Concentrating on the Future: The Benefits of Large-Scale Solar Electric Technologies

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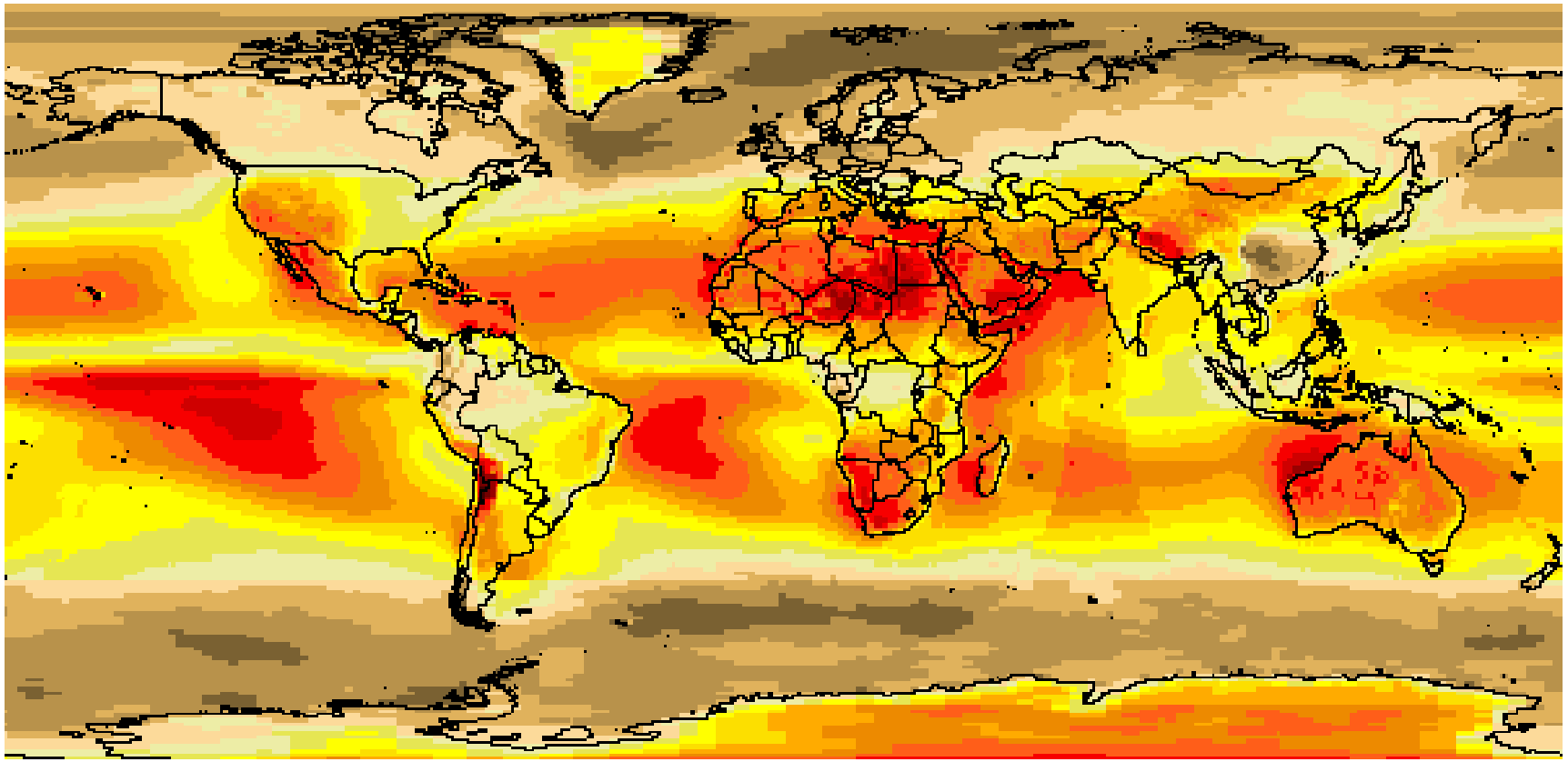
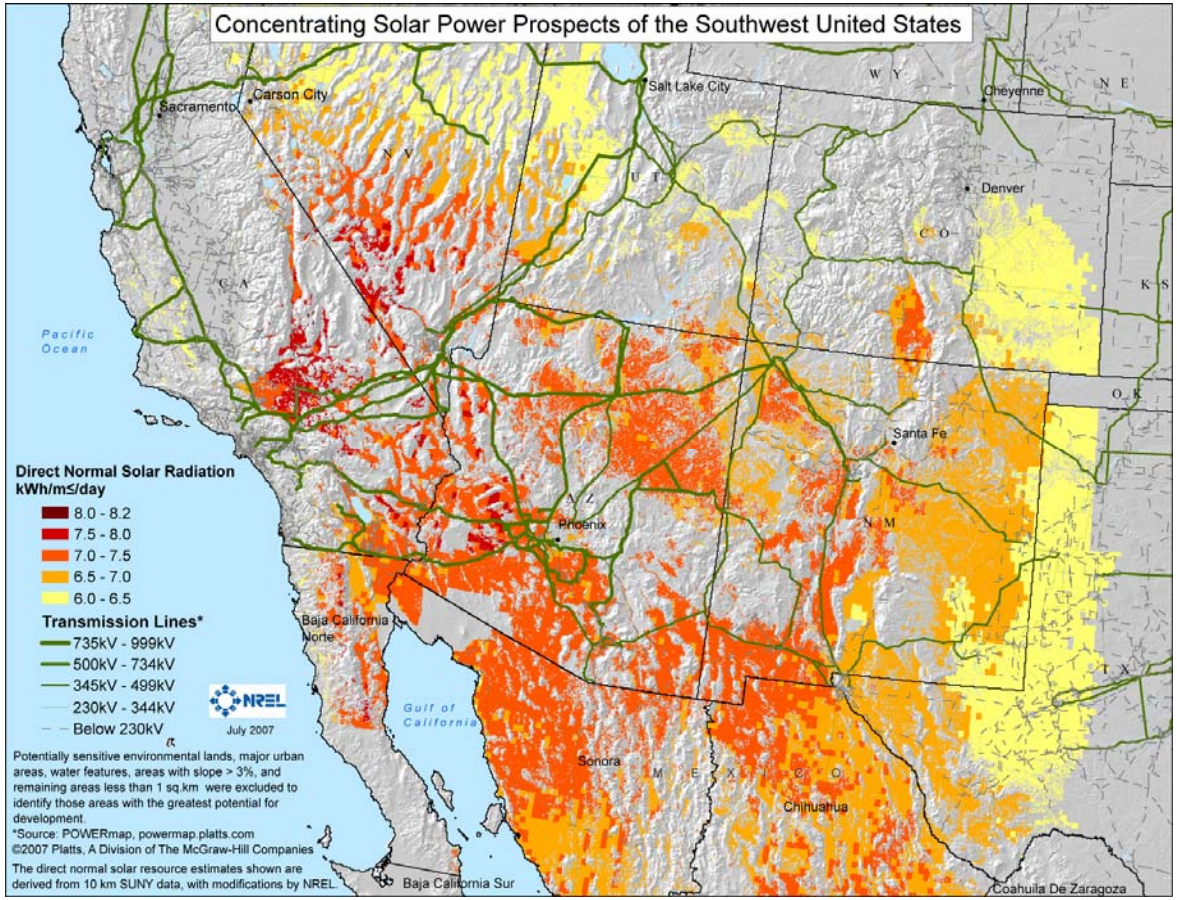
Sunlight: 70 Minutes = 1 Year of Global Energy Consumption



Source: ***United Nations Environment Programme, Solar and Wind Resource Assessment, http://na.unep.net/swera_ims/map/.***

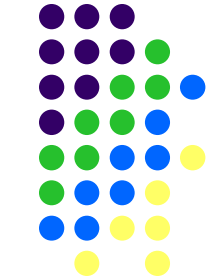
U.S. Southwest is Rich in Solar Resource: Direct and Diffuse

Annual Average Direct Normal Insolation, Land with ≤3% Slope



Source: ***National Renewable Energy Laboratory***

Major Large-Scale Solar Power ("LSSP") Technology Types



- *Thermal Electric Systems*
  - Combine Heat Transfer Fluid ("HTF") + engine to generate AC electricity
    - Parabolic trough systems *
    - Dish/engine systems
    - Solar power tower systems *
    - Compact linear Fresnel systems *
- *Photovoltaic Systems*
  - Generate DC electricity directly
    - Concentrating photovoltaic ("PV") systems
    - Large-scale (non-concentrating) PV systems.

* Indicates Thermal Energy Storage ("TES") Commercially Available

Thermal Electric Systems: Parabolic Troughs

- Uses DNI only; concentration ratio = 80
- HTF = Synthetic oil, water/steam, or molten salt.; 736-1022ºF (391-550ºC)
- Installed on N-W axis; tracking is E-W
- 13-15% annual solar-to-electric efficiency
- 25.9% solar-only annual capacity factor; 41.04% with TES

Kramer Junction, California
Source: ***National Renewable Energy Laboratory***

Thermal Electric Systems: Dish/Engine Systems

- Uses DNI only; concentration ratio = 500-1500
- HTF = Hydrogen or helium gas; 1472ºF (800ºC)
- 2-axis tracking
- 22% annual solar-to-electric efficiency
- 24+% solar-only annual capacity factor; TES under development

Source: ***Sandia National Laboratories***

Thermal Electric Systems: Compact Linear Fresnel

- Uses DNI only; concentration ratio ≤ 80
- HTF = Water or oil; 545ºF (285ºC)
- 1-axis tracking
- 12-14% annual solar-to-electric efficiency
- 24% solar-only annual capacity factor; 40% with TES

Kimberlina, California **Source: *Ausra, Inc.***

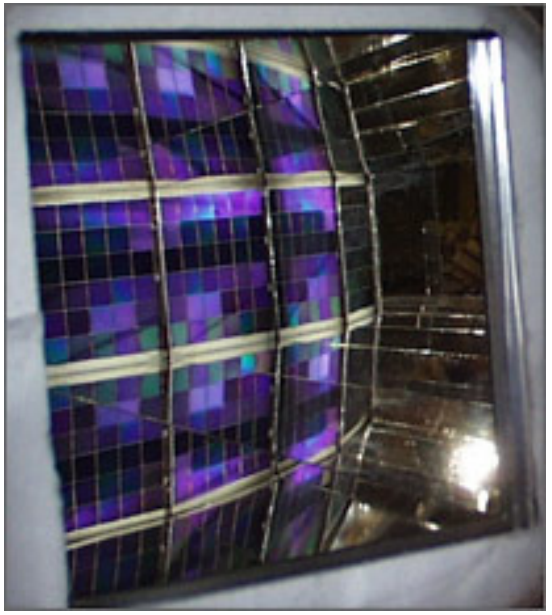
Thermal Electric Systems: Solar Power Tower Systems

- Uses DNI only; concentration ratio = 500-1500
- HTF = Water or molten salt; 1050ºF (565ºC)
- 2-axis tracking
- 17% annual solar-to-electric efficiency
- 20% solar-only annual capacity factor; ~41% with TES

10 MW Solar Two Project, Daggett, California
Source: ***Sandia National Laboratories***

Photovoltaic Systems: Concentrating PV

- Uses DNI only; 100-1000 concentration ratio
- Directly generates DC electricity
- 1-axis tracking
- 20-26% annual solar-to-electric efficiency
- 22.22% solar-only annual capacity factor



Source: ***National Renewable Energy Laboratory***

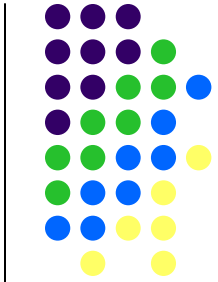
Photovoltaic Systems: Non-Concentrating PV

- Utilizes both DNI and diffuse sunlight
- Typically non-tracking
- 15-17% annual solar-to-electric efficiency
- 22-24% annual capacity factor

15 MW PV, Nellis Air Force Base, Nevada
Source: ***Sunpower Corp.***

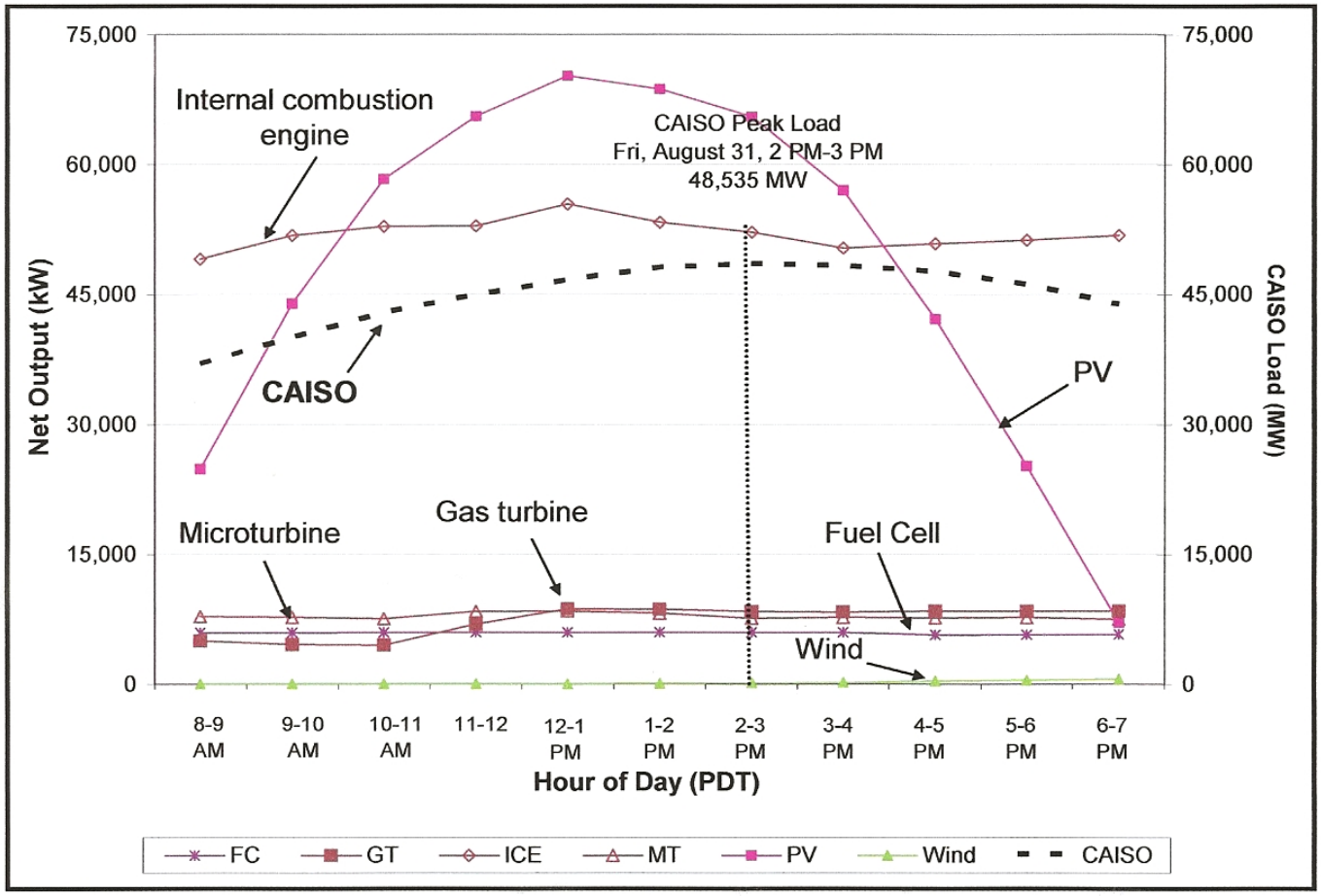
10 MW Thin Film Project, El Dorado, Nevada
Source: ***First Solar***

Value Proposition Depends On:



- Avoided Generator Technology
  - Natural gas-fired peaking generator
  - Natural gas-fired combined cycle plant
- Location
  - Available solar resource
    - California-specific analysis
  - Location of LSSP within the electric grid
    - At transmission level, at distribution level, or on-site
- LSSP Technology and Operating Characteristics
  - Solar-only generation
  - Integrated TES
  - Hybridization with natural gas
- Timing of Solar-Generated Power vs. Peak Demand
  - Effective Load Carrying Capability (“ELCC”)

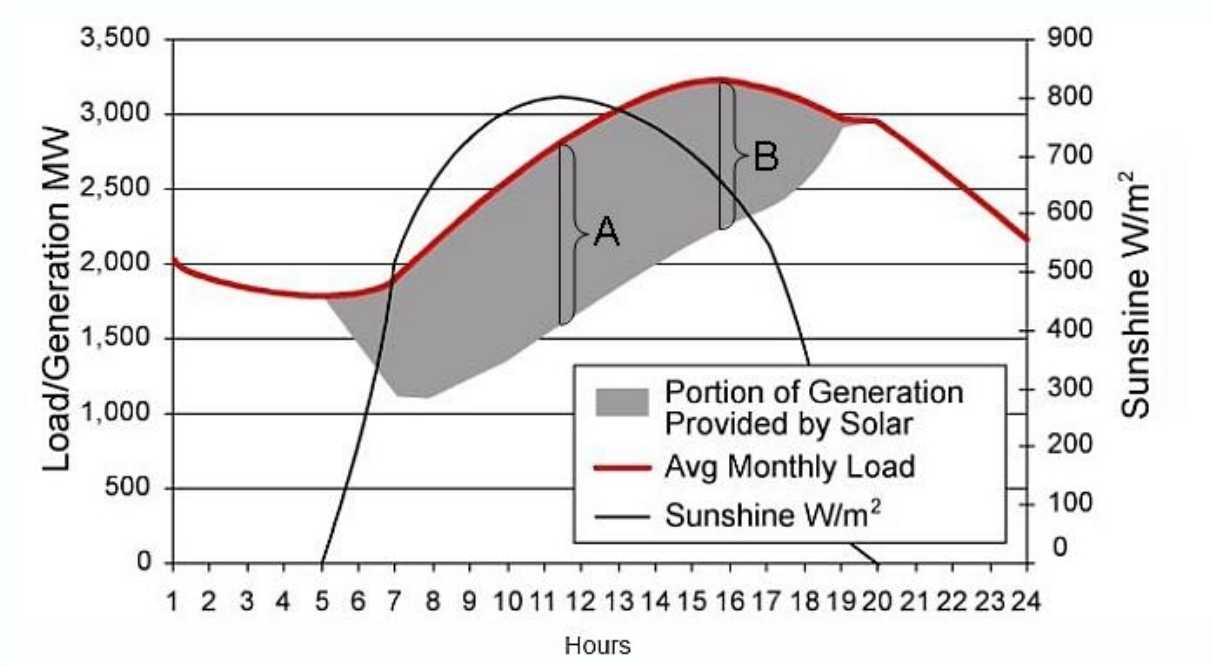
Solar-Only Generation Peaks Earlier than California Demand



Source: Itron, *CPUC Self-Generation Incentive Program Seventh-Year Impact Evaluation Final Report*, September 2008; data for 2007.

ELCC of Solar-Only Generation <100% at System Peak

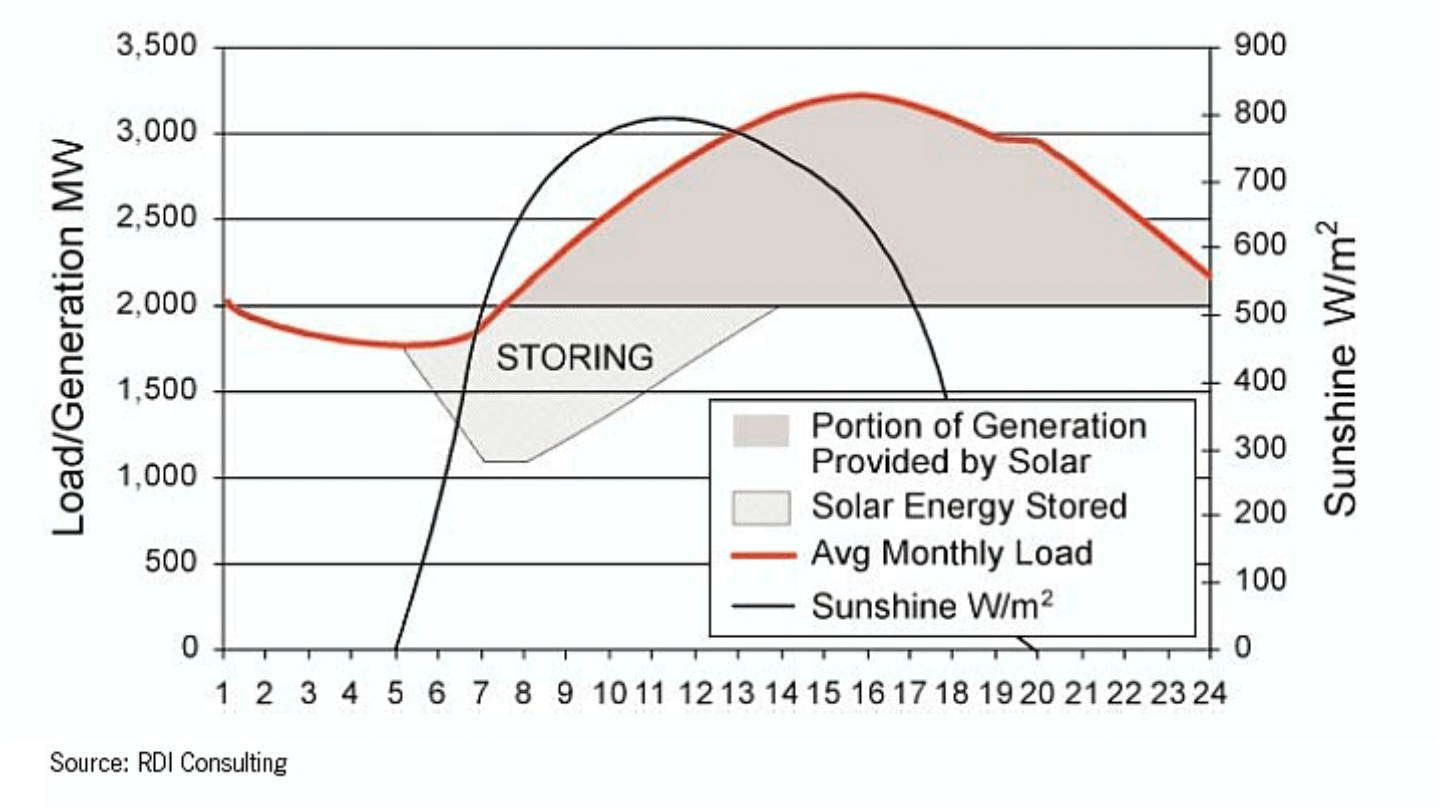
- How much less depends on timing of system peak (e.g., NV peak load is later than CA)



Source: RDI Consulting (With added peak MW metrics.)

Source: National Renewable Energy Laboratory, *Fuel from the Sky: Solar Power's Potential for Western Energy Supply*, NREL/SR-550-32160, p. 55.

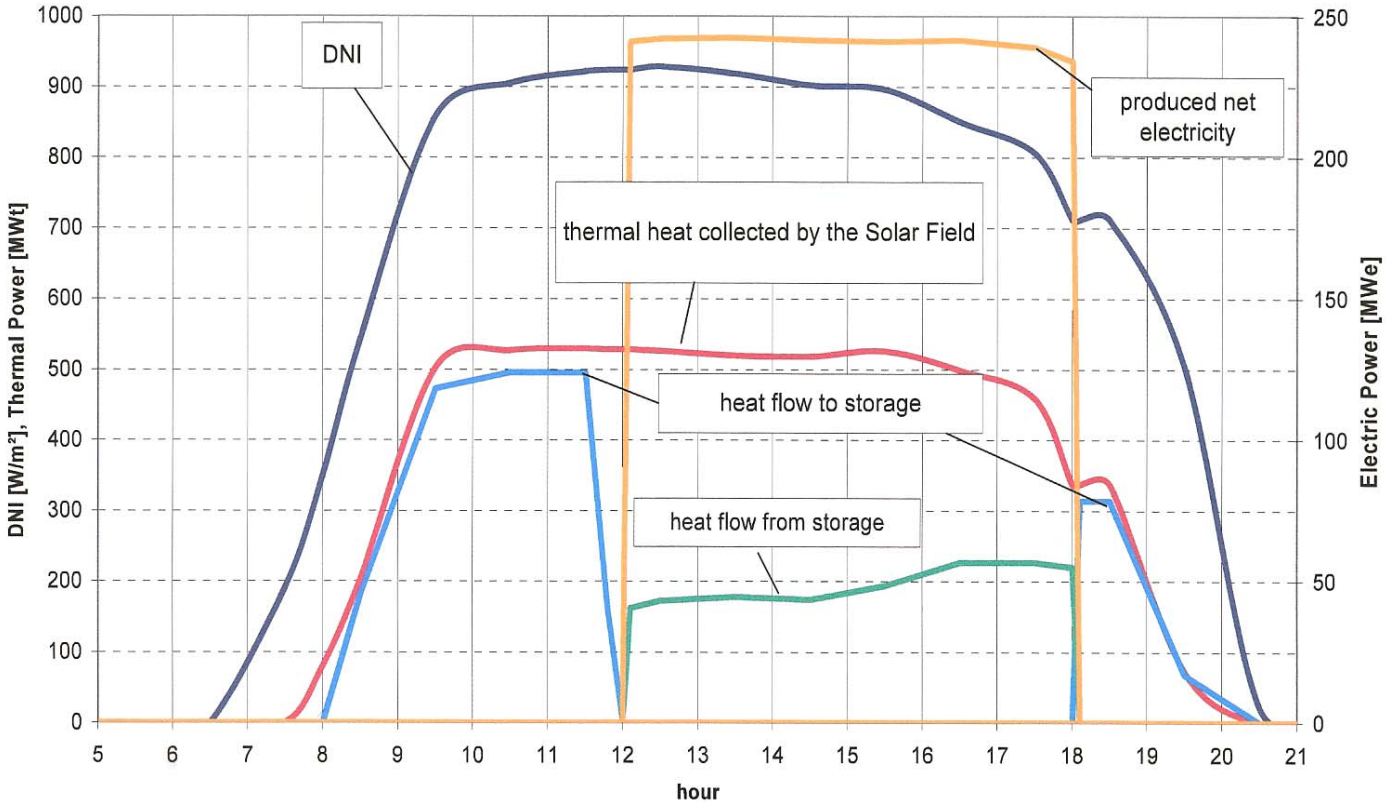
TES Allows Dispatch of LSSP; Increases ELCC



Source: RDI Consulting

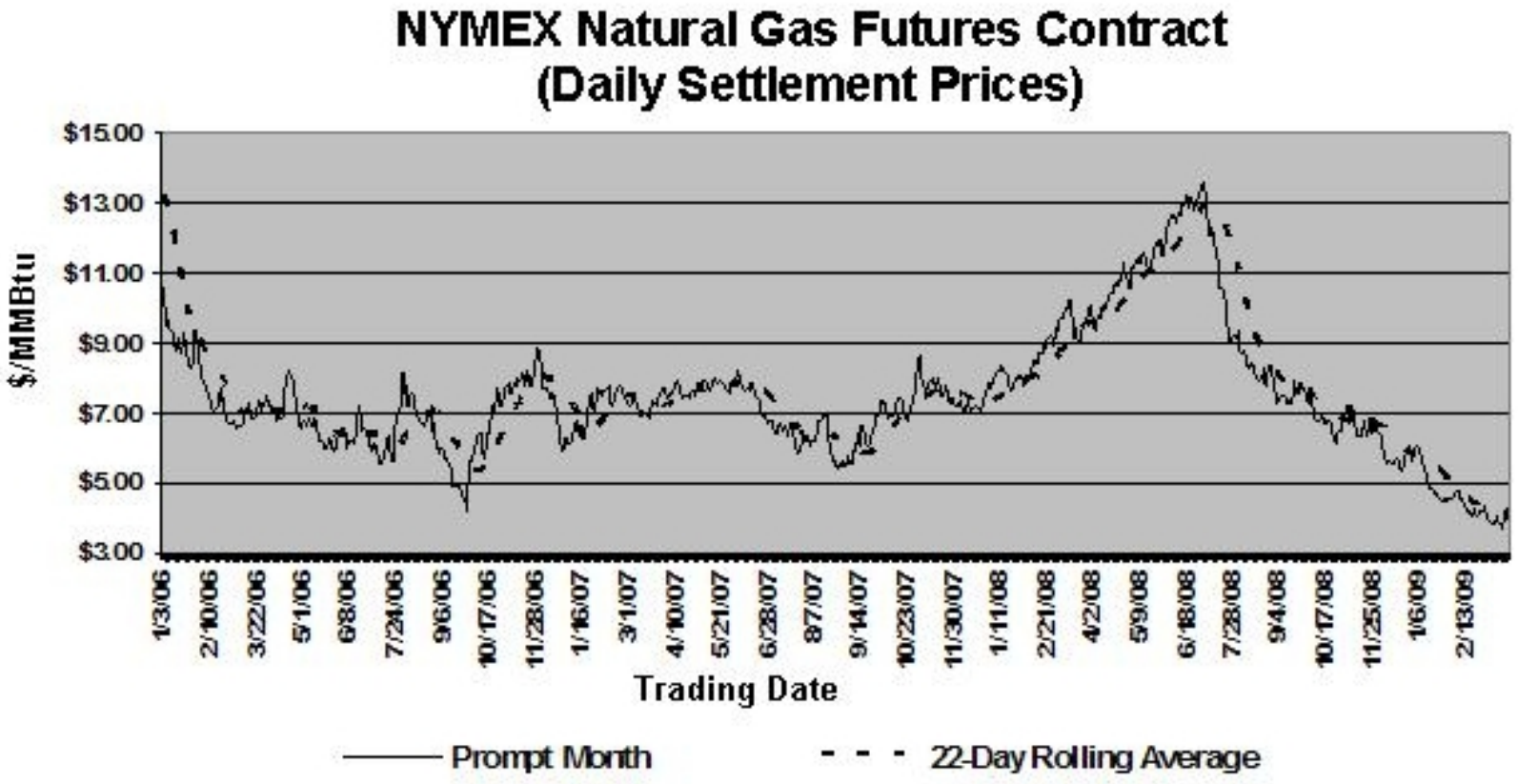
Source: National Renewable Energy Laboratory, *Fuel from the Sky: Solar Power's Potential for Western Energy Supply*, NREL/SR-550-32160, p. 56.

Alternative Use of TES Increases Peak Generation



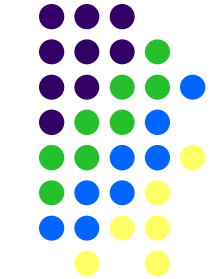
Source: Aringhoff, Rainer, Presentation to IEA Solar PACES, 14th Biennial Concentrating Solar Power Symposium, Las Vegas, NV, March 5, 2008.

LSSP Provides Hedge Against Natural Gas Price Volatility



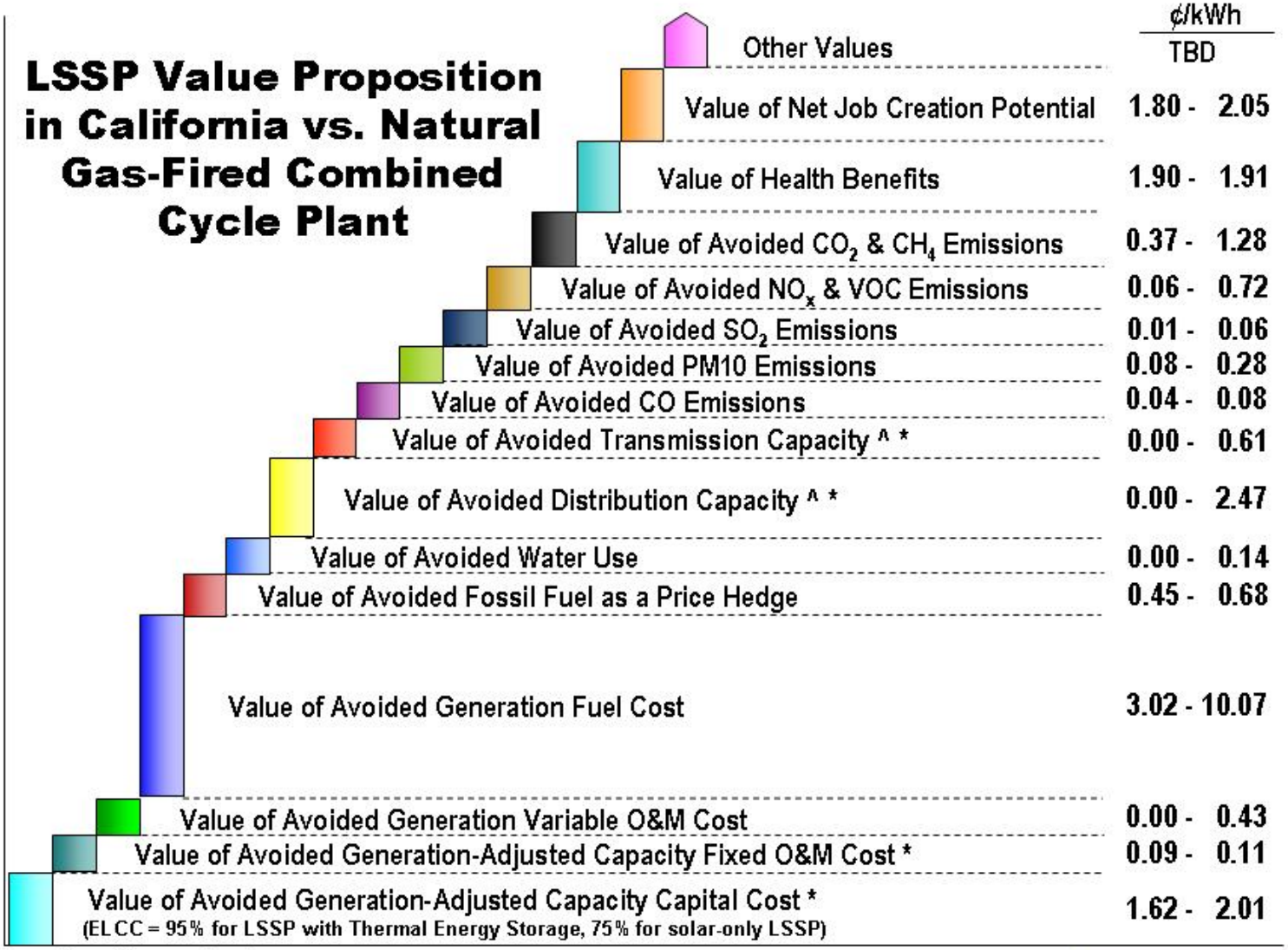
Data Source: New York Mercantile Exchange

Avoided Emissions Contribute to AB32 Reduction Goals



- 2020: Projected 10,000 MW of LSSP installed capacity in California
  - Estimate derived from industry and literature
  - 2/3 thermal electric (50% with TES); 1/3 PV
- Could avoid 12.3-16.7 million metric tonnes of CO_2 emissions vs. natural gas-fired gen
  - 7-10% of AB32 goal of 172 million metric tonnes of reduced greenhouse gas emissions by 2020
  - LSSP not counted in initial AB32 measures

LSSP Value Proposition in California vs. Natural Gas-Fired Combined Cycle Plant

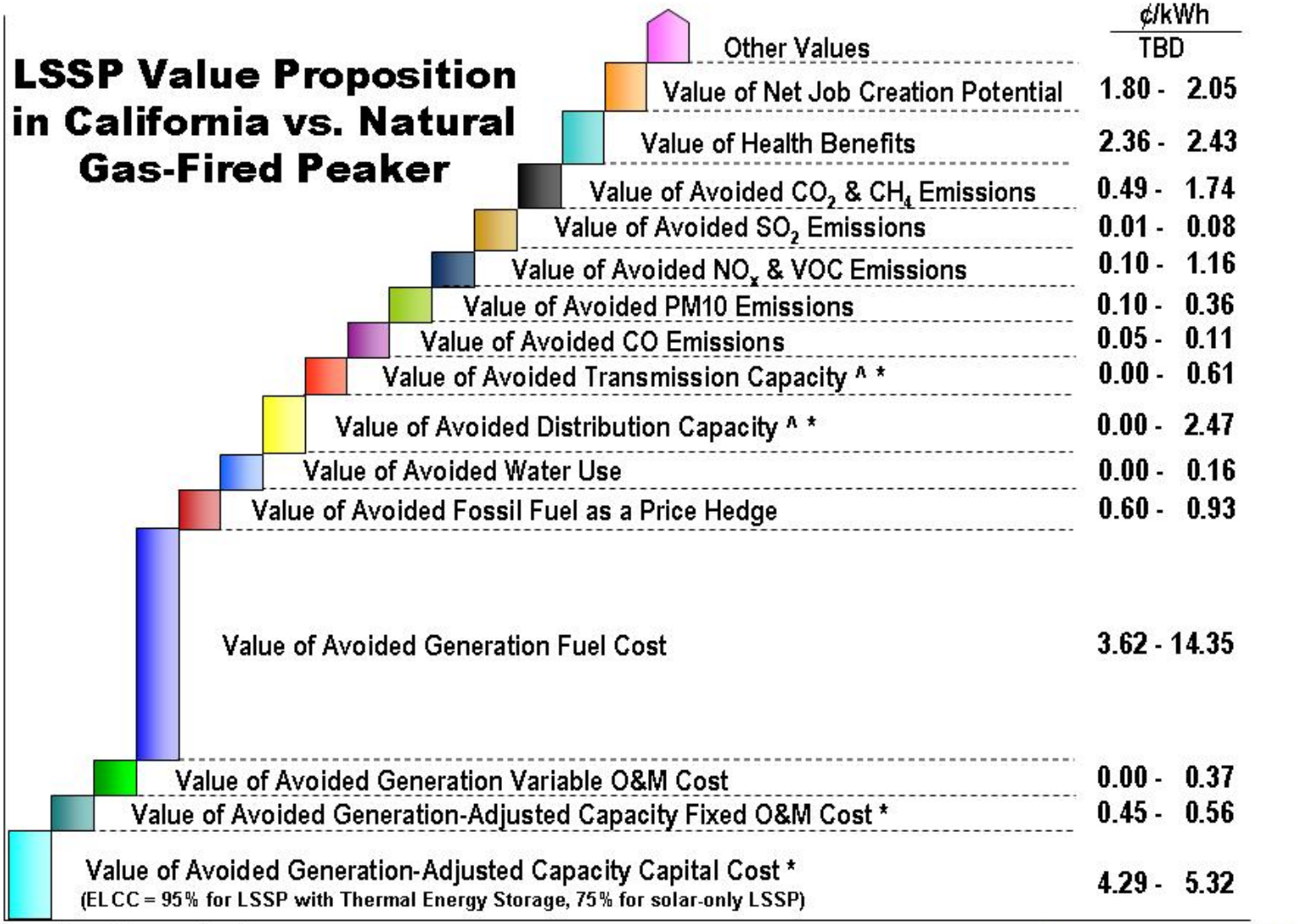


^ Location Dependent
* Impacted by Storage

TOTAL LSSP VALUE PROPOSITION: 9.4 – 22.9¢/kWh

4/21/2009 EF R7

LSSP Value Proposition in California vs. Natural Gas-Fired Peaker

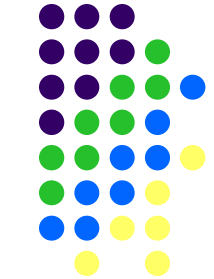


^ Location Dependent
* Impacted by Storage

TOTAL LSSP VALUE PROPOSITION: 13.9 – 32.7¢/kWh

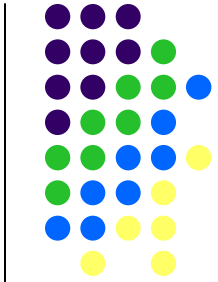
4/21/2009 EF R7

LSSP Hybridization with Natural Gas Systems



- Enhances dispatchability and firmness of solar-generated power
  - Increases ELCC
  - Increases ELCC-dependent value components
- Reduces benefits of other value components
  - Value of Avoided Generation Fuel
  - Value of Avoided Fossil Fuel as a Price Hedge
  - Value of Avoided Emissions
  - Value of Related Health Benefits

Acknowledgments



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  - Large-Scale Solar Association
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