



U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy



Solar Energy Technologies Program

# Concentrating Solar Power Water Needs and Alternative Cooling Method Impacts

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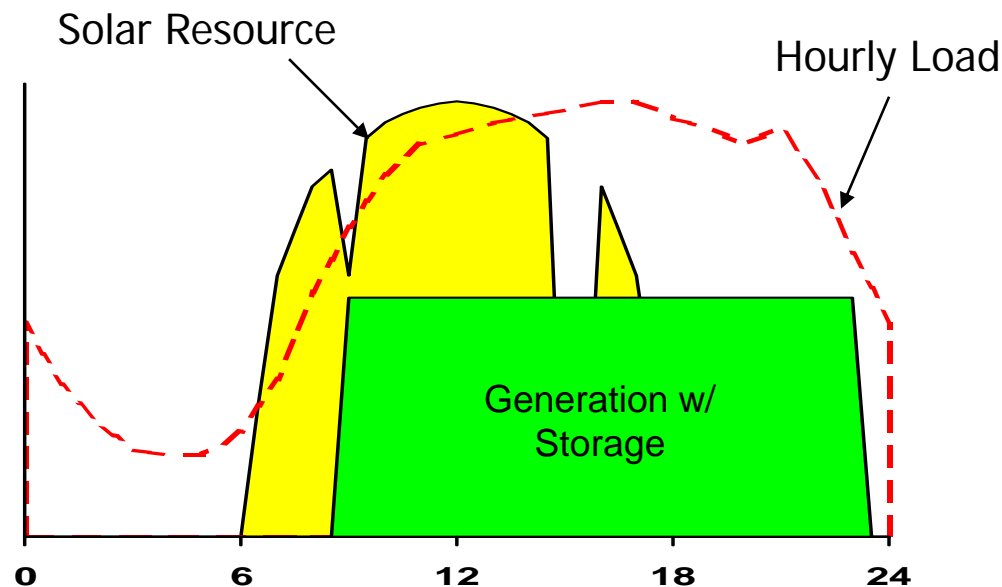
**Sentech, Inc.**

Supporting the US Department of Energy  
Office of Energy Efficiency and Renewable Energy  
Solar Energy Technologies Program (SETP)  
Concentrating Solar Power Program Area

- Technology
- Water Usages
- Impacts of Alternatives
- CSP Market Projections and State / Regional freshwater consumption impact.

# The Value of CSP

- Dispatchable
- Large scale
- Energy input from CSP is 100% renewable, will not emit GHG
- CSP integrates with grid
- Market ready: 1 GW of CSP in USA in the next three years.
- Renewable Energy Storage that is Low-cost High efficiency

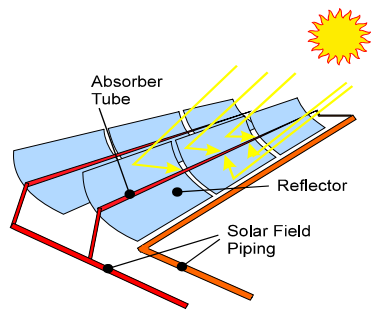


# Concentrating Solar Power Technology

## Steam Turbine Generator Dispatchable, Integrates with Storage



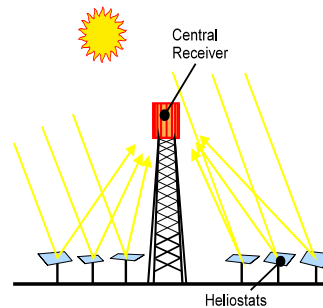
**Trough**



- Most cost effective 250+MW
- 75 suns concentration
- Operating temp: 400C
- Annual efficiency: 14%



**Towers**

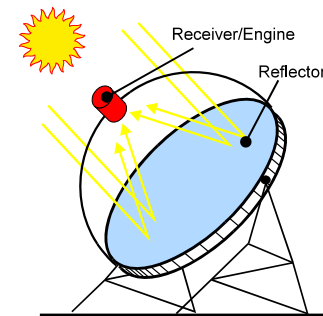


- Most cost effective 250+MW
- 800 suns concentration
- Operating temp: 560C
- Annual efficiency: 18%

## Stirling Engine-Alternator High Efficiency, no Storage



**Dishes**



- Modular 30 kW units
- 3000 suns concentration
- Operating temp: 800C
- Annual efficiency: 23%

# CSP Water Requirements

- Mirror washing
- Hotel Use
- Steam cycle cooling
  - Accounts for 90% of water consumption
- Comparison to other traditional power generation technologies:
  - 850 gal / MWh CSP
  - 600 gal / MWh Coal
  - 250 gal / MWh CC Nat gas.

Evaporative cooling - most efficient and cost effective

1400 acre-ft per year for a 250 MW CSP trough power plant

To produce the same amount of energy:

500 acre-ft for combined cycle natural gas plants

1000 acre-ft per year for coal fired power plants

# Alternative Cooling Methods – Dry cooling

- 90% Less Water
- 6 % loss in production
- 20% reduced capacity at hottest hours
- 10% capital cost increase
- 1-2 ¢ / kWh increase in cost of power
- Thermal Storage:
  - Collect peak solar resource
  - Produce electricity during cooler hours
  - Capacity still reduced during hottest hours

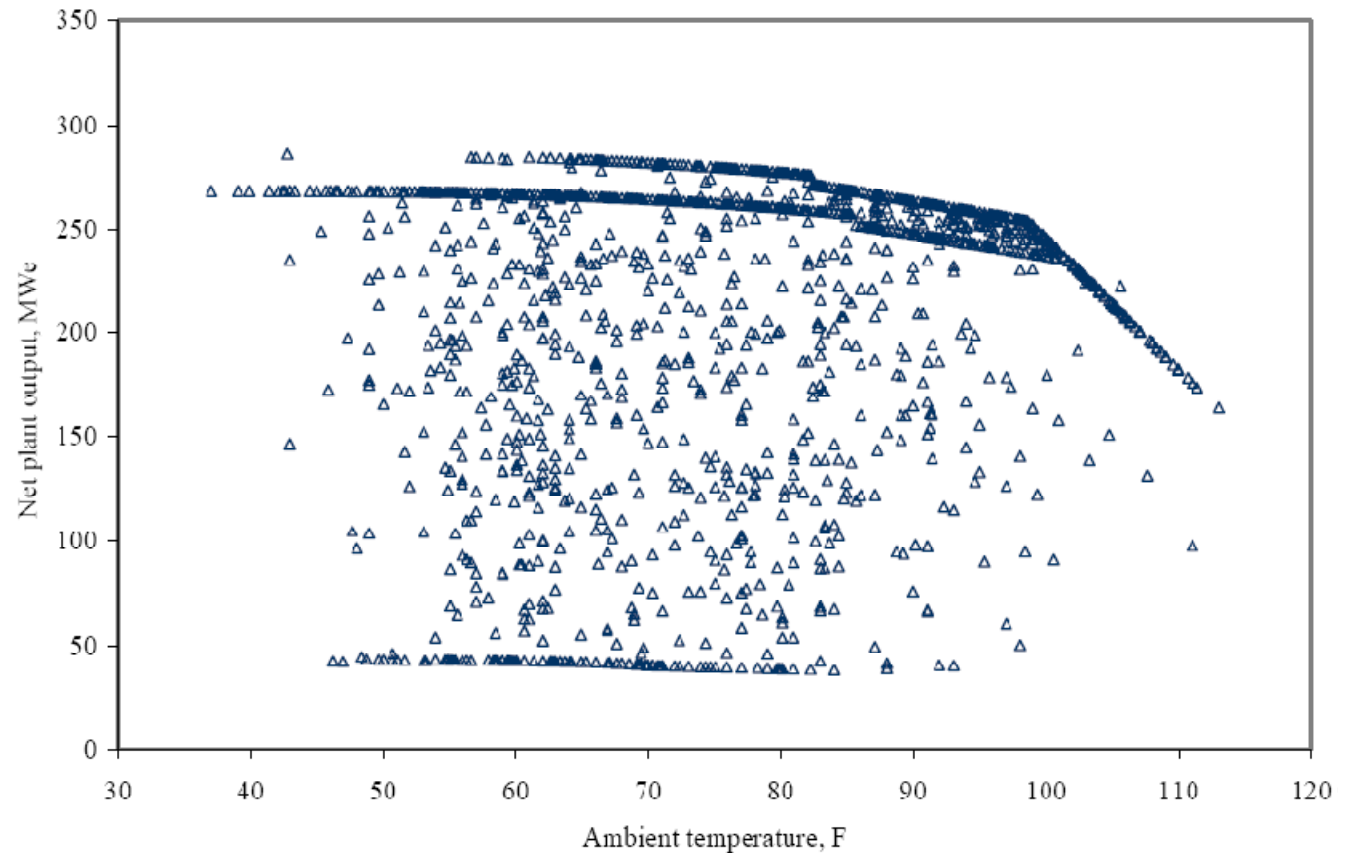


Figure 5 Net Plant Output as a Function of Ambient Temperature; Dry Heat Rejection

# Alternative Cooling Methods – Hybrid cooling

80% Water Reduction  
2% loss in productivity

50% Water Reduction  
1% loss in productivity

89% Water Reduction  
4% loss in productivity

Similar economic impact  
as Dry Cooling

Higher Capacity at  
Peak Demand Periods

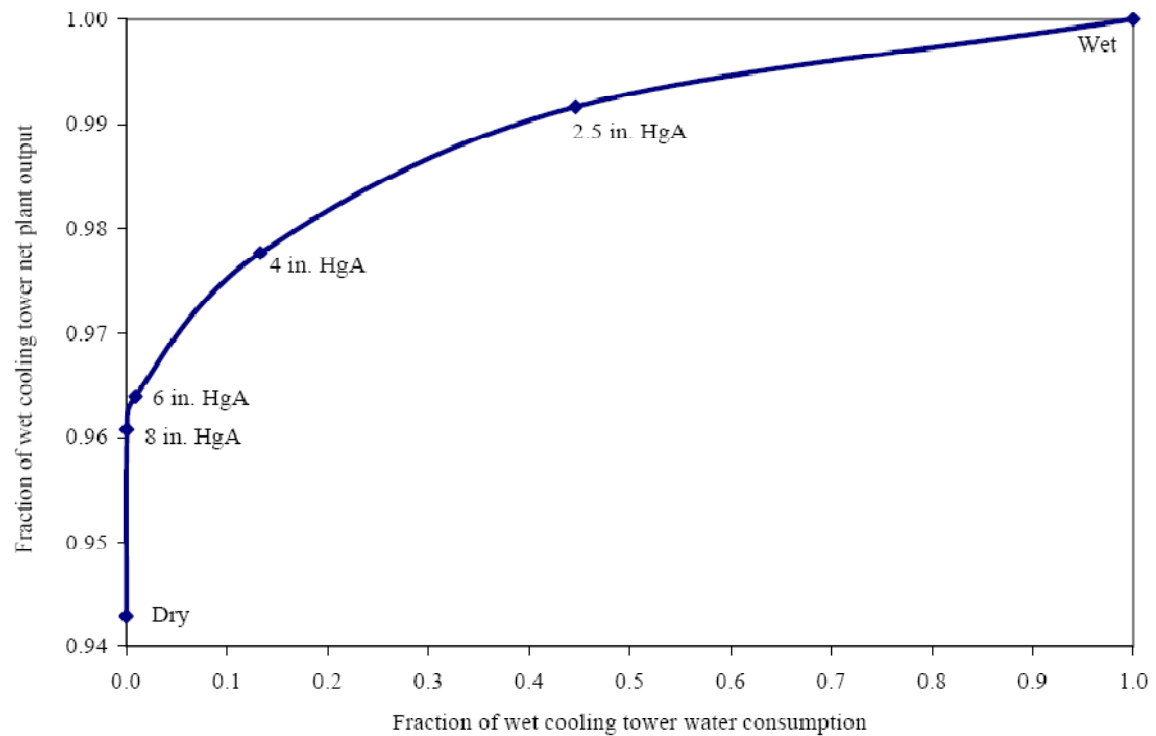
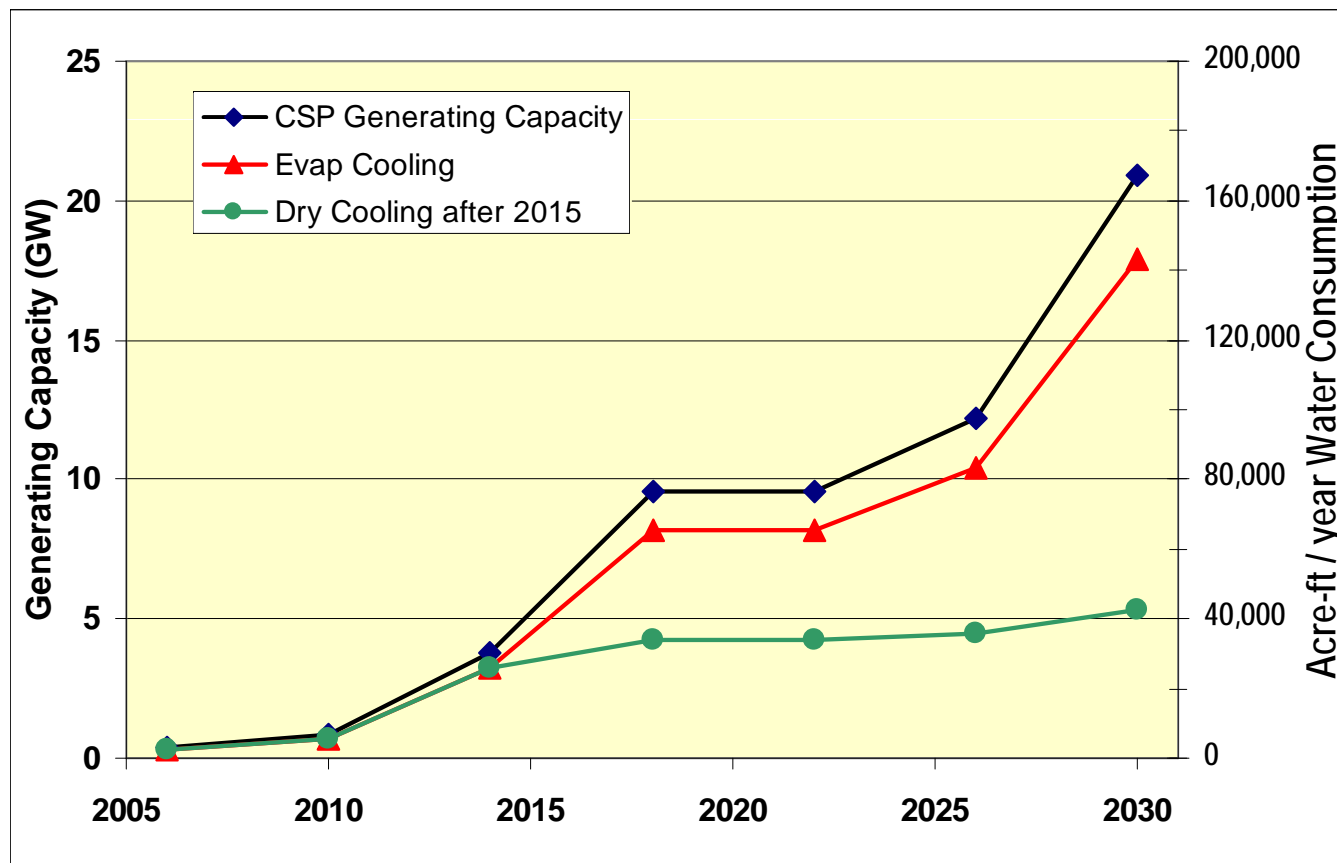


Figure 6 Net Plant Output as a Function of Wet Cooling Tower Water Consumption

# CSP Market Growth

NREL modeling projects limited growth of CSP Market in the next 20 years. Growth projections based on BLM applications do not consider market forces. The CSP market will struggle to be a significant contribution to GHG reduction without significant near term growth to establish the industry.





## Market Growth – Local Water Impact

Majority of CSP Growth will likely be in CA and NV  
but also TX, AZ, CO and NM

2020 Projected Growth 10 GW CSP nationally

CA 6 GW = 35,000 acre-ft/yr if evaporative cooled

25,000 acre-ft / yr	Traditional fossil generation
3,500 acre-ft / yr	If all dry cooling
4-10,000 acre-ft / yr	If all hybrid cooling

NV 1.5 GW = 9,000 acre-ft / yr

TX 0.8 GW = 5000 acre-ft/yr

AZ 0.8 GW = 5000 acre-ft/yr

NM 0.8 GW = 6000 acre-ft/yr

# Thank You

## Contact Information:

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## Further Resources:

[www1.eere.energy.gov/solar/  
pdfs/csp\\_water\\_study.pdf](http://www1.eere.energy.gov/solar/pdfs/csp_water_study.pdf)

[www.solareis.anl.gov](http://www.solareis.anl.gov)

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