Sixth Northwest Conservation & Electric Power Plan

Concentrating Solar Power (CSP) Resource Assessment

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Generating Resources Advisory Committee

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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

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 totalling 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

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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 totalling 1180 MW in CA & AZ
- Power sales agreements for 177 MW Carrizo Plains Fresnel Reflector project

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Parabolic trough selected for further analysis

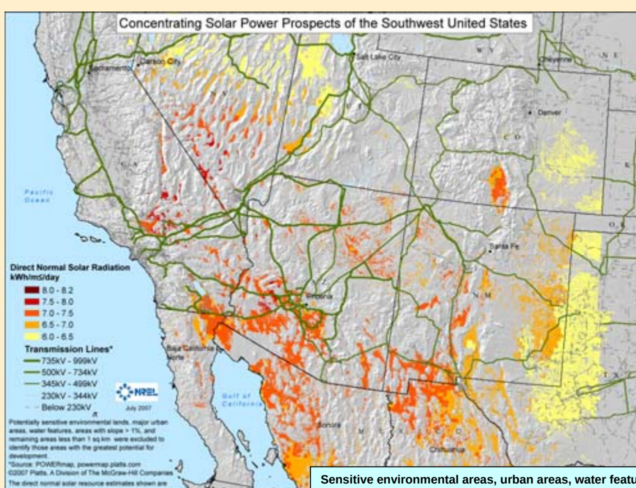
Each technology is likely ultimately to play a commercial role

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.

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

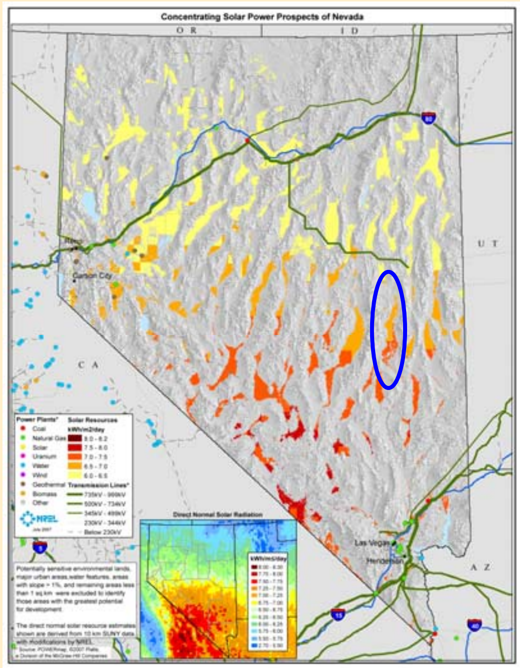


Sensitive environmental areas, urban areas, water features and sloping sites screened

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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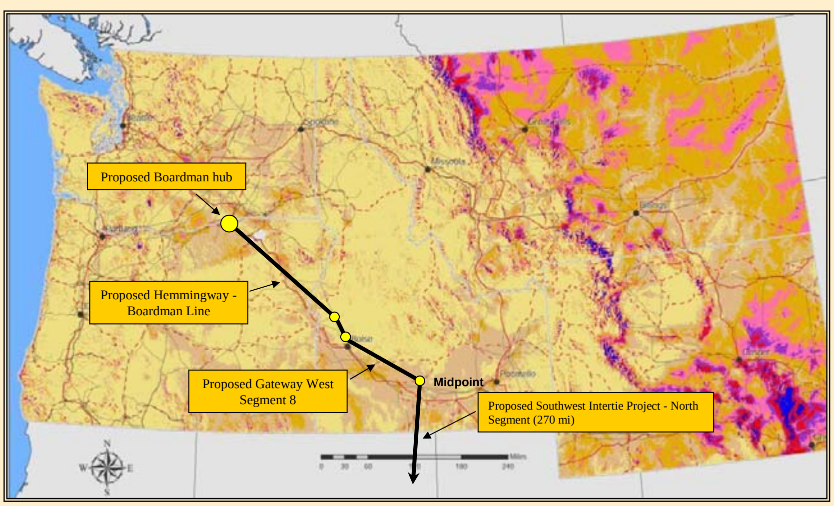
Central NV CSP to S. Idaho, Oregon & Washington



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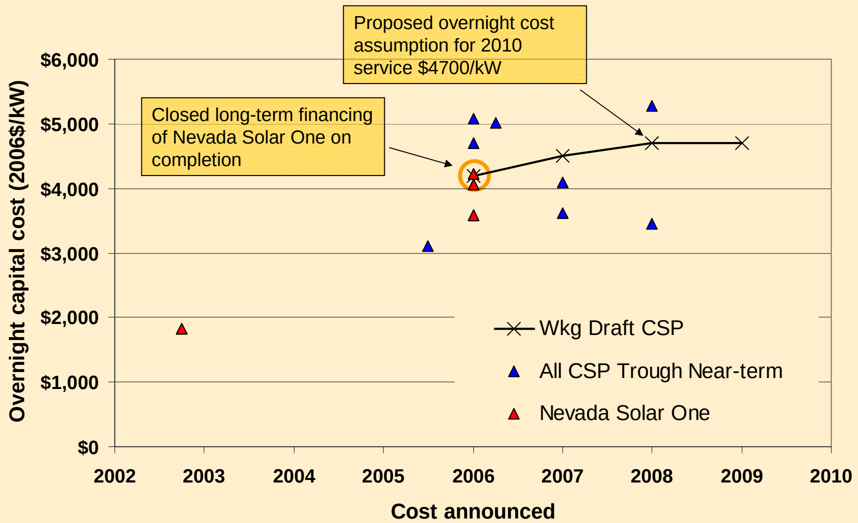
Derivation of CSP capital cost assumption



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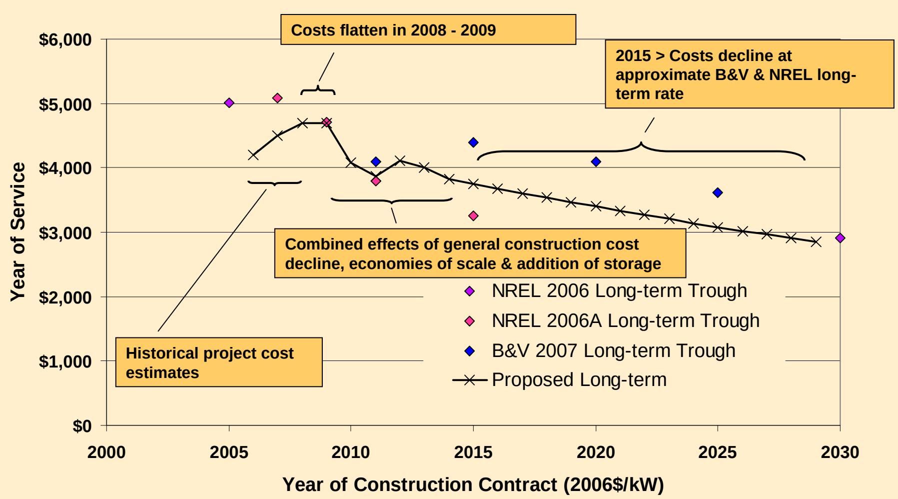
Construction costs over the long-term



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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.
- Transfer cost based on expected capacity factor (~40%)
- Estimates based on line miles and substations proposed for B2H, appropriate 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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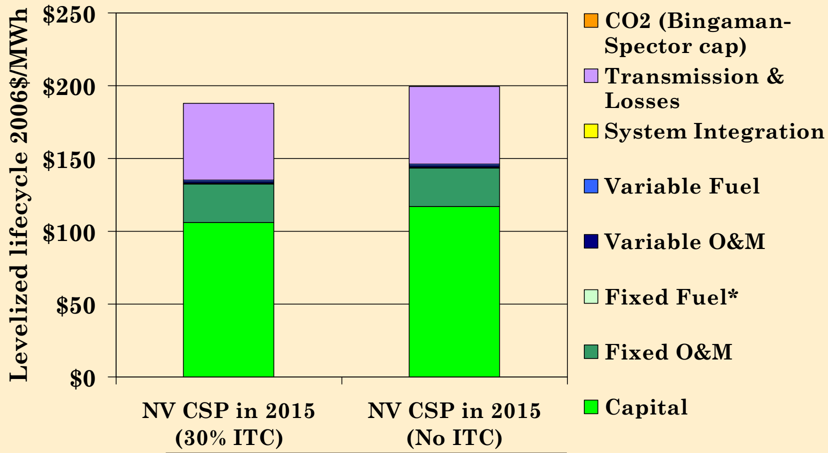
CSP plant cost elements

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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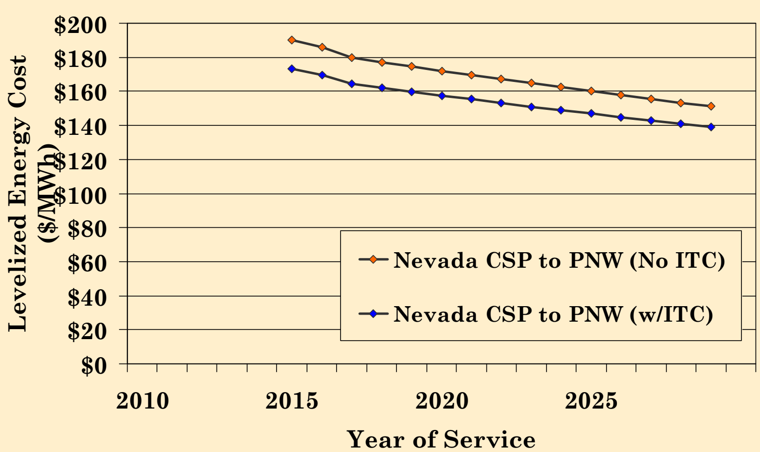
Effect of historical and forecast cost trends



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