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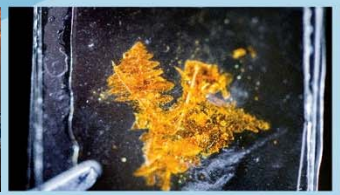


The Value of CSP with Dispatchable Thermal Energy Storage

Mark Mehos
Group Manager, Thermal Systems R&D
Program Manager, CSP NREL

ISES Webinar: Concentrating Solar Thermal Power with Built in Thermal Storage
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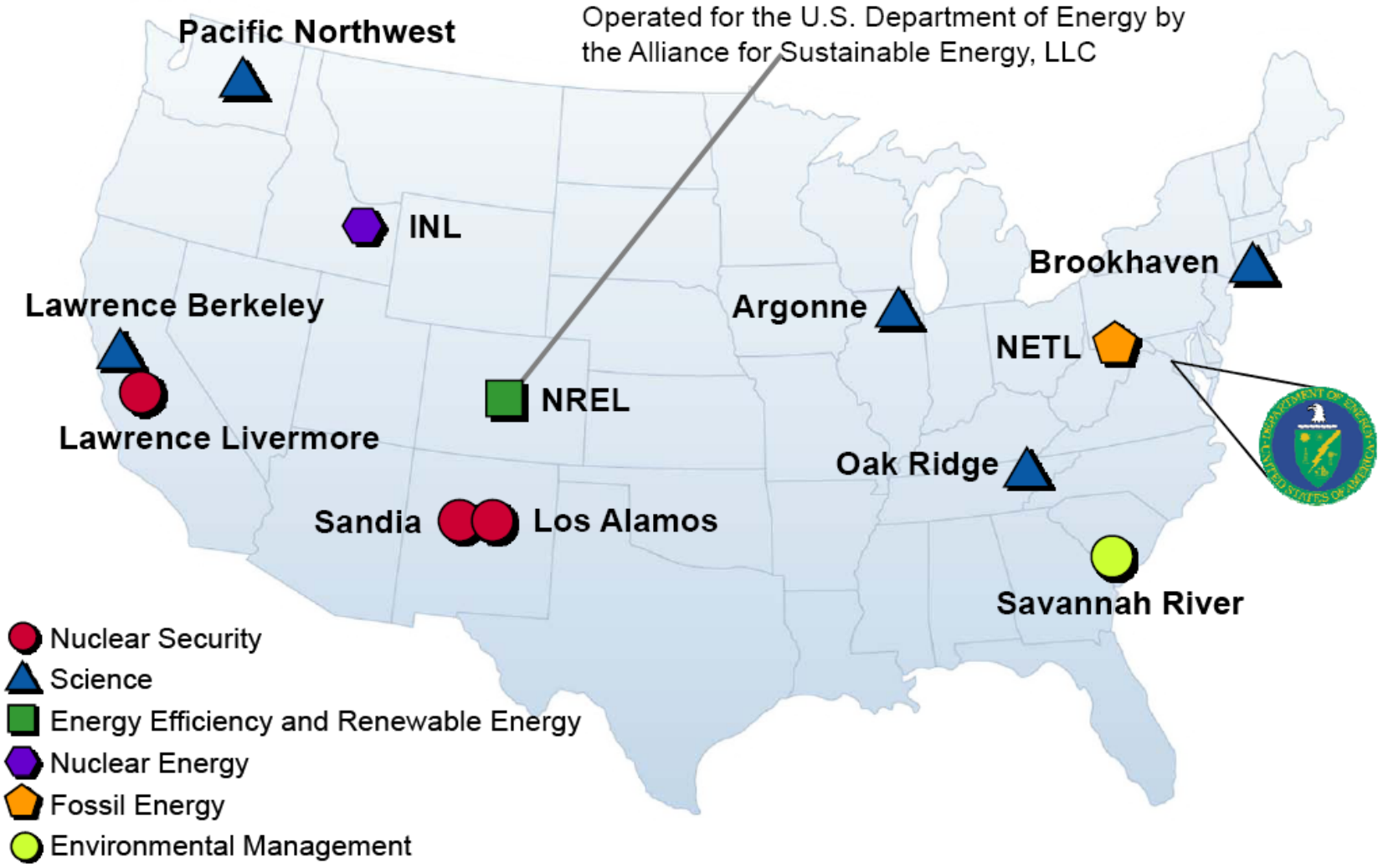
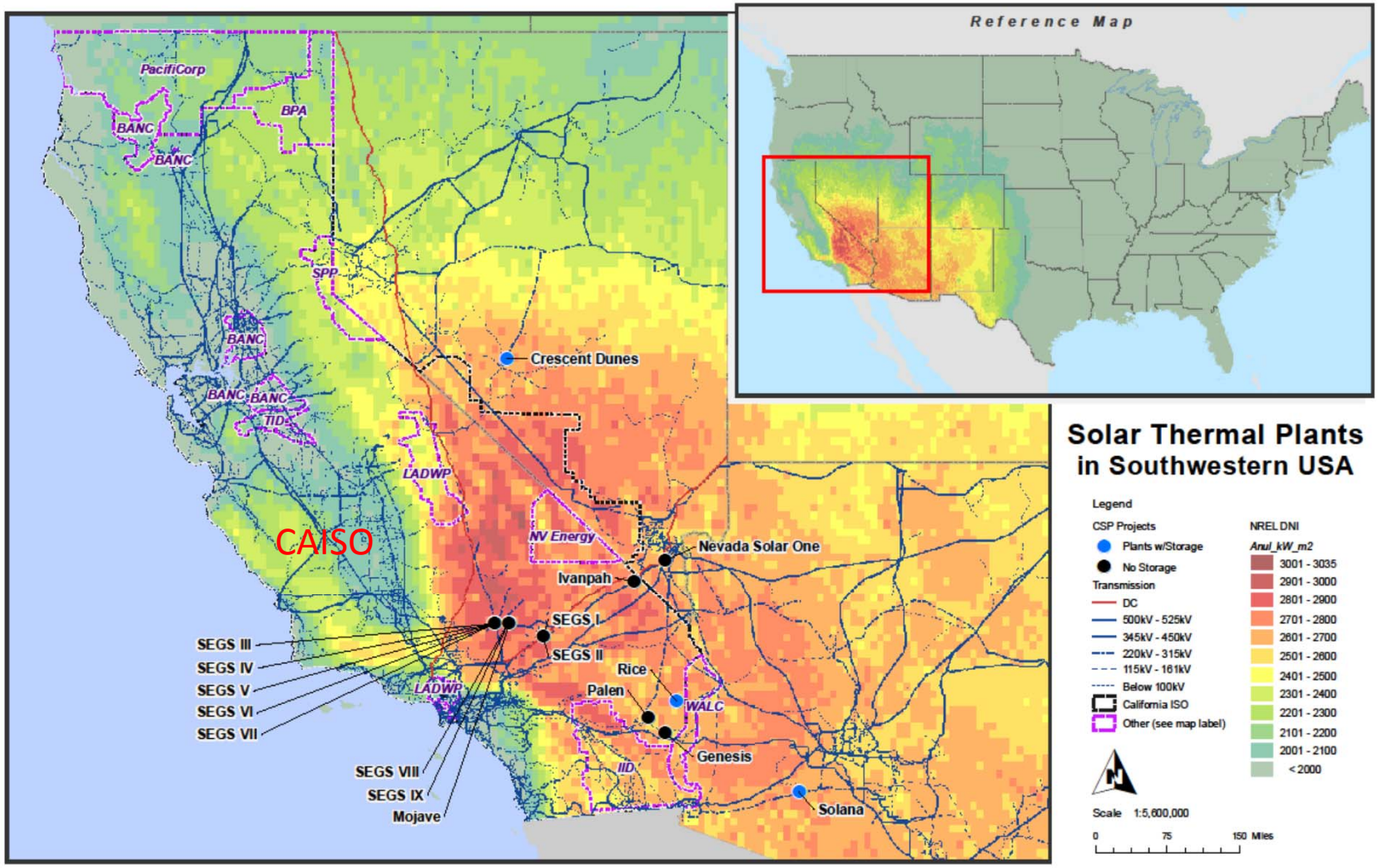


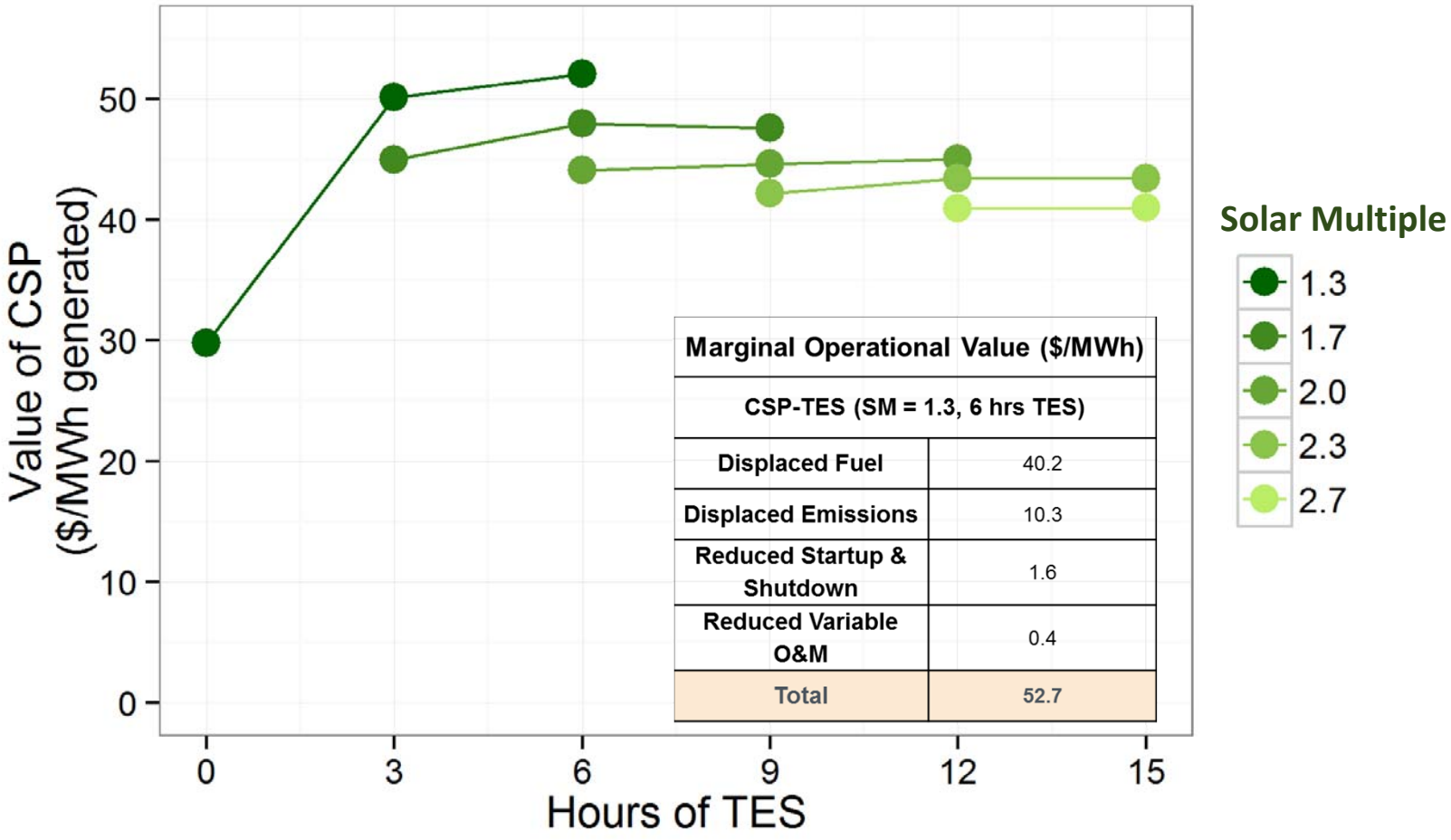
Summary

- CSP with dispatchable thermal energy storage provides and maintains both operational benefits and capacity benefits to regional grids.
- This is especially true at high penetrations of variable renewable technologies such as PV and wind.
- CSP can support additional generation of variable technologies due to its flexibility relative to inflexible baseload coal generation.

PLEXOS Analysis of Operational and Capacity Benefits of CSP in the U.S. Southwest Balancing Area



CAISO Analysis – Operational Value



Marginal Operational Value ($/MWh)	
CSP-TES (SM = 1.3, 6 hrs TES)	
Displaced Fuel	40.2
Displaced Emissions	10.3
Reduced Startup & Shutdown	1.6
Reduced Variable O&M	0.4
Total	52.7

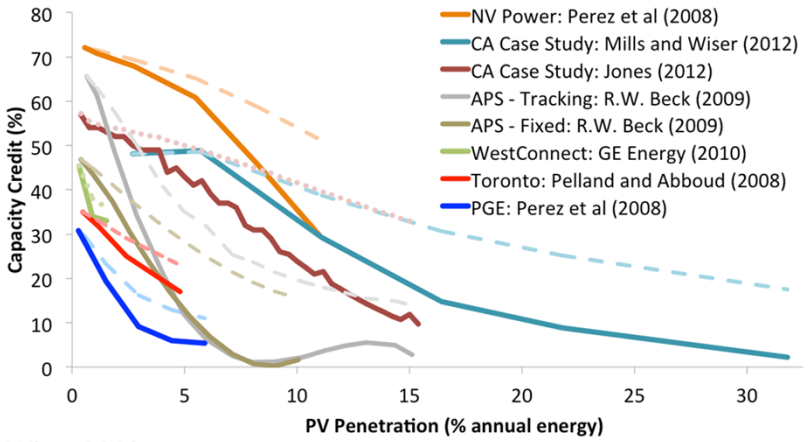
Lowest solar multiples (lower annual capacity factors) yield the highest operational system value

CAISO Analysis – Capacity Value

CSP integrated with thermal energy storage maintains high capacity value

	Capacity Credit (%)	
	CSP-TES (with > 3 Hrs Storage)	PV
33% RPS Scenario	92.2%	22%
40% RPS Scenario	96.6%	3.4%

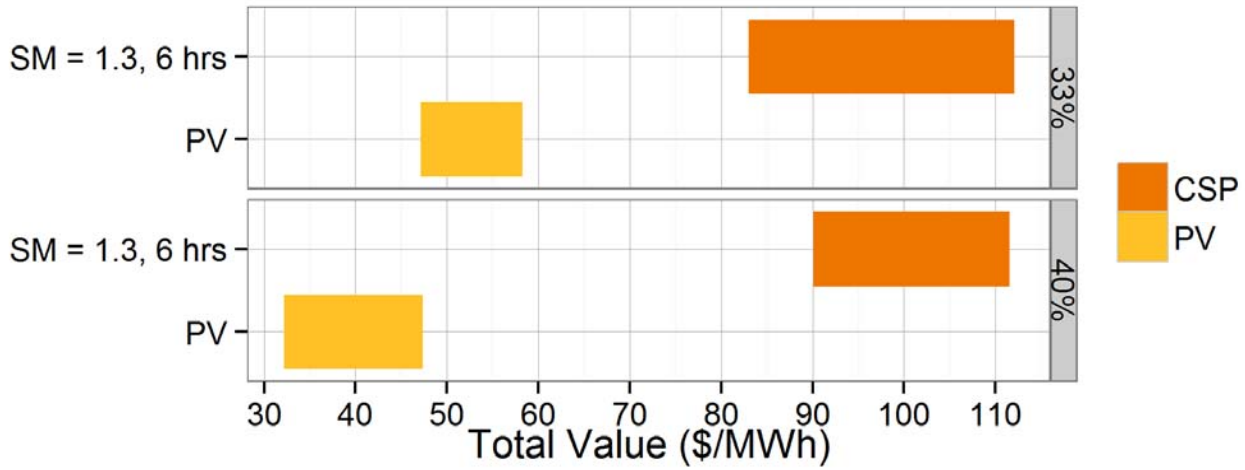
NREL 2014



Mills and Wiser 2012

CAISO Analysis – Total Valuation

- Relative value of CSP is $48/MWh greater than PV in the 33% scenario and about $63/MWh greater in the 40% scenario



What About Cost?

Net System Cost: Solar as a capacity product

- We have investigated the following options for procuring firm capacity and renewable energy:
  - Combustion Turbine (peaker)
  - Combined Cycle (intermediate and baseload)
  - CSP-TES Plant (various configurations)
  - PV Plant + Long-duration storage device
  - PV Plant + Gas combustion turbine (CT)

$$\frac{\textbf{Annualized Capital Cost of each option} - \textbf{Avoided Operational Costs}}{\textbf{Net Cost of each option}}$$

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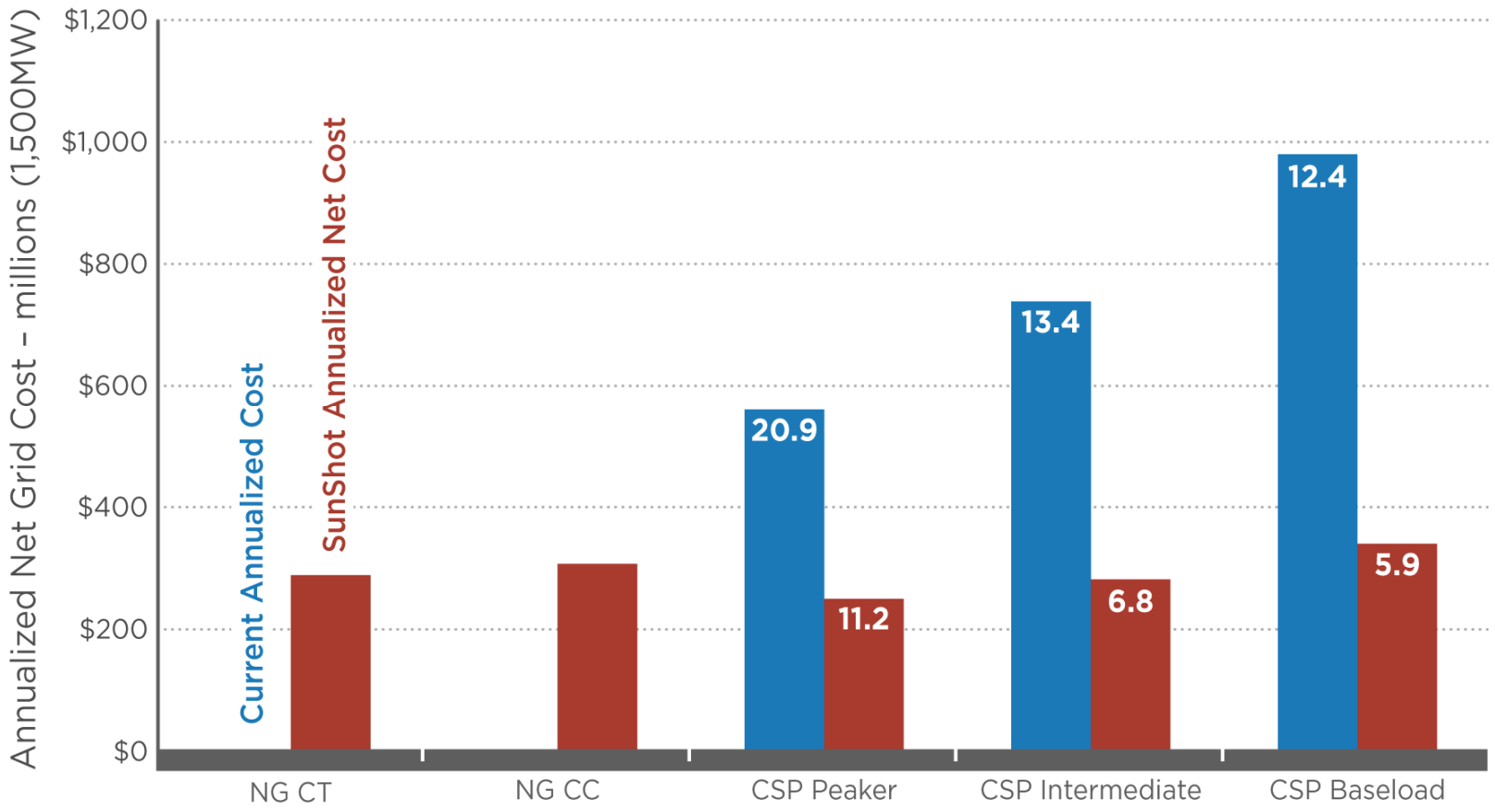
Comparison of annualized net cost of current and SunShot CSP configurations for low natural gas and carbon cost scenarios



Values shown are LCOEs calculated by SAM for each CSP configuration.

Quantifying the Benefits of CSP with Thermal Energy Storage

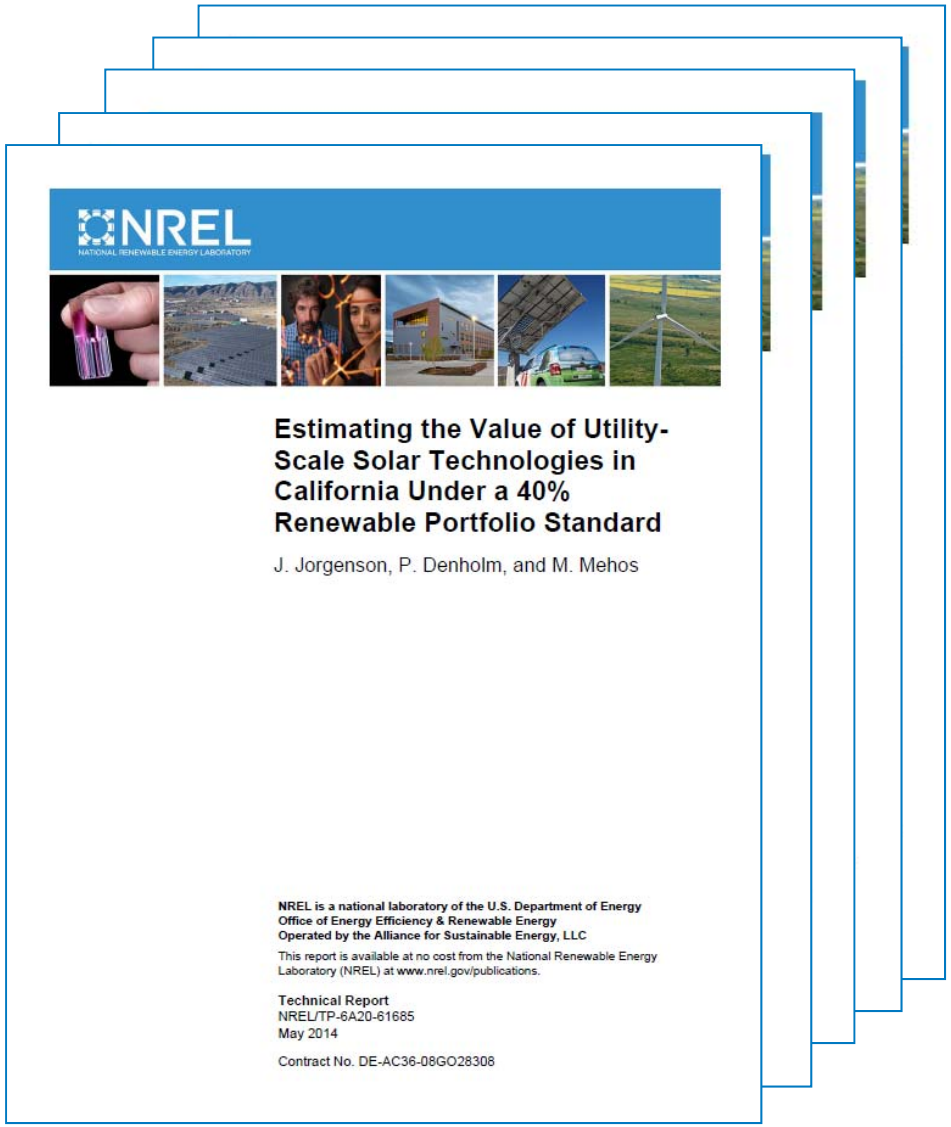
Reports available at https://www.nrel.gov/research/publications.html

Authors:

- Paul Denholm
- Jennie Jorgenson
- Mark Mehos

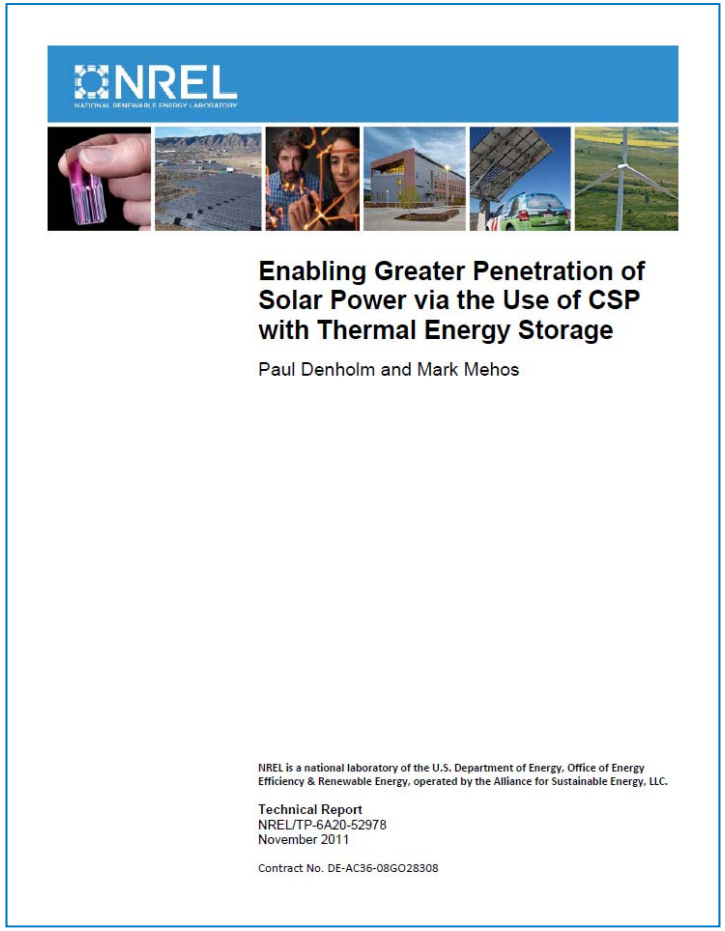
Key Words

- Concentrating Solar Power

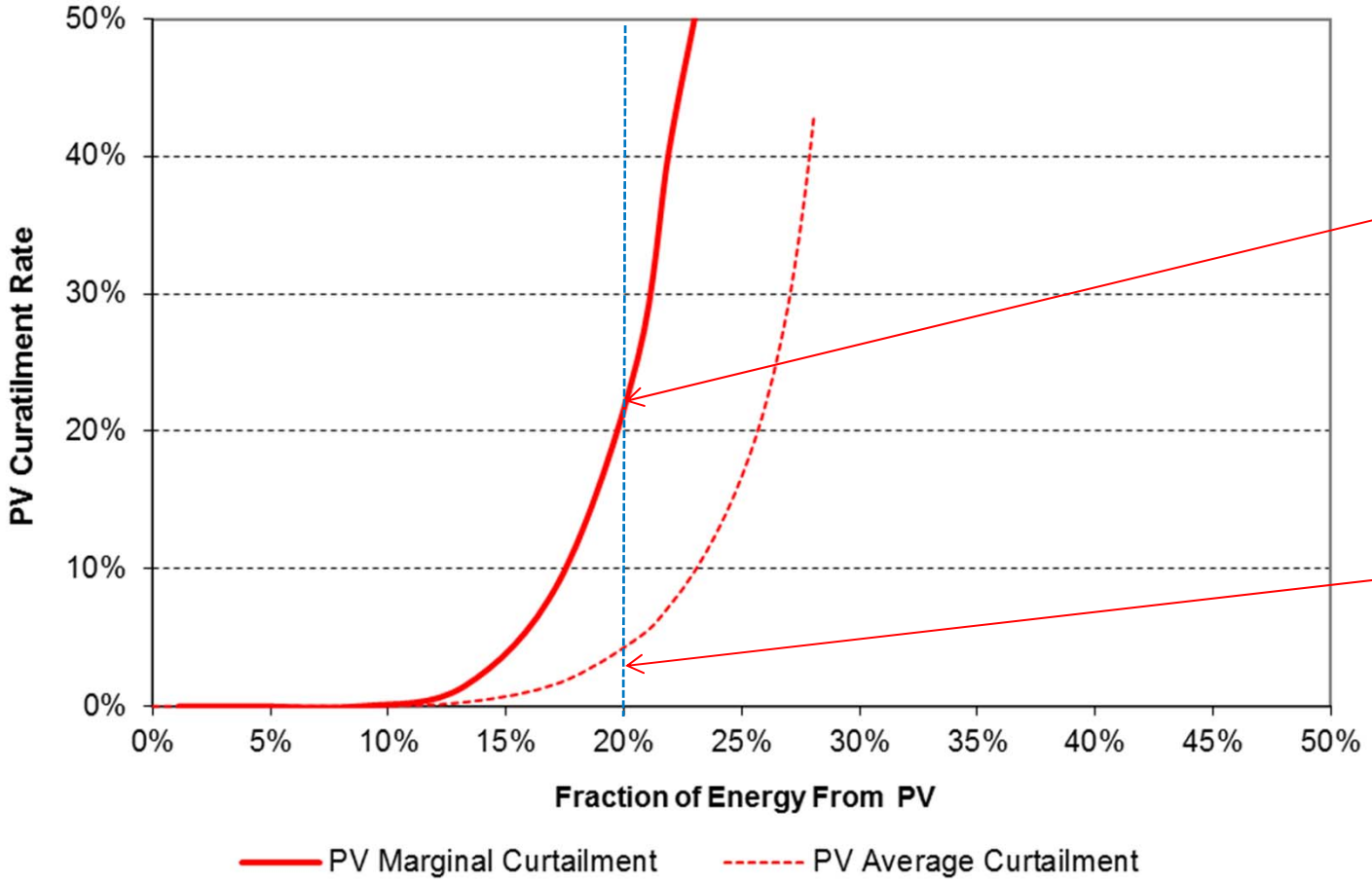


Synergistic Benefits of PV and CSP with Thermal Energy Storage

Investigated the impact of CSP w/ thermal energy storage as an enabling technology for high penetrations of solar (PV and CSP).



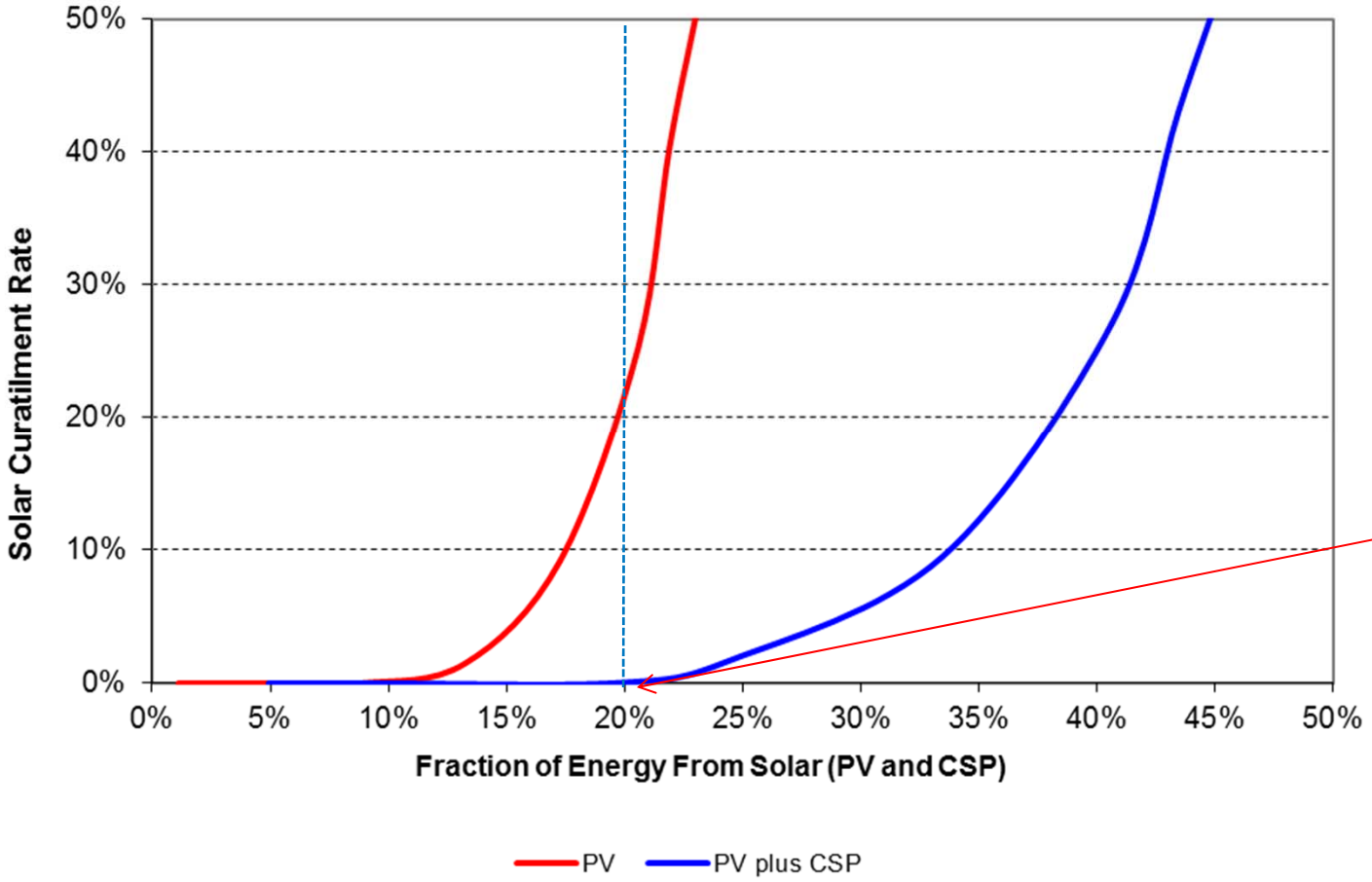
Average and marginal curtailment rates of PV in base scenario



≈ 23% marginal curtailment at 20% penetration

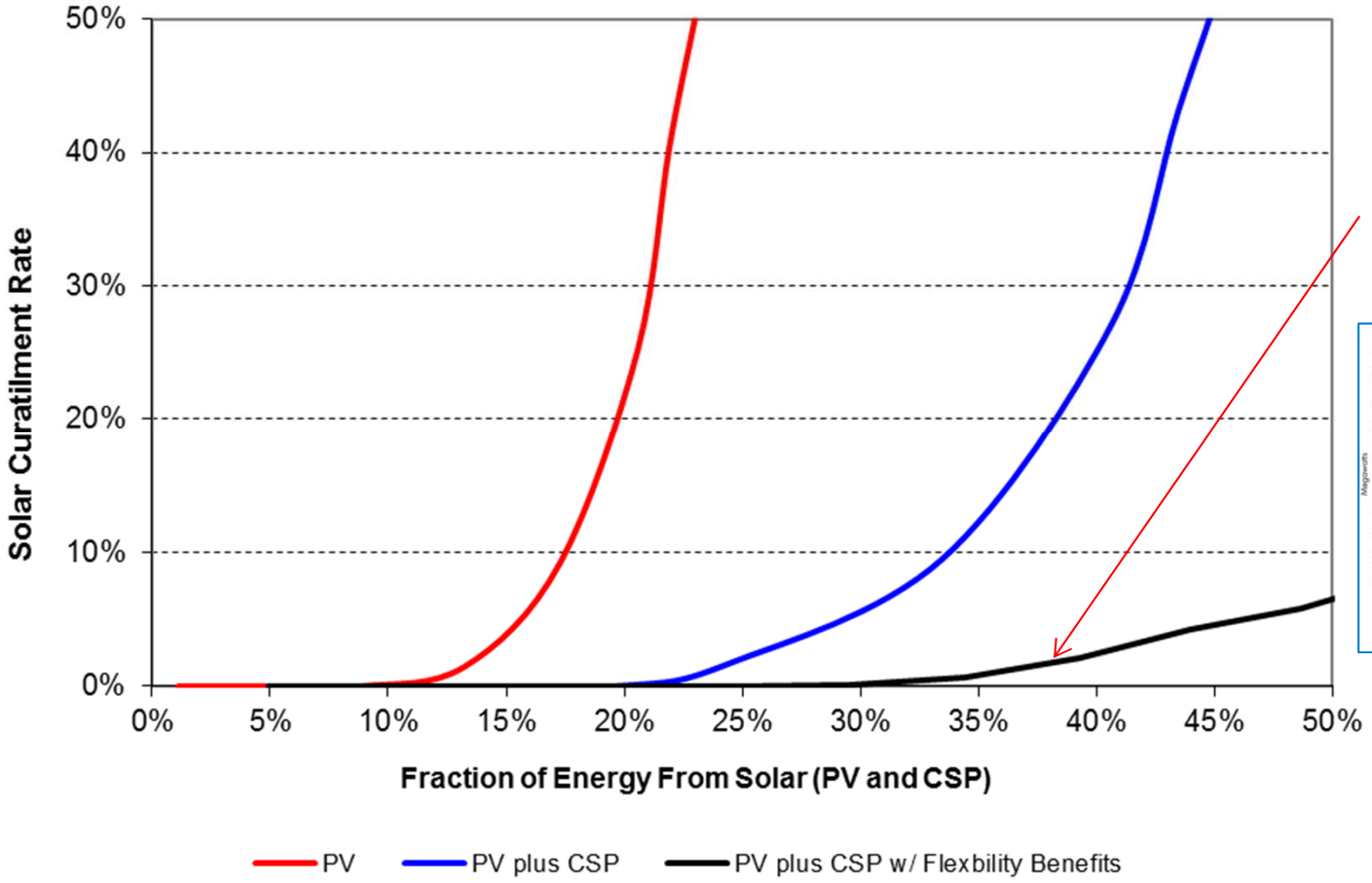
≈ 5% average curtailment at 20% penetration

Marginal curtailment of solar assuming equal energy mix of PV and CSP

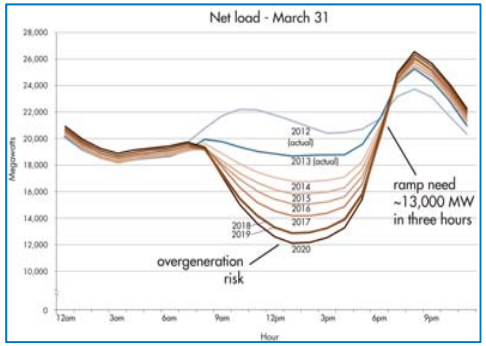


No curtailment at 20% Solar Penetration

Marginal curtailment of solar assuming equal energy mix of PV and CSP and additional CSP grid flexibility



Low curtailment at 30% solar penetration



Summary

- CSP with dispatchable thermal energy storage provides and maintains both operational benefits (fuel and emissions) and capacity (reliability) benefits to regional grids.
- This is especially true at high penetrations of variable renewable technologies such as PV and wind.
- CSP can support additional generation of variable technologies due to its flexibility relative to inflexible baseload coal generation.

Thank you!

For more information:

http://www.nrel.gov/csp/

Mark Mehos
USA 303-384-7458
mark.mehos@nrel.gov