
- Transfer capacity provided for 100% of project output.
- Estimates based on line miles and substations proposed for B2H, Gateway, SWIP North segments.
- Assumed additional 100 mi lateral + receiving substation w/transformation from White River Valley to SWIP Thirtymile sub.
- Lines assumed to be single-circuit 500kV AC w/1500 MW transfer capacity
- Line and substation unit costs are as recommended by Bonneville Nov 2008.
- ROW, communication, EPC, owner's cost and O&M cost percentages are from MSTI proposal.
- Losses are from 2006 NTAC Canada-Northwest-California study

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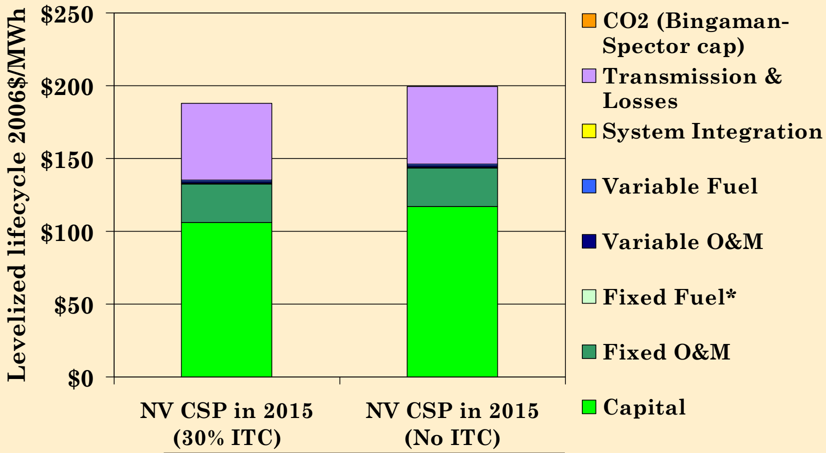
CSP plant cost elements

IOU financing
2015 service
40 % CF (Central NV)
WA/OR delivery



* Fixed fuel cost would be about $25/MWh if pipeline capacity to provide firm peaking capacity were secured.

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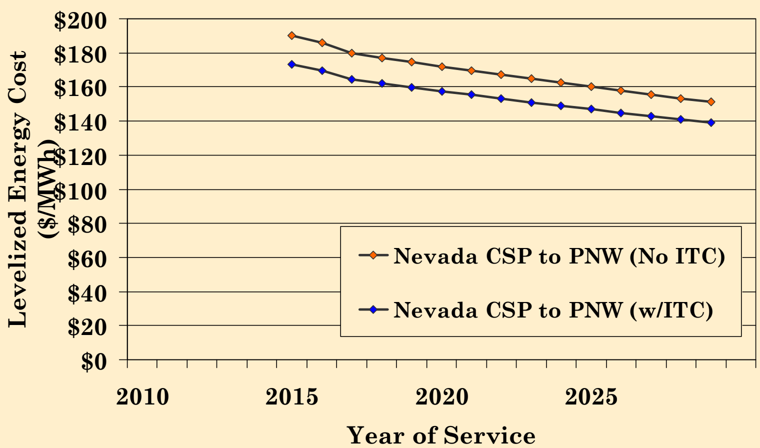
Effect of historical and forecast cost trends



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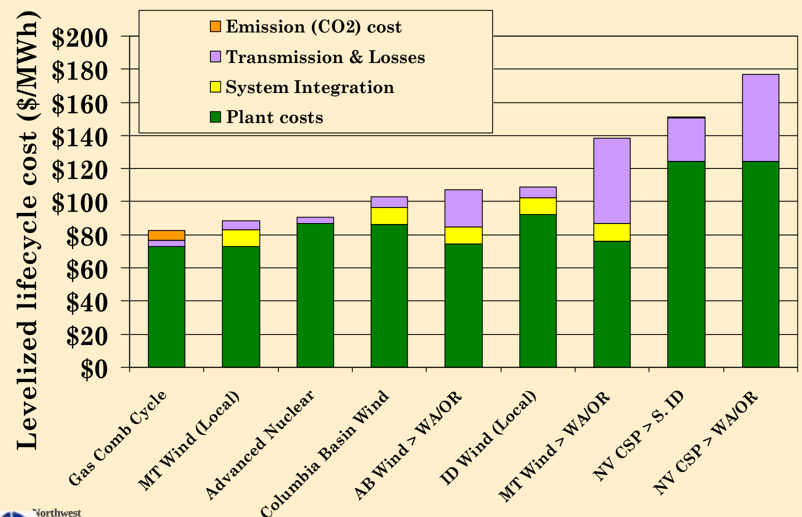
Resource options, early 2020s

Transmission cost & losses to point of LSE wholesale delivery
No federal investment or production tax credits
Baseload operation (CC - 85%CF, Nuc 87.5% CF)
Medium NG price forecast (Proposed 6th Plan)
Bingaman/Specter safety valve CO2 cost



CSP Parabolic Trough power plant

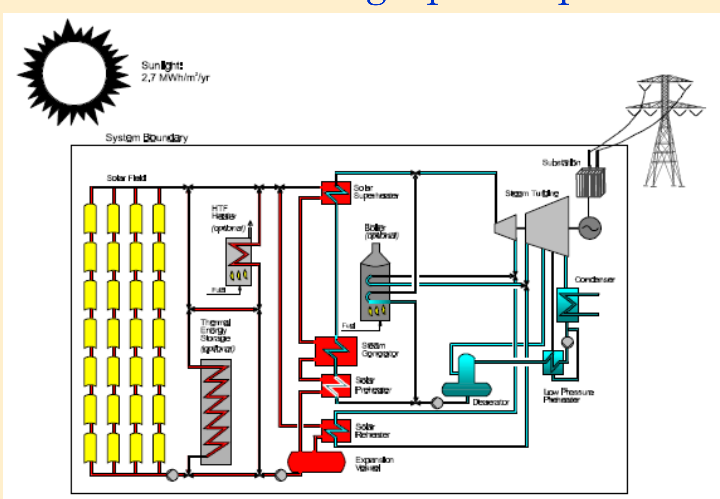


Figure 1. Solar/Rankine parabolic trough system schematic [1].