Integrating Renewable Energy into the Power Grid

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Agenda

- California's Renewable Portfolio Standard Program
- Renewable energy sources
- Managing the electric power grid
- Challenges in integrating renewables into the grid
- Potential solutions
- The urban sustainability perspective

California's Renewable Portfolio Standard

2002: SB1078 establishes the RPS program, requiring 20% renewable energy by 2017

2003: Energy Action Plan I recommends accelerating the 20% deadline to 2010

2005: Energy Action Plan II recommends a further goal of 33% by 2020

2006: SB107 codifies the 20% by 2010 deadline into law

2008: Gov. Schwarzenegger issues Executive Order requiring 33% renewables by 2020

Renewables for Urban Sustainability

Distributed Solar

Small Hydro

Tide/Wave

Small Wind

Biomass

Geothermal

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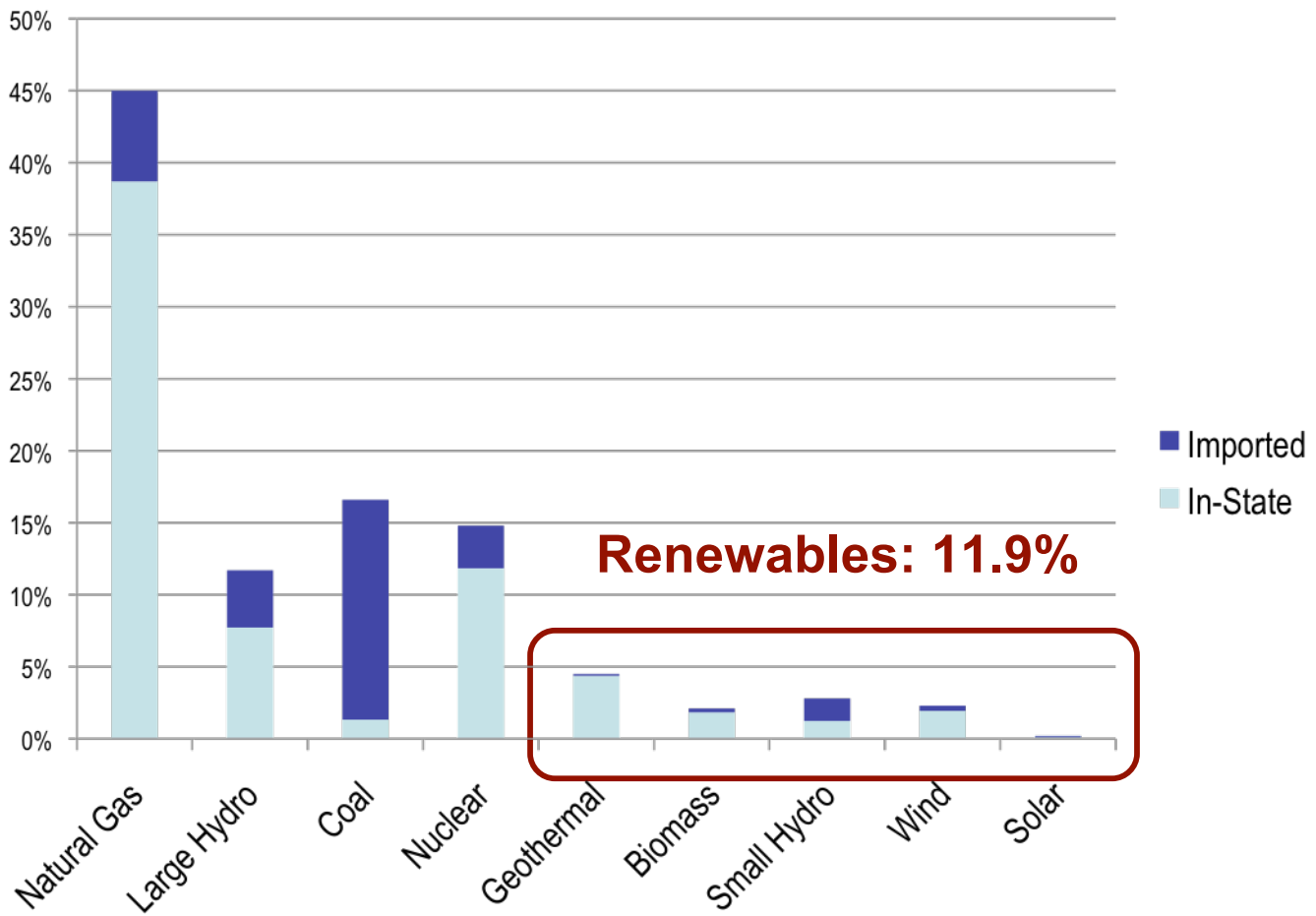
California Energy Sources - 2007



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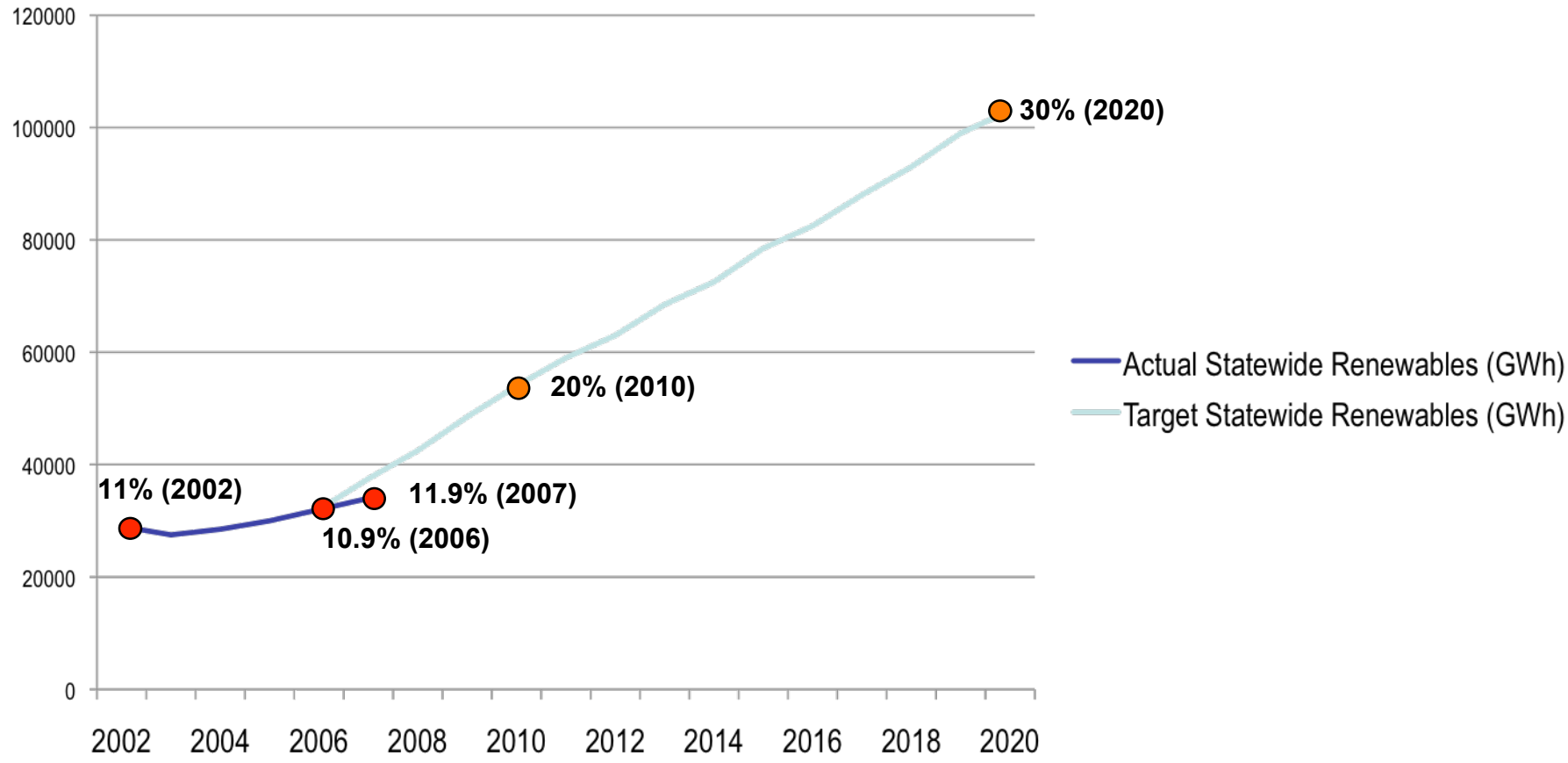
How Well is California Doing?



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Managing the Power Grid

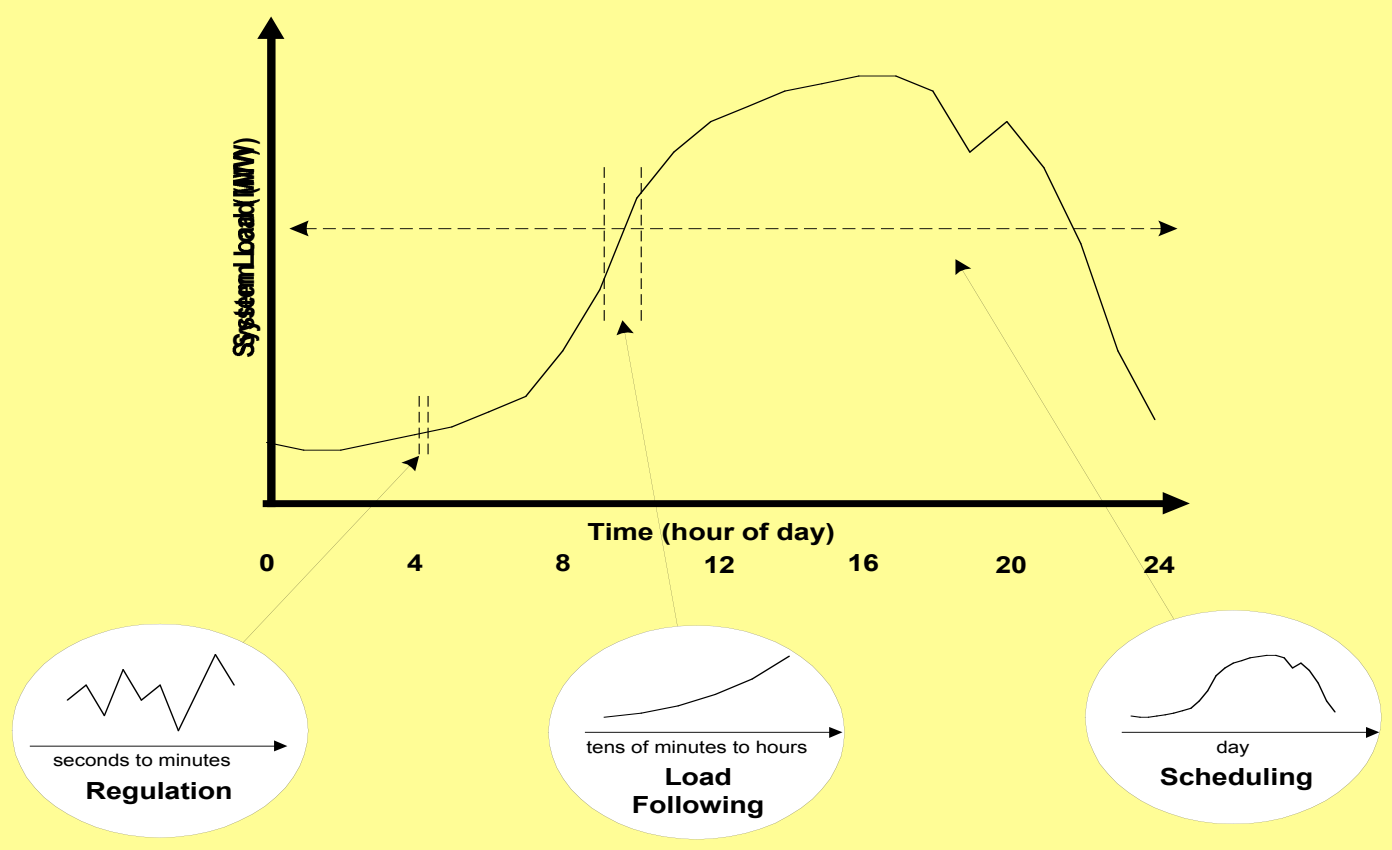
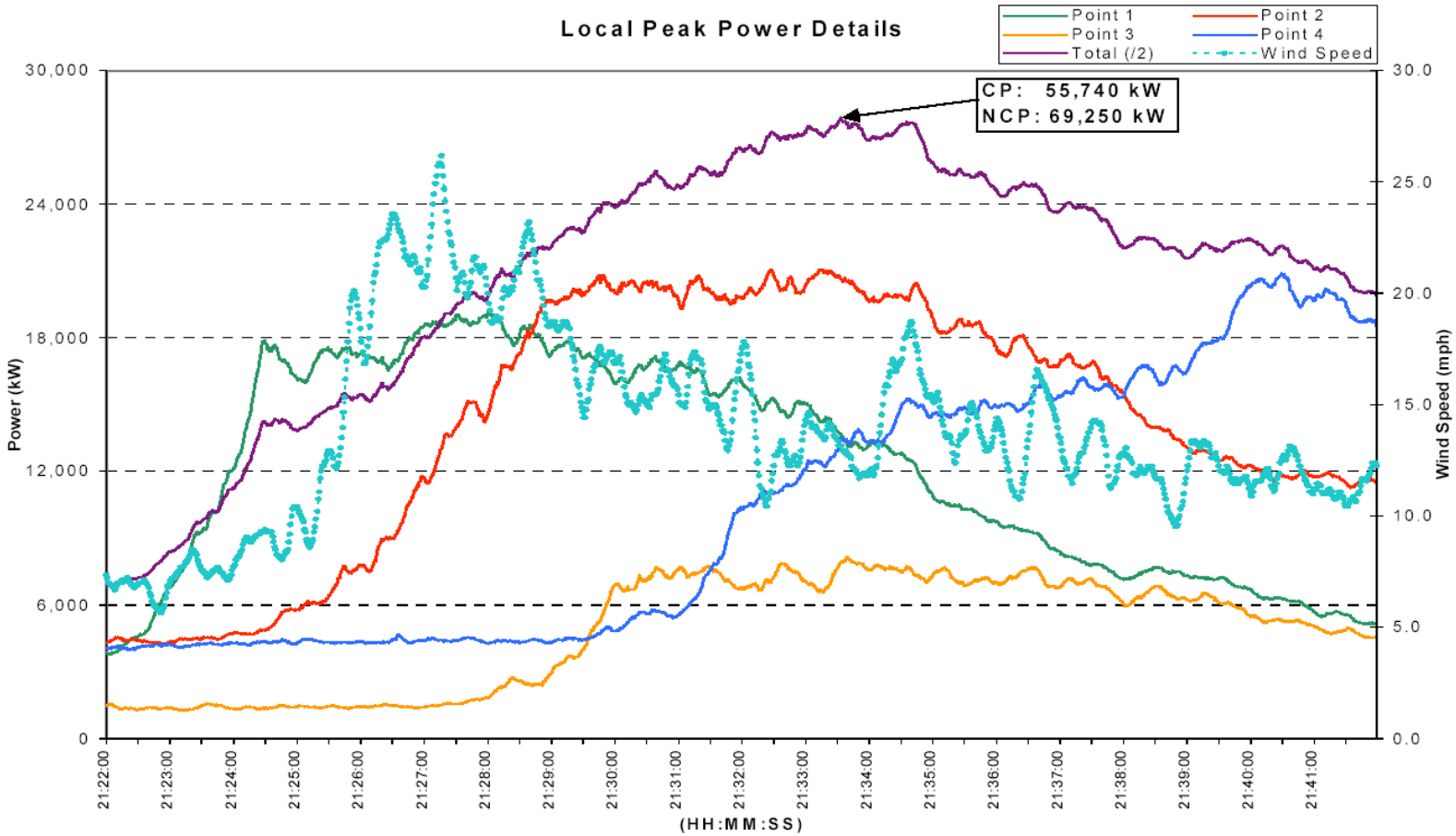


Chart from DeMeo and Milligan, NREL

Challenges: Variability



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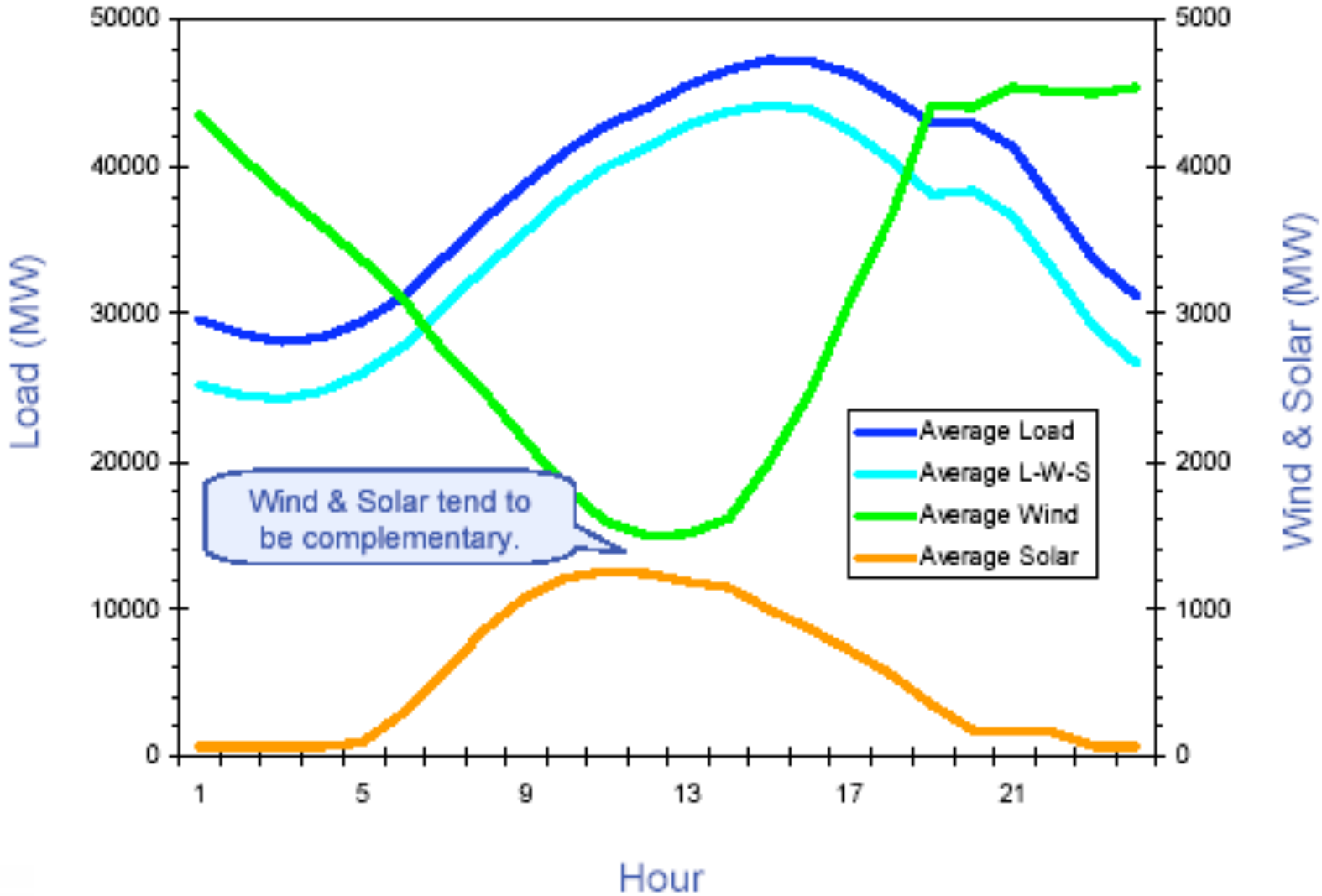
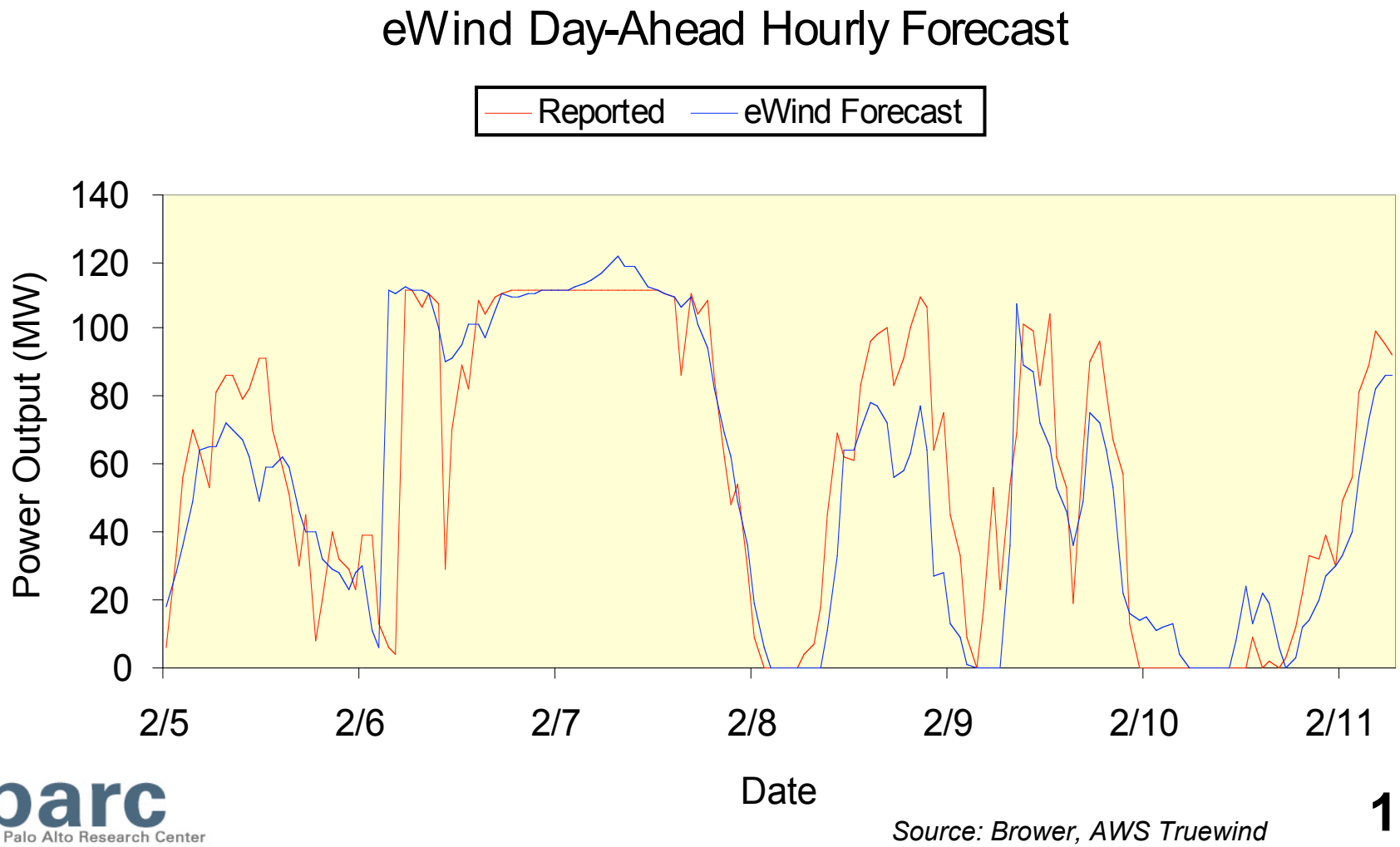
Source: Brower, AWS Truewind

Variability of Wind and Solar



Source: CEC PIER-funded study by GE Energy, July 2006

Challenges: Uncertainty



Source: Brower, AWS Truewind

Supply-Side Solutions:
Non-Renewables as Reserve

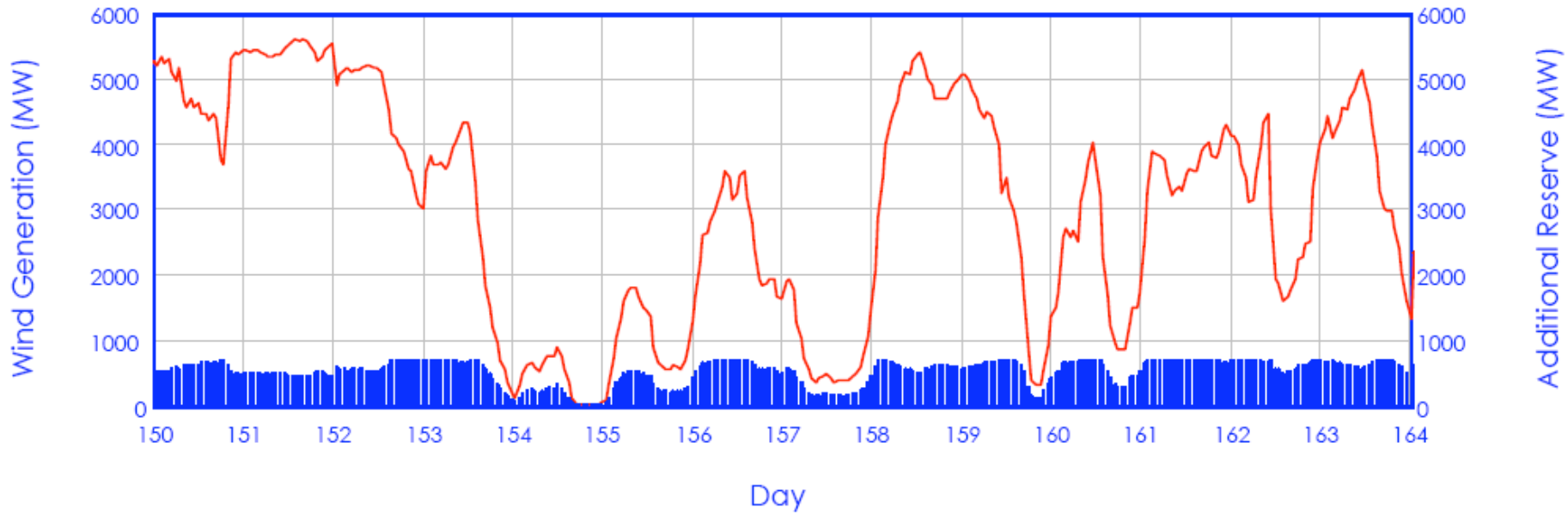


Figure 30: Illustration of time varying "operating reserve margin" developed from statistical analysis of hourly wind generation variations.

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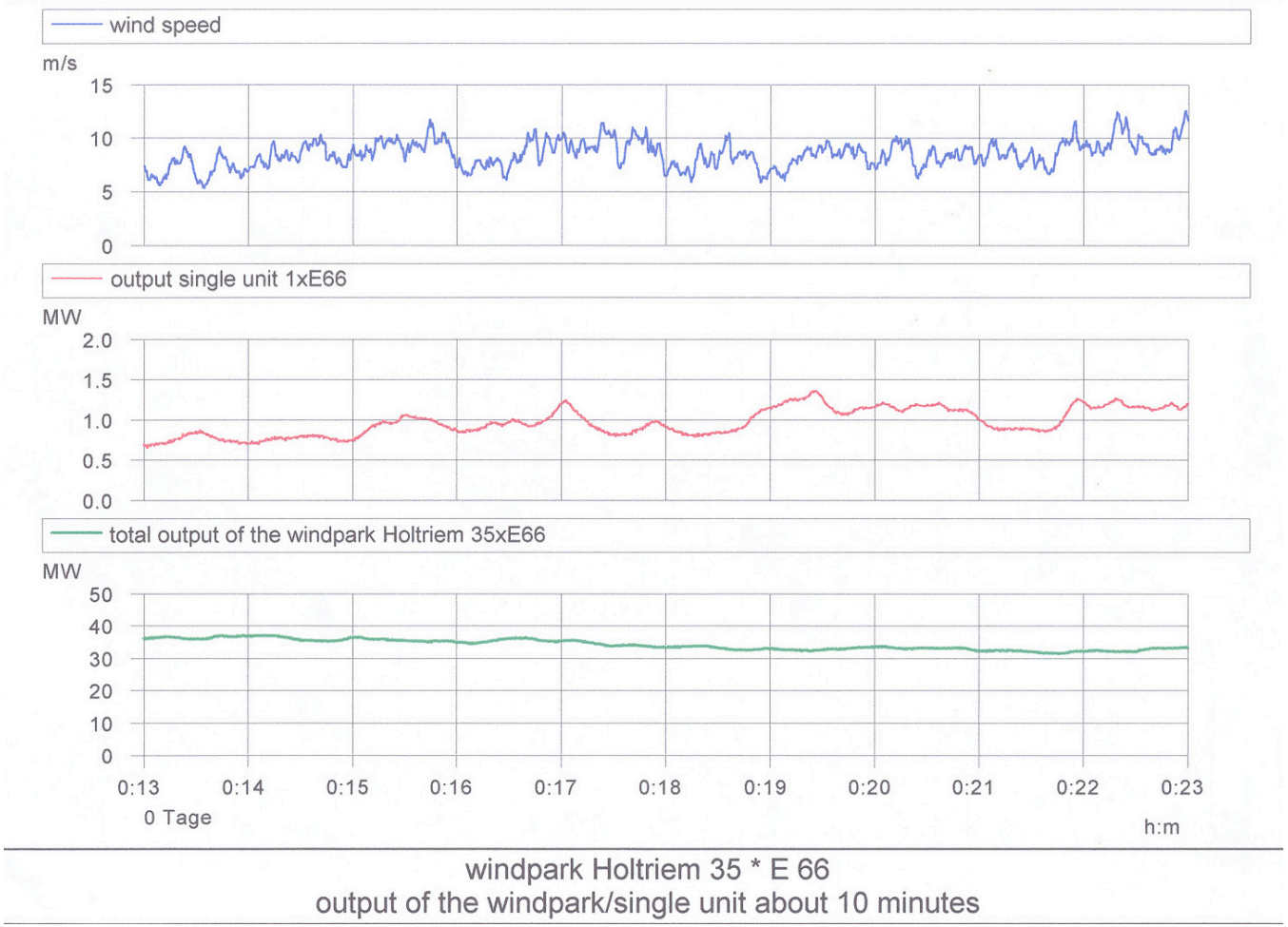
Source: Milligan, NREL

Supply-Side Solutions:
Spatial Diversity



Transmission capacity is the major bottleneck!

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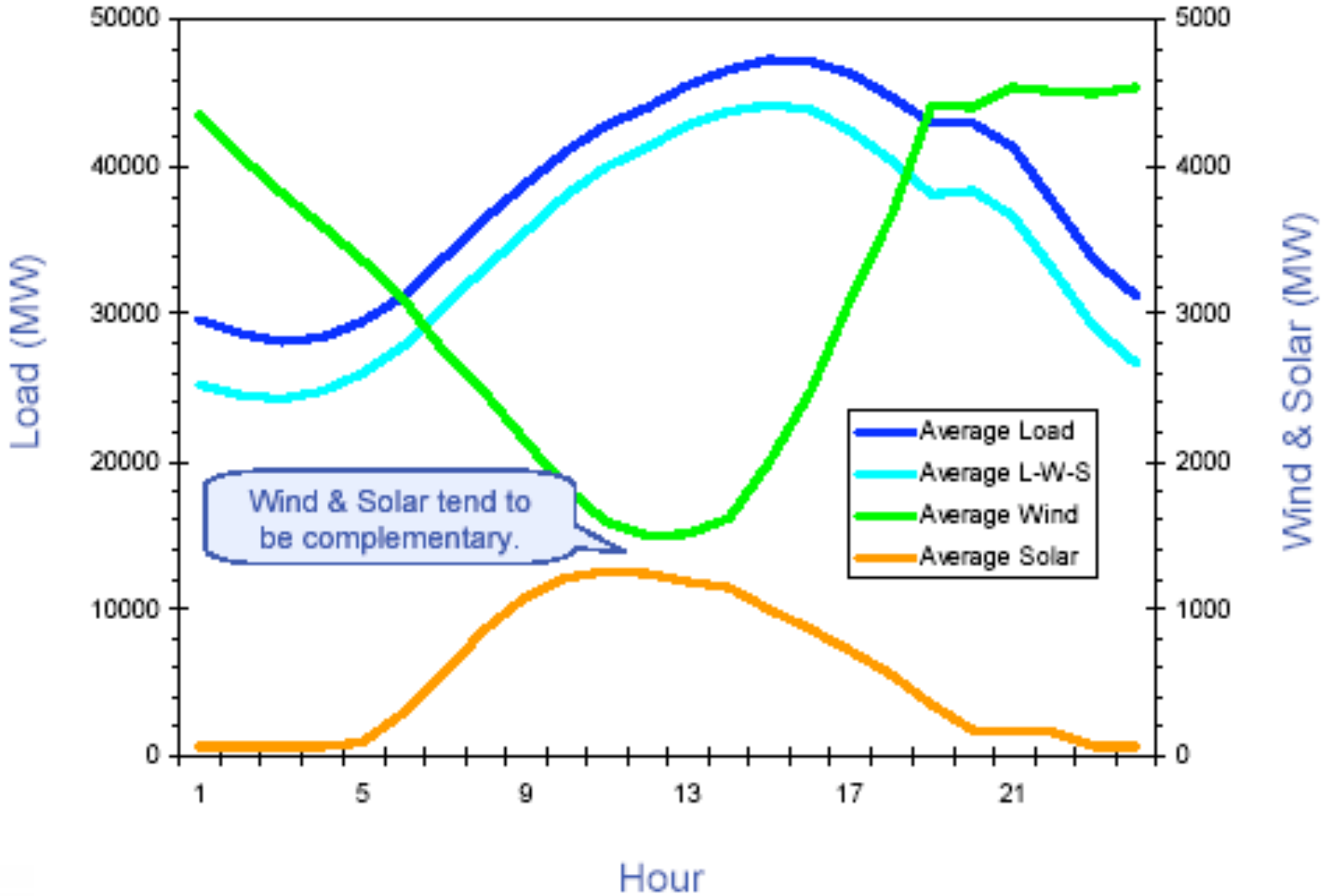
Source: Brower, AWS Truewind

Supply-Side Solutions:
Complementary Sources



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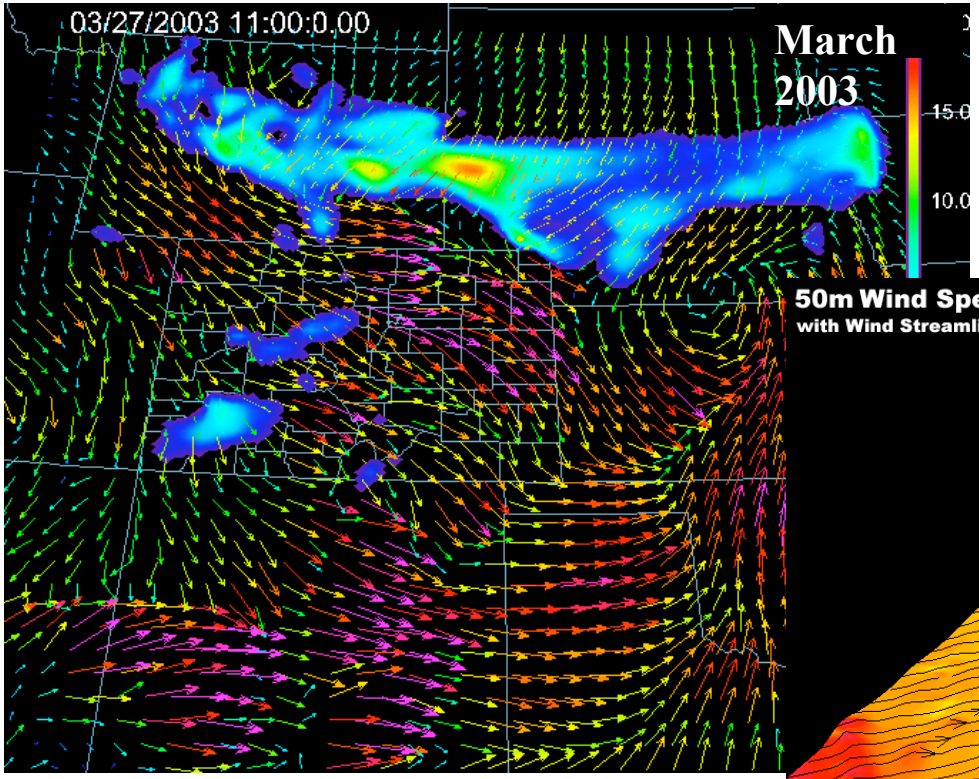
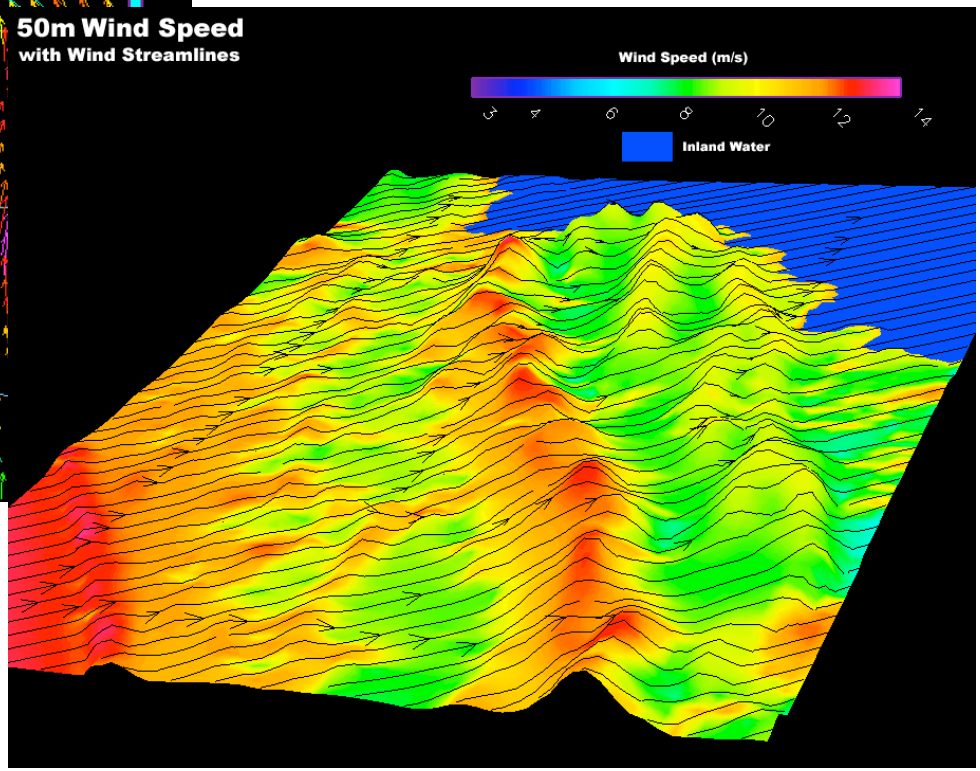
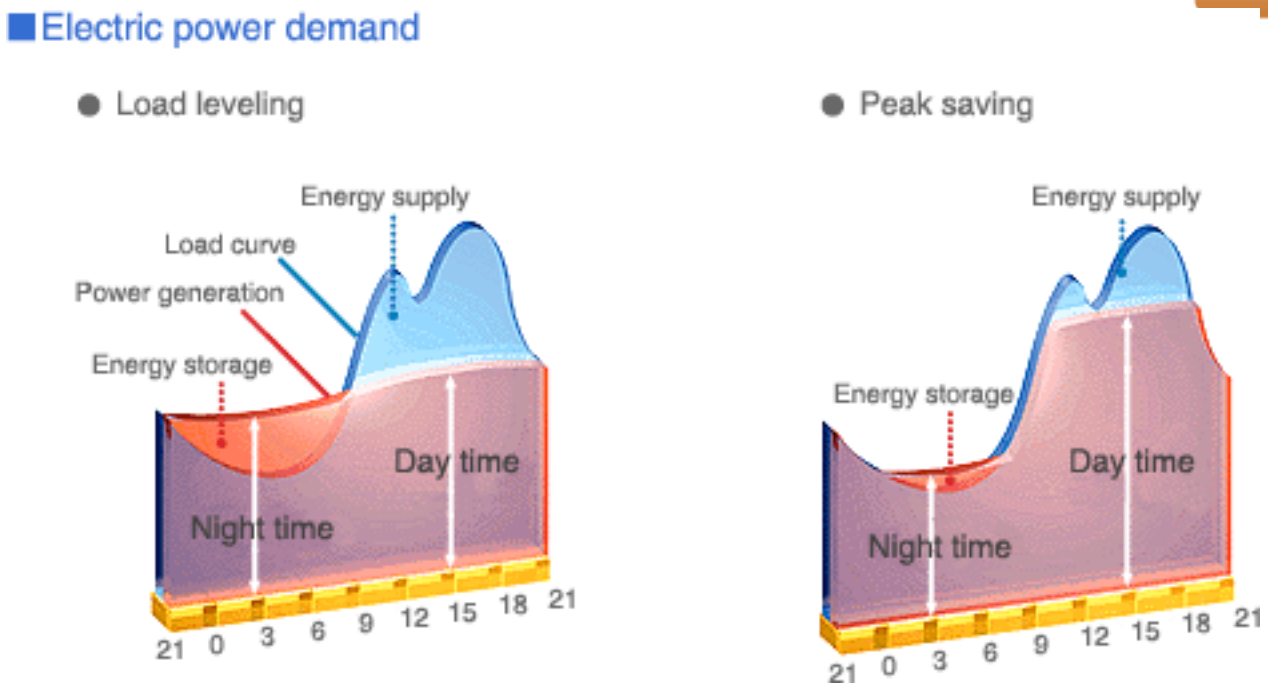
Supply-Side Solutions:
Better Forecasting





Source: Brohm, WindLogics

Supply-Side Solutions:
Storage



Source: NGK

Pumped Water Hydro

Flywheel Energy Storage

PHEVs (Chevy Volt, etc.)

Sodium Sulfur (NaS) batteries

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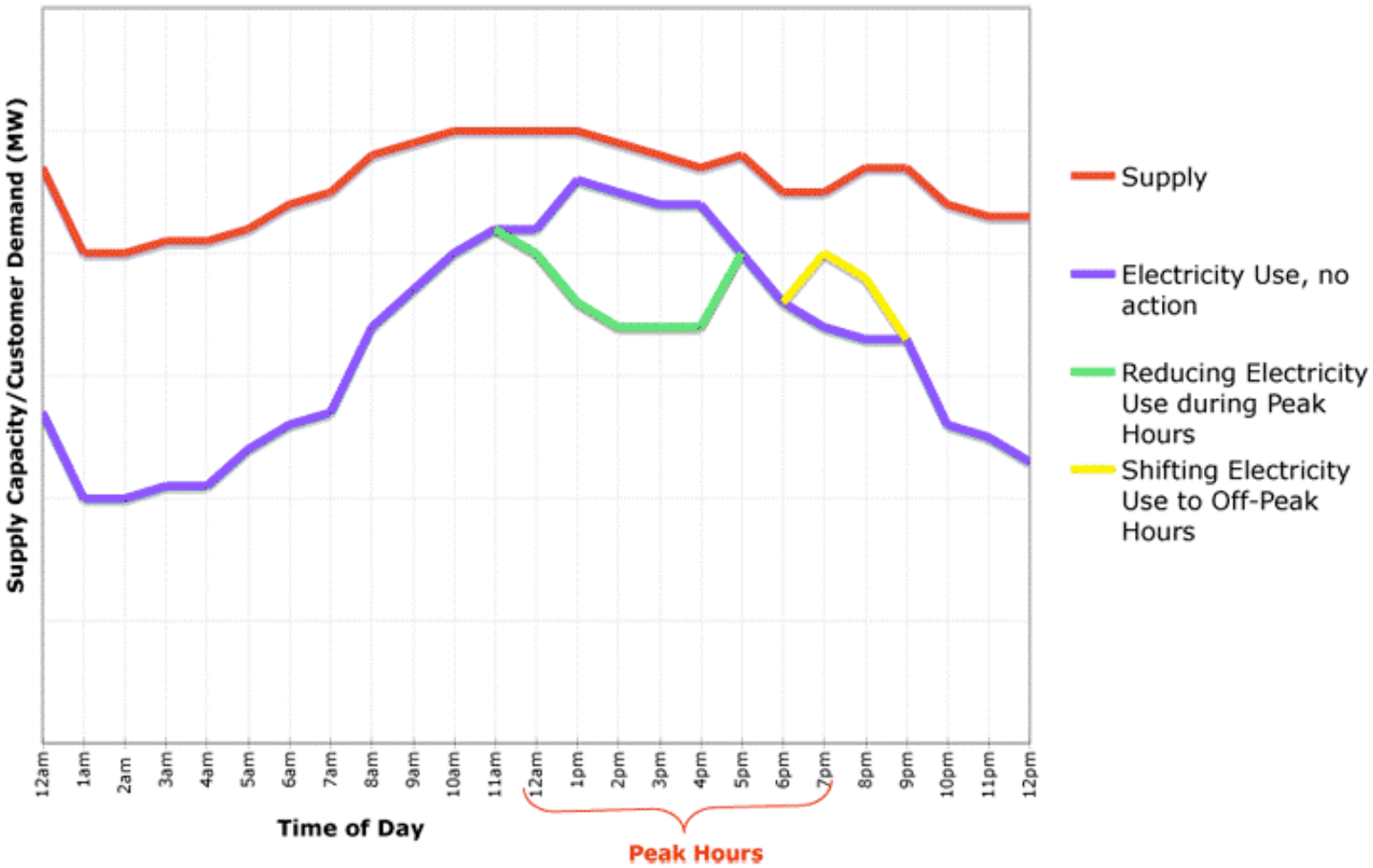
Demand-Side Solutions:
Time-Shifting Flex Loads



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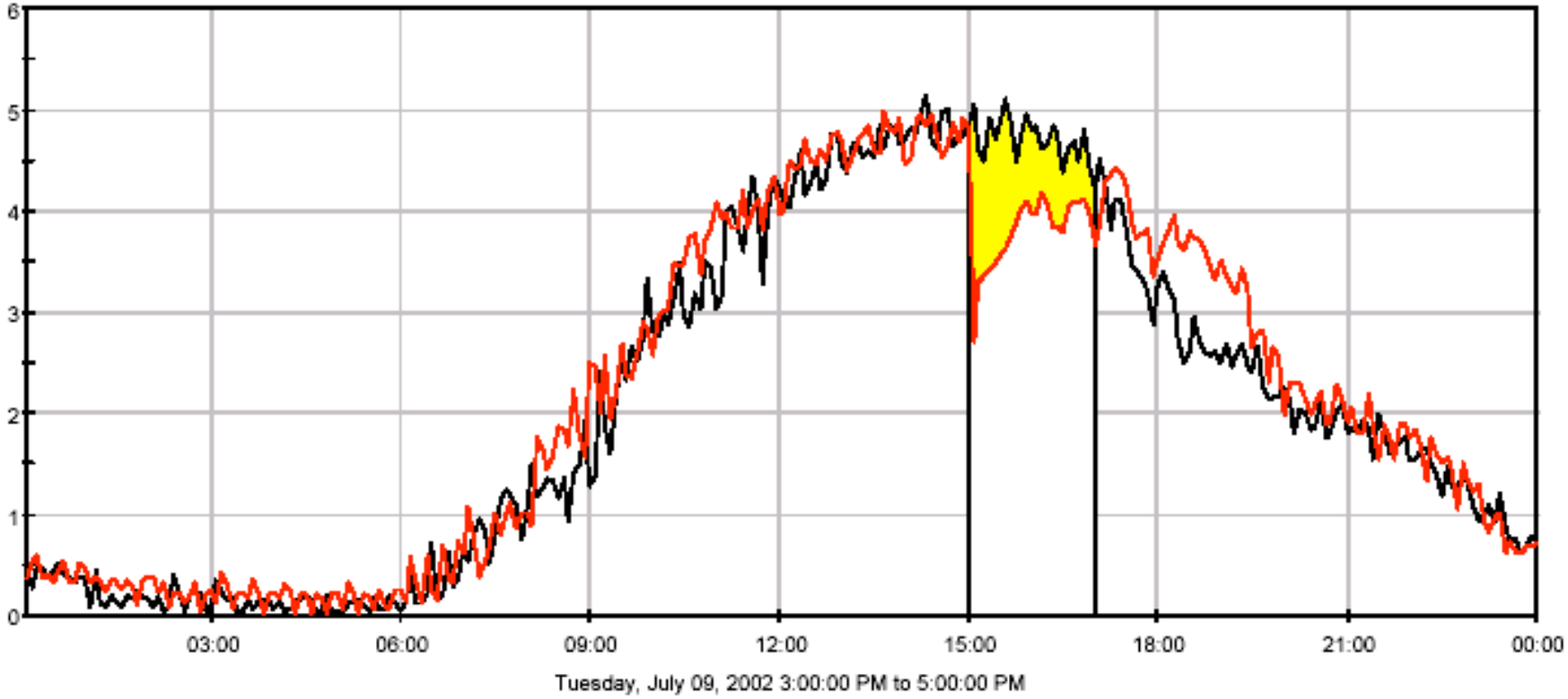
Demand-Side Solutions:
Demand Response

Example of Smart Thermostat Response for Small Commercial Customers. Thermostat Raised 4º F



Source: Program Impact Evaluation of the 2002 SCE Energy $mart Thermostat Program Final Report, RLW Analytics, 2/28/2003

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Urban Sustainability using Renewables

Supply Side

- **Local production**
  - Distributed Solar
  - Small Wind
  - Geothermal
  - Small Hydro
  - Biomass
- **Local storage**

Demand Side

- **Demand shaping**
- **Load shifting**
- **Demand response**
- **Local Power Markets**

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- Jan 29: Lonnie Jonson: thermoelectric engines
- Feb 5: Rosa Yang: environmental impact of cleantech
- Feb 19: Alex Rau: carbon cap and trade
- Feb 26: Arno Harris: Distributed solar
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