Cisco Smart Grid
The Challenge of Renewables

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Renewable Energy Resources

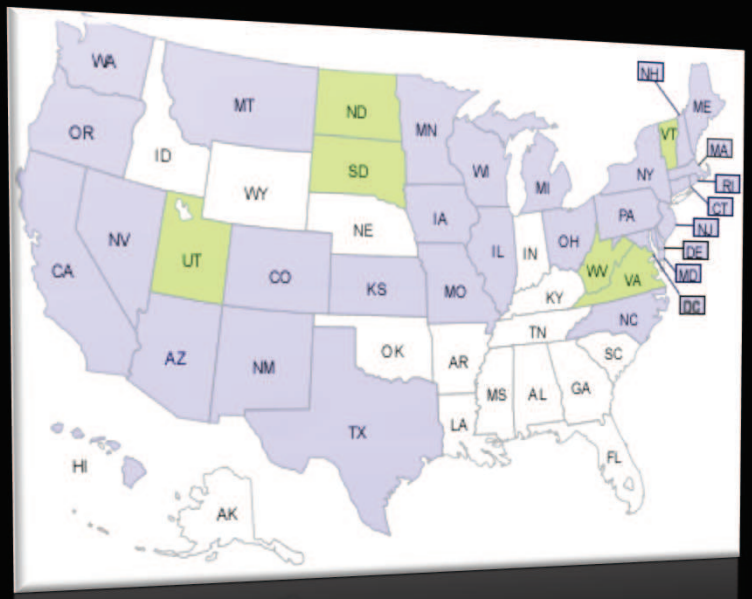
Renewable Challenges:
- Variability
- Dispatch and Balancing
- Power Quality

Managing Environmental Impacts

- Monitoring emissions
- Tracking renewable energy production
- Compliance with renewable portfolio standards
- Participate in CO2 Cap & Trade Markets

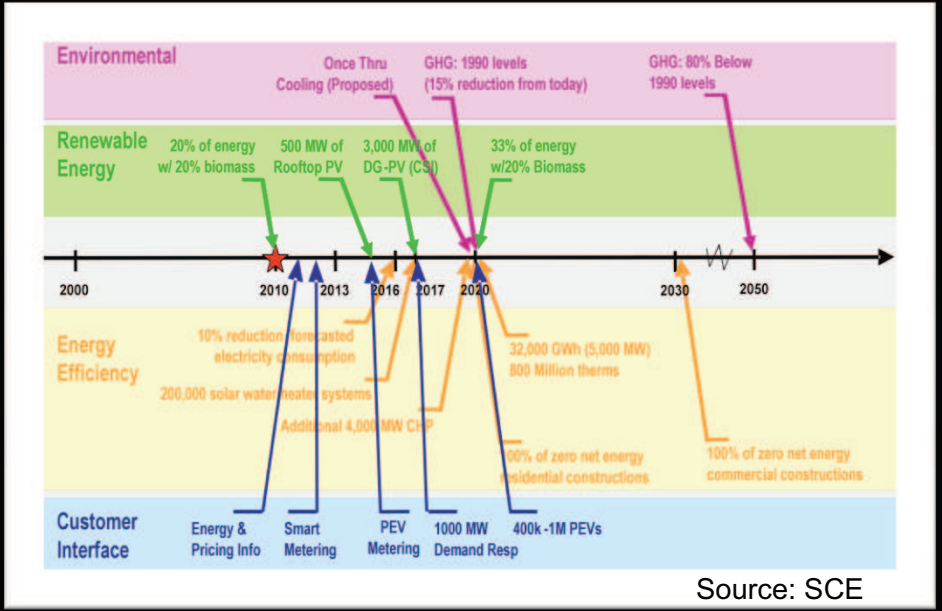
Environmental Policy Drivers

States are Moving Forward Irrespective of National Policy



35 States have either Renewable Portfolio Standard (RPS) or Renewable Portfolio Goal (RPG)

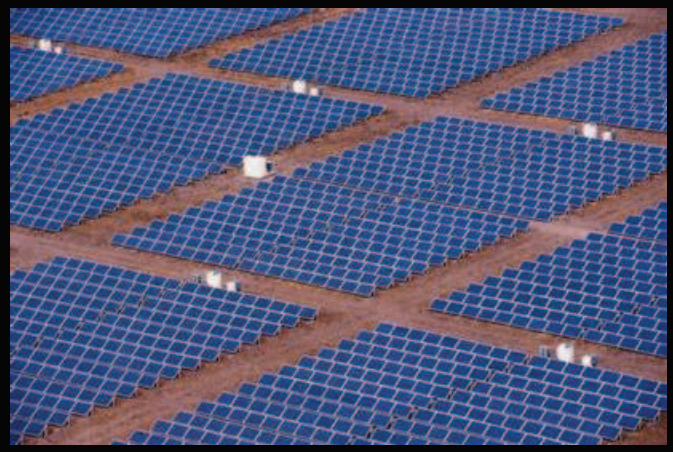
California policies are the most aggressive but many states incl Ohio have pursued similar broad policies



Source: SCE

Renewables Interconnect

- Transmission
  - Megawatts
  - SCADA control
  - Large scale storage
- Distribution
  - Fractional megawatts
  - Standby generation or Co-gen
- At the Premise
  - Kilowatts
  - No visibility, no control
  - Premise scale storage



Solar Parking Lot

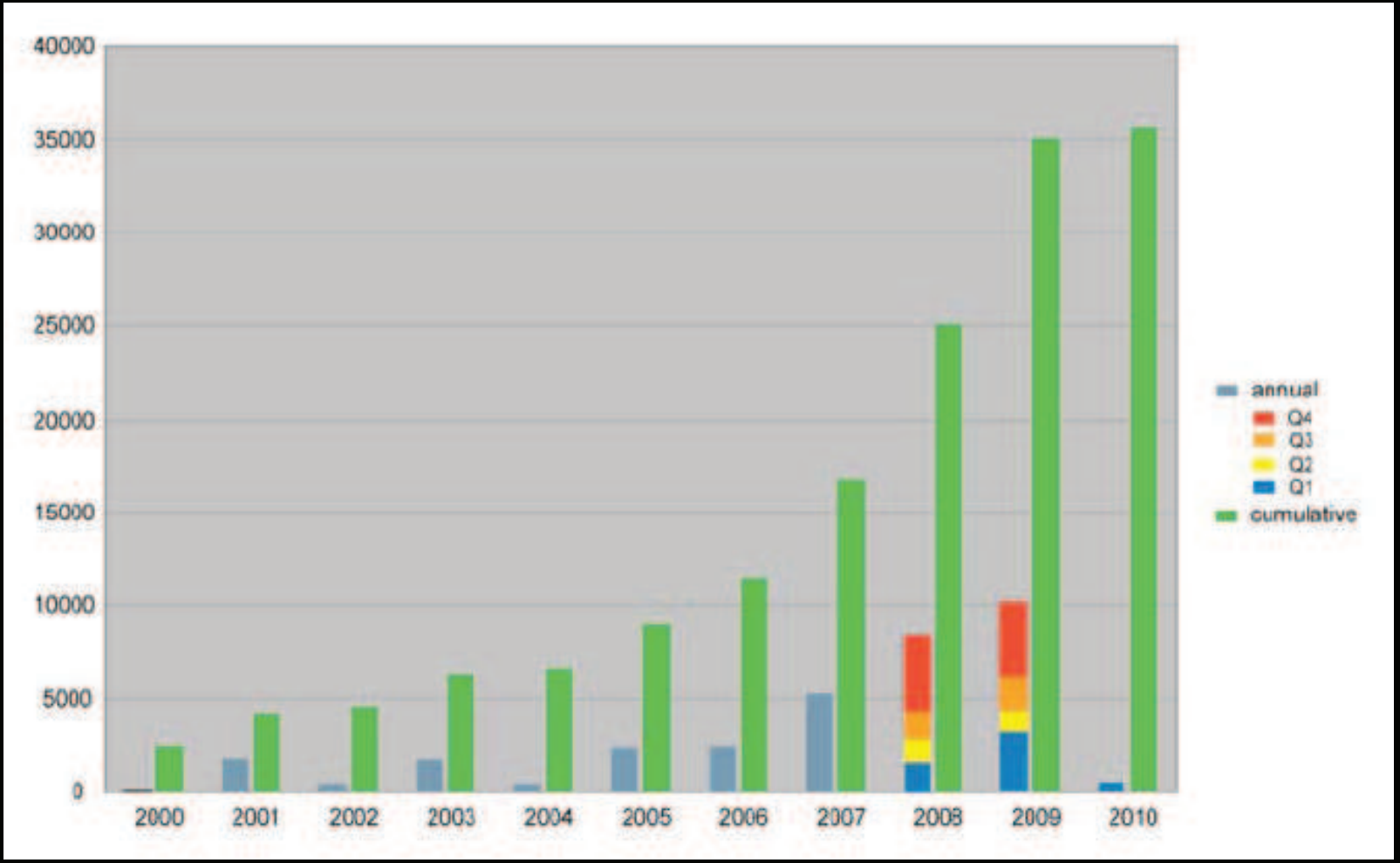
Residential Energy Resources

Distributed Energy Challenges:
How do we cope with
Electric vehicles for peak
residential loads?

Distributed Energy Examples:
Electric vehicles
Solar and Wind

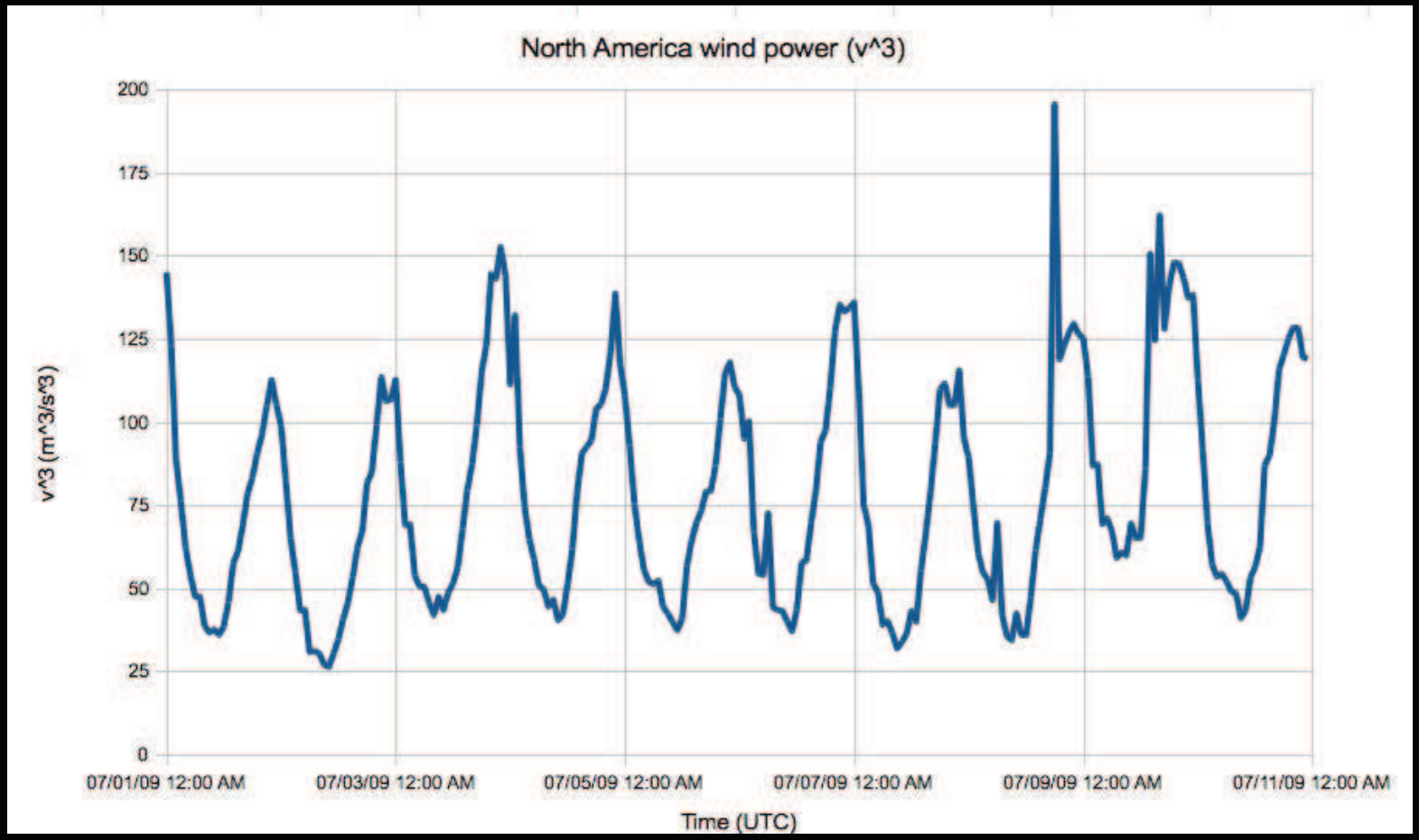
What If ?

US Cumulative Wind Power



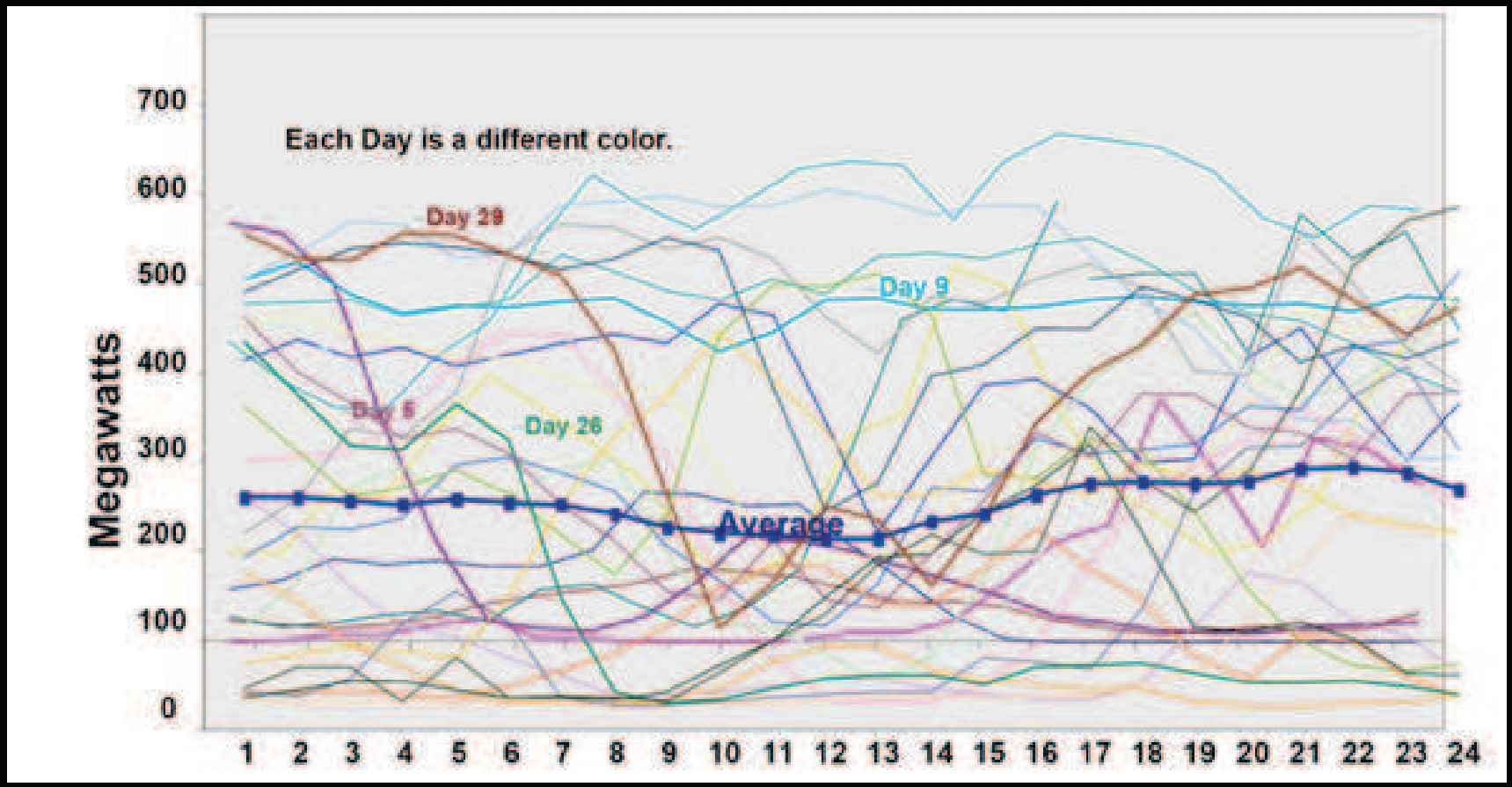
Source: American Wind Energy Association

Wind – Hourly Variation



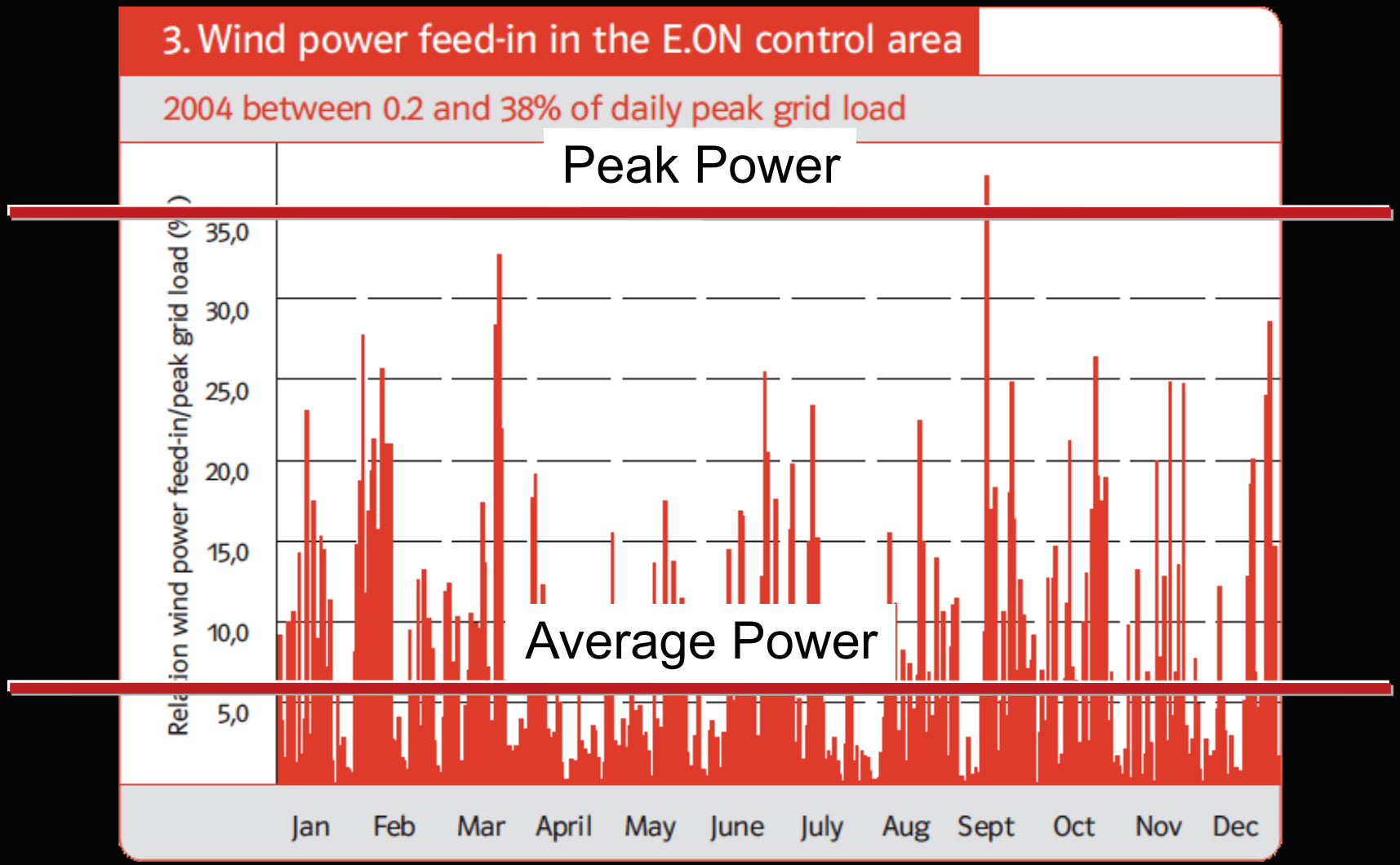
Source: NOAA METAR

Tehachapi Wind

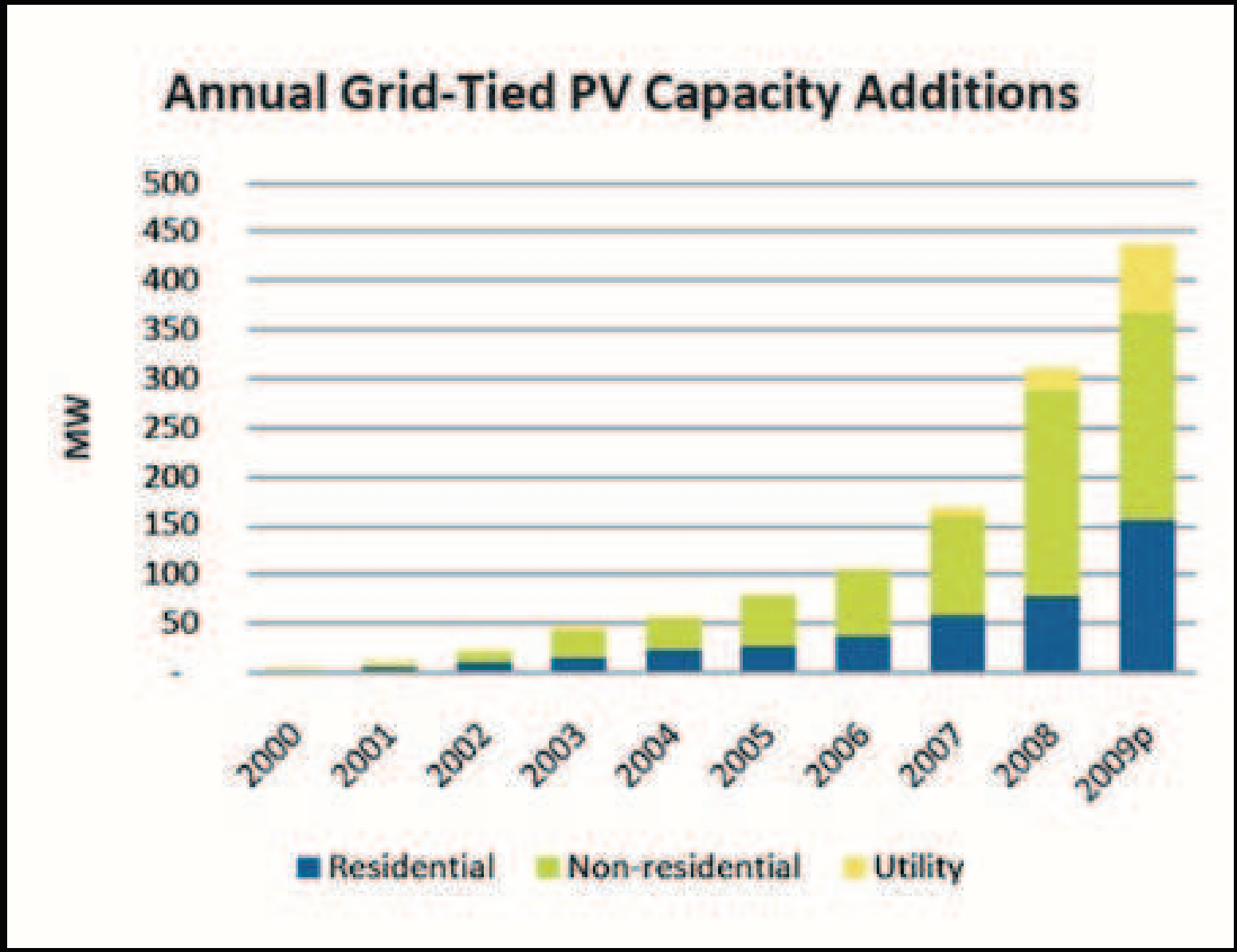


Source: California Independent System Operator

Wind – Daily Variation

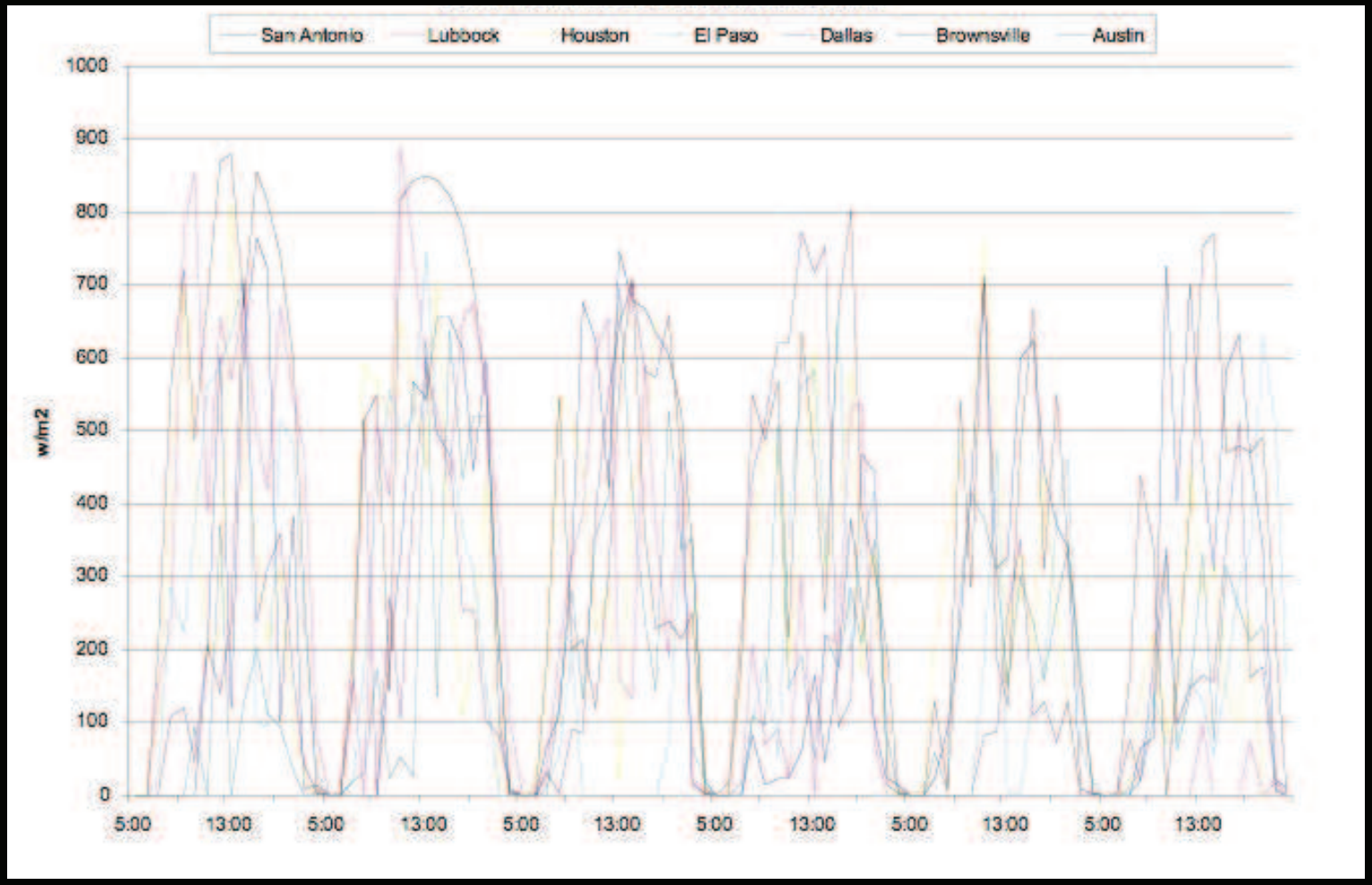


Source: E.ON Wind Report 2005



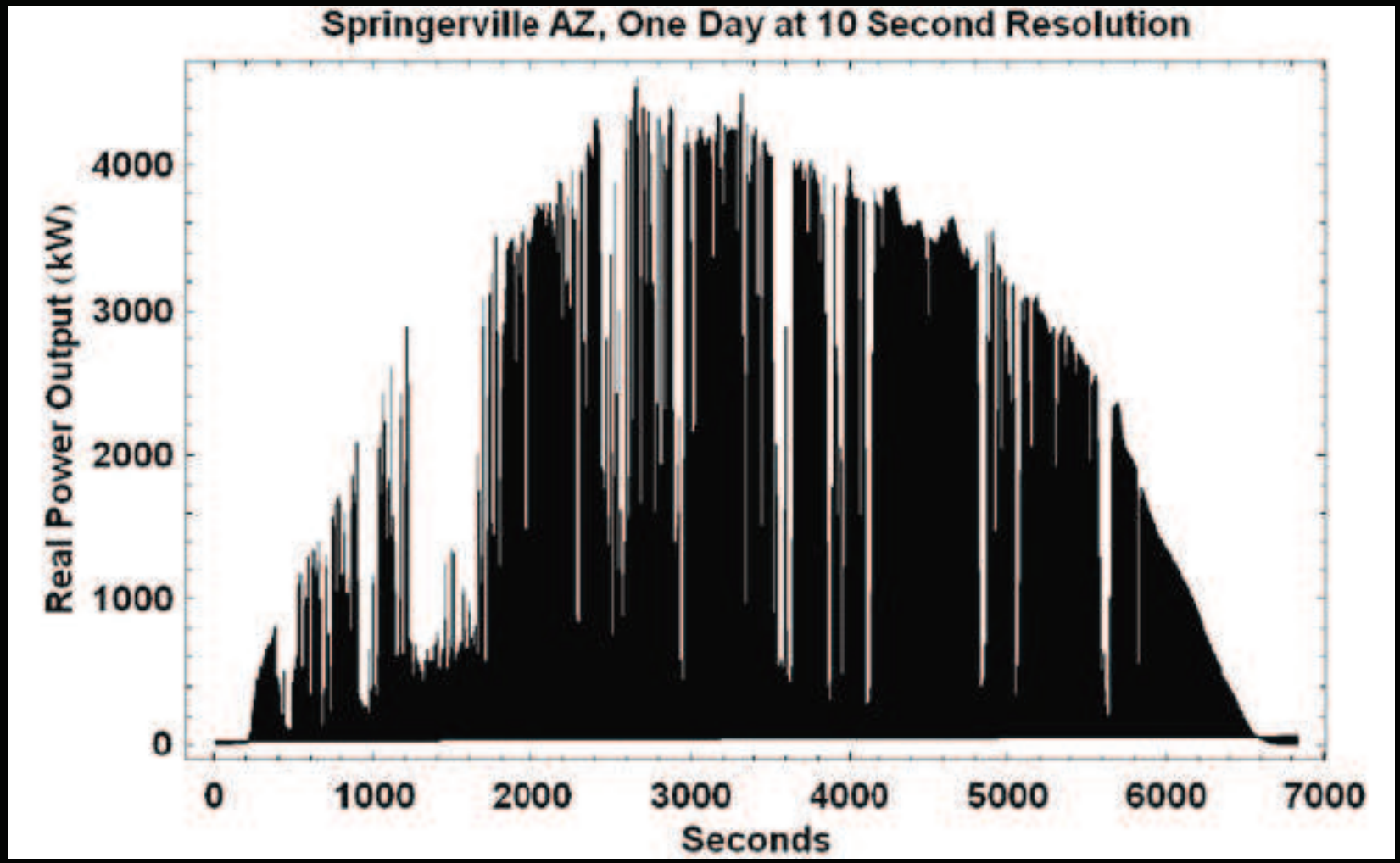
Source: Solar Energy Industries Association

Solar – Hourly Variation



Source: Texas State Energy Conservation Office

Solar Short Term Variability



Source: Carnegie Mellon Electricity Industry Center

DISPATCH AND BALANCING

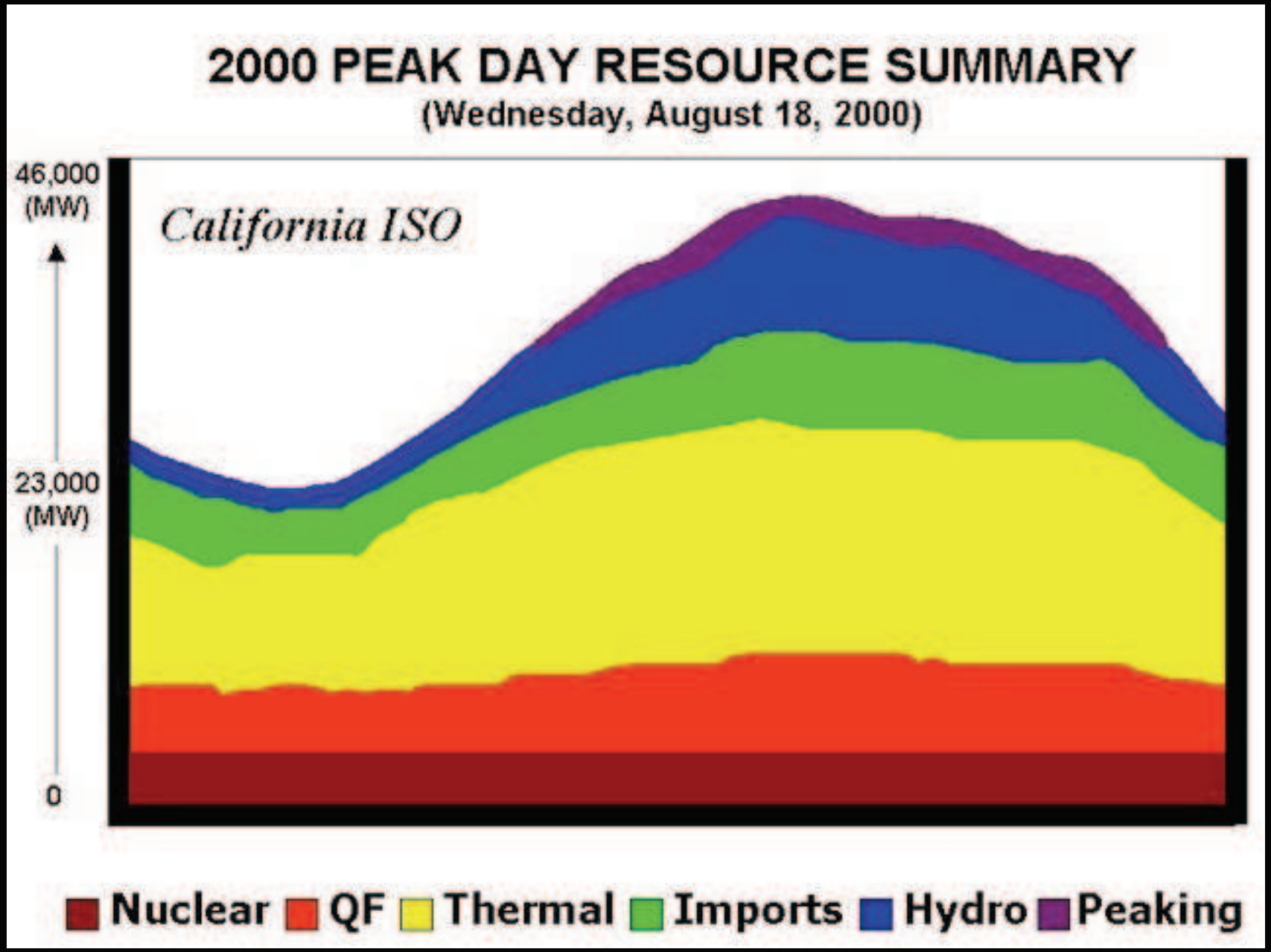
“Open Loop” Electric Power Supply

- 131 Balancing Authorities (ref: NERC)
- 24 Hour advance forecast – minute by minute
  - Estimated by on history and weather forecast

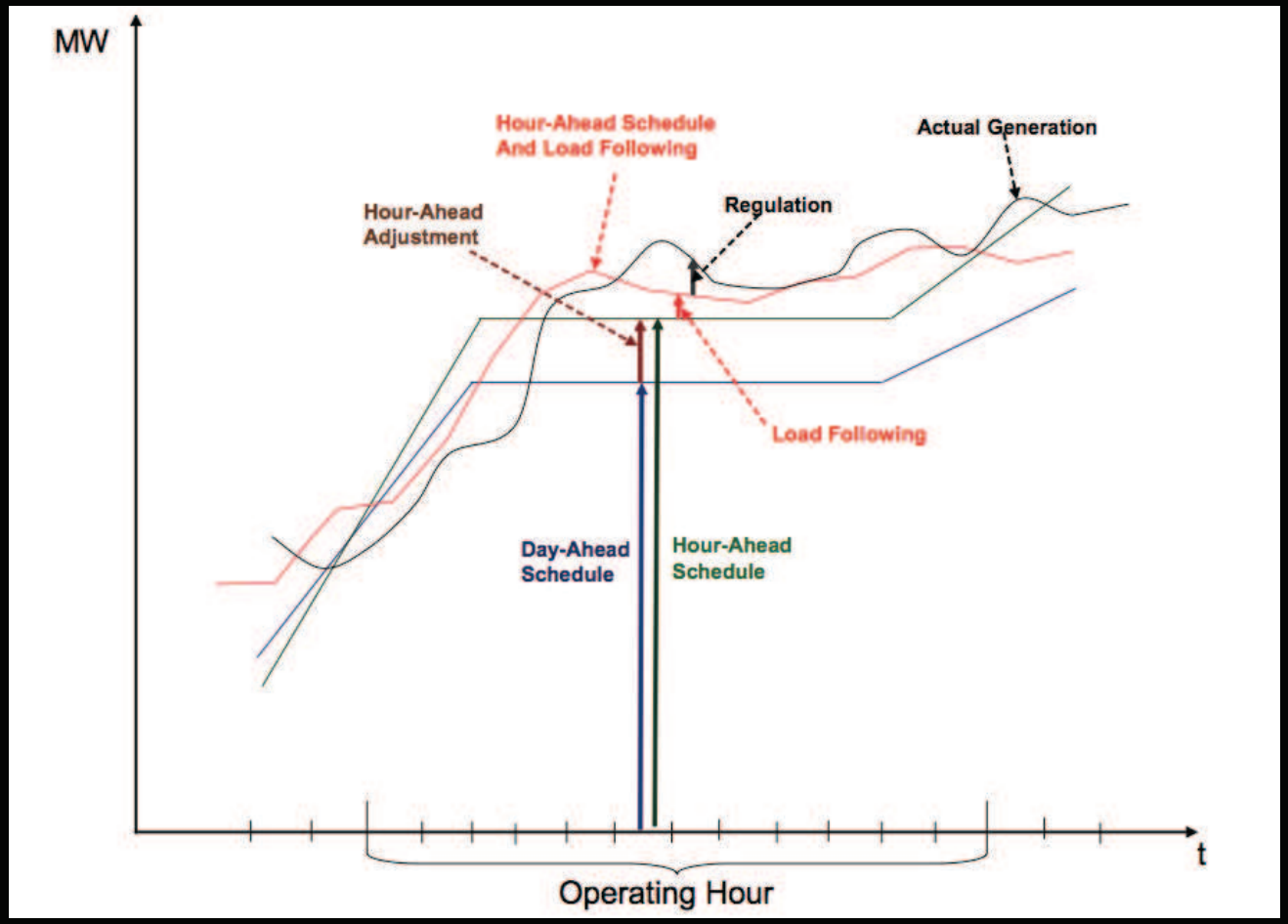
- Dispatch Plan
  - Buy/Sell base load
  - Buy/Sell & Schedule margin, peaking generation
  - Buy/Sell spinning reserve

Generation Dispatch
Load Balancing

- Historic Usage
- Weather Forecast
- Wind Forecast
- Maintenance Schedules
- Day Ahead Pricing
- 24 Hour Forecast, minute by minute, buy/sell
  - Base Load, Variable Load, Peaking Generation, Spinning Reserve
- Hour Ahead – presented 75 Minutes prior
- 5 minutes ahead


2000 PEAK DAY RESOURCE SUMMARY
(Wednesday, August 18, 2000)
46,000
(MW)
23,000
(MW)
0
California ISO
Nuclear
QF
Thermal
Imports
Hydro
Peaking

Cal ISO
Hour Ahead Generation Scheduling



Source: California Independent System Operator

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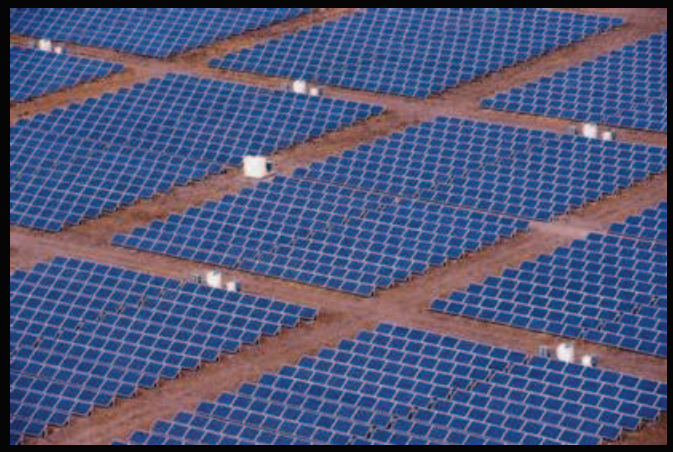
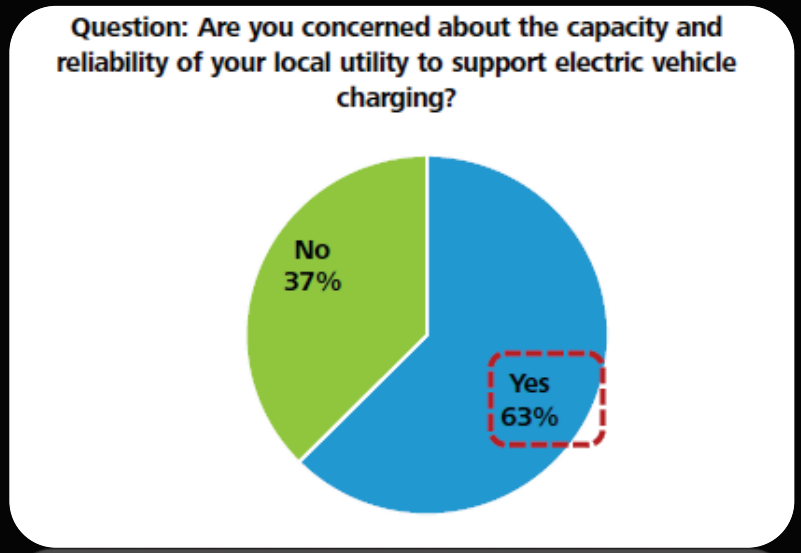


Plug-in Electric Vehicles

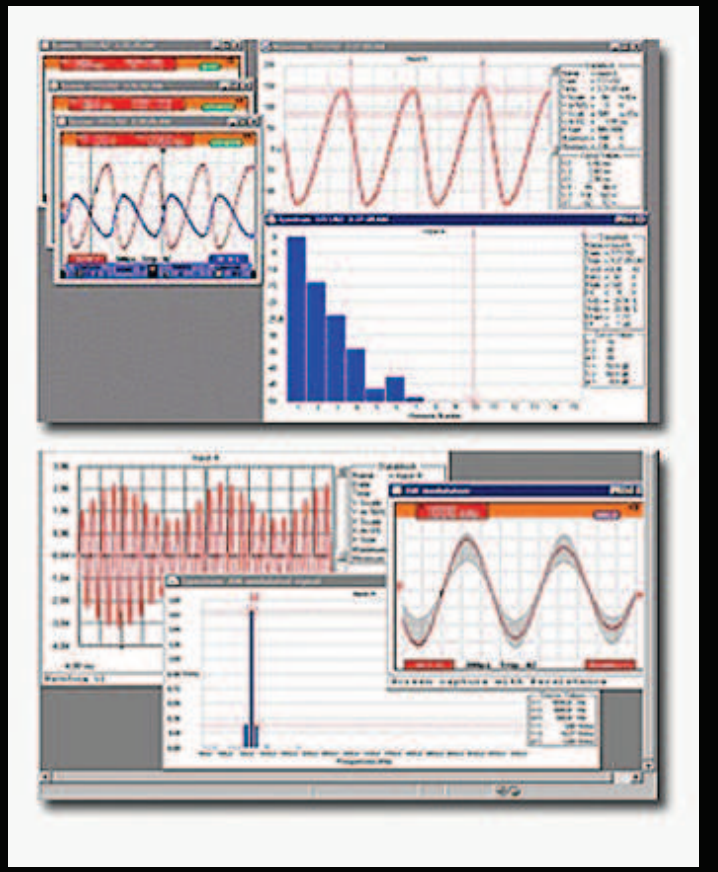
Forecasts range from 2% to 20% of new vehicle sales by 2020

- Research by EPRI and several utilities indicates the need to upgrade 4kv to higher distribution voltage and replace 25kVA transformers to 50kVA
- Early adoption areas tend to be in affluent neighborhoods that have high degree of existing hybrid vehicle ownership
- EV residential charging and separate metering infrastructure installation processes can average 45 days



Source: Deloitte

For the first time a load will (should?) ask if capacity is available.

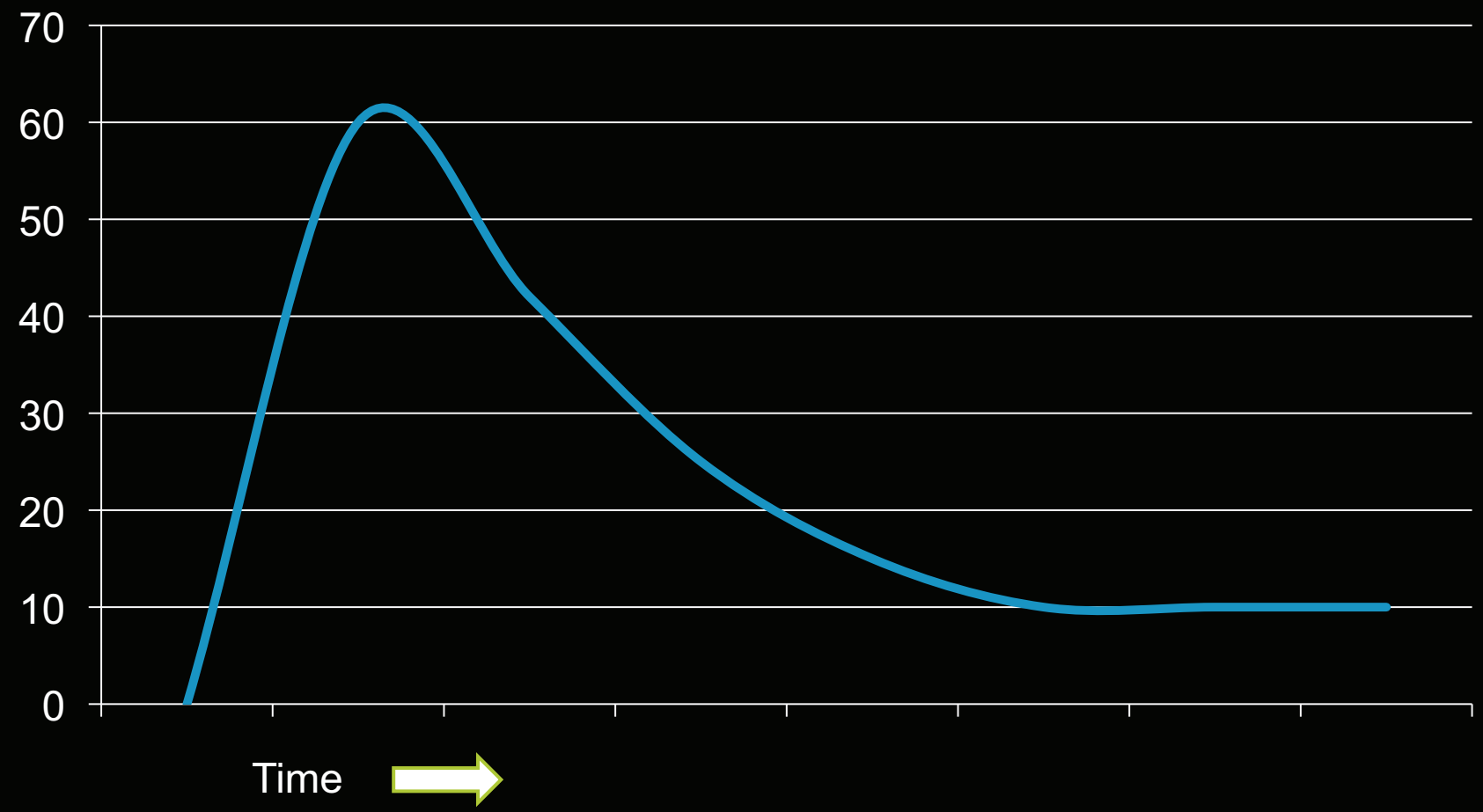


POWER QUALITY

Power Quality

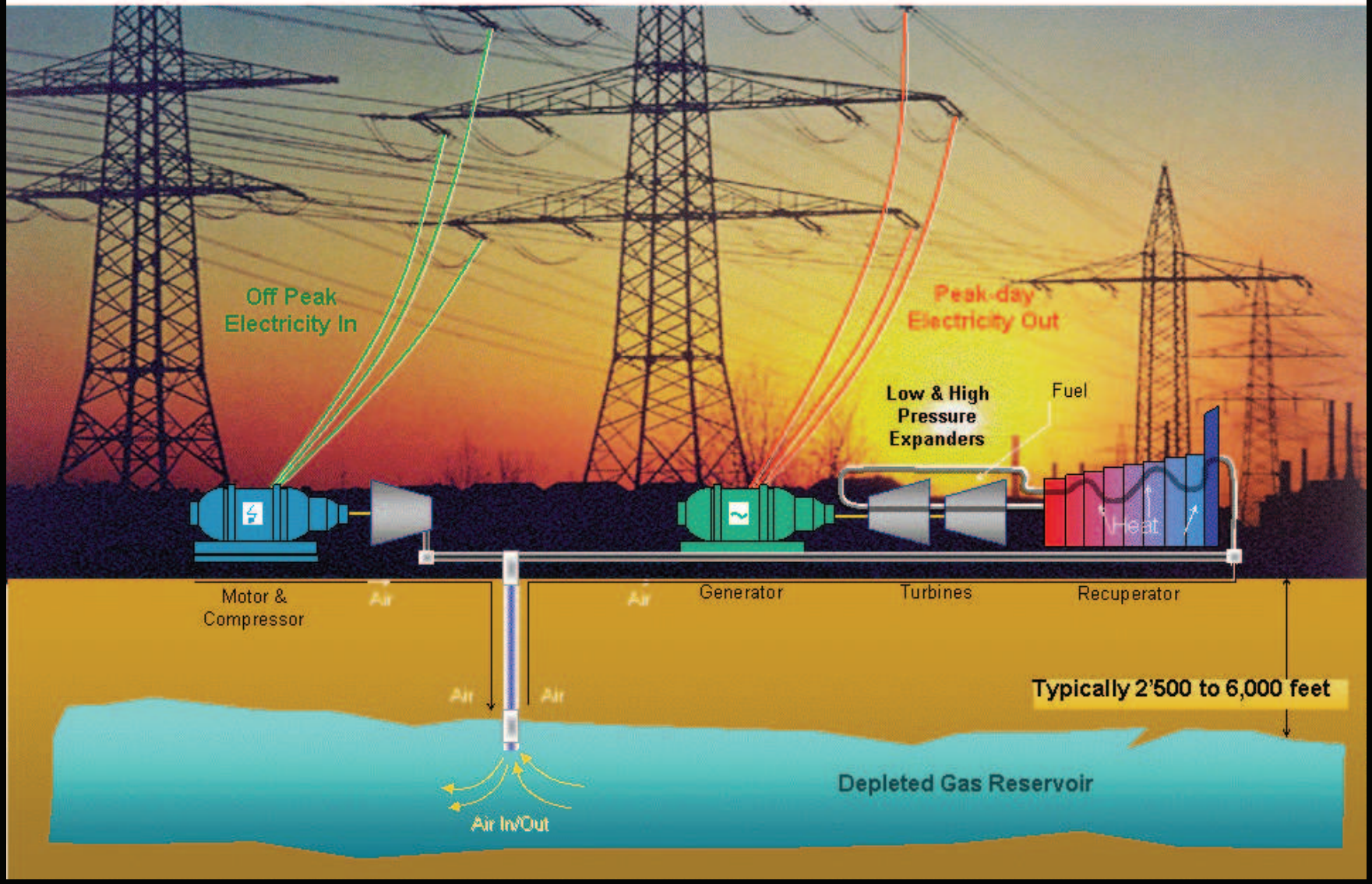
- Volt/VAR control
- Capacitor Bank Switching
- Static Compensators
- Frequency Control
- Harmonics
- Damping Factor

Motor Startup Current
Approx 6X Running Current



Pumped Water Storage

Compressed Air Energy Storage



Source: EPRI

Electric Power Storage

- Generation Scale Storage

  Pumped Water, Compressed Air, Sodium-Sulfur Batteries

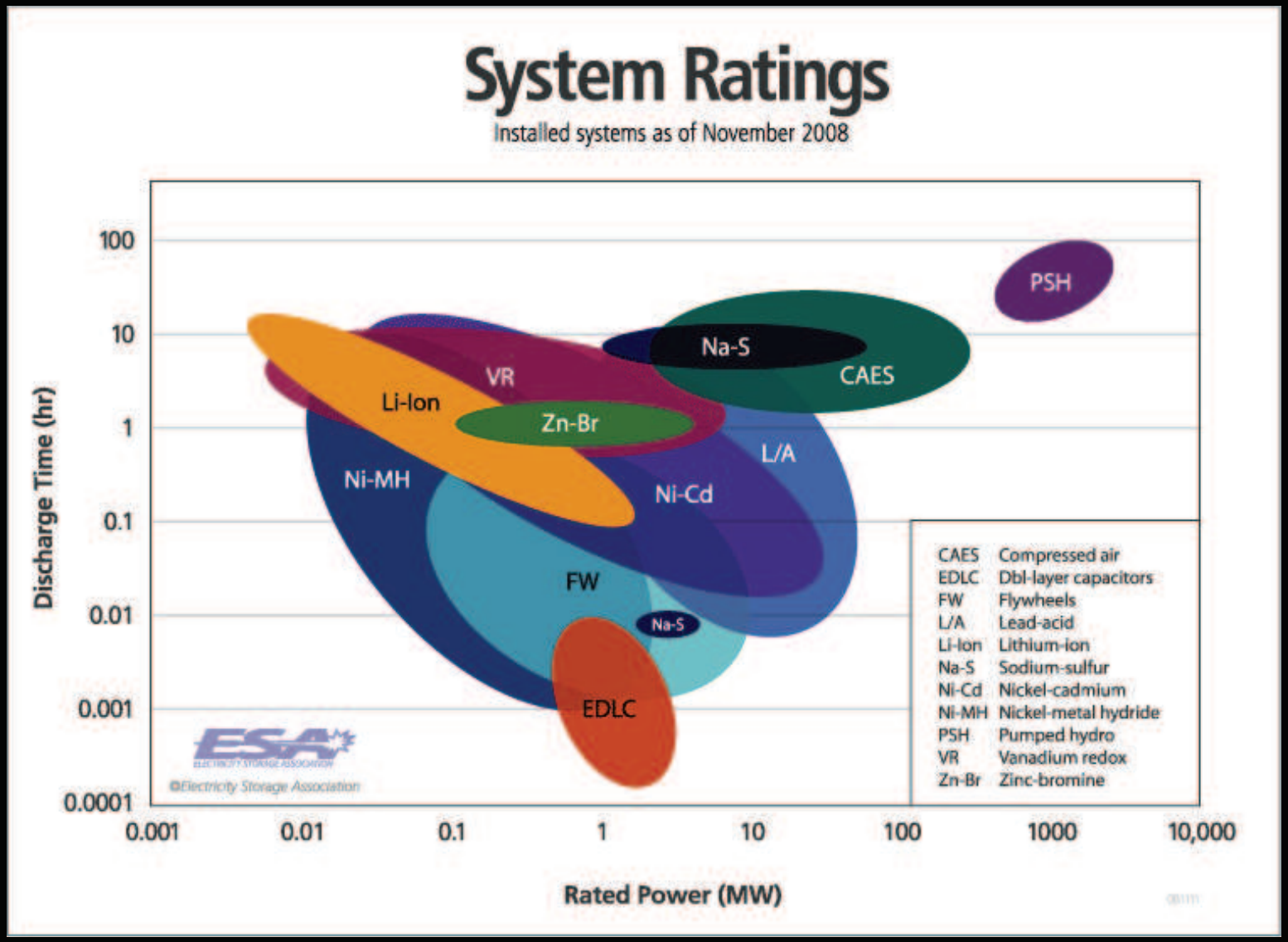
  Research: Fuel Cells, Flywheel, Battery, Ice, Molten salt, ultra capacitors, Flow Batteries, Electrolysis Hydrogen, etc.

- Business/Residential

  Batteries

What About
Electric Vehicles ?

Electric Power Storage



Resources

- “Integration of Renewable Resources”, Cal ISO, 2007
- Dept of Energy, Energy Information Administration
- IEEE Power & Energy Society
- American Wind Energy Association
- Solar Energy Industries Association
- Carnegie Mellon Electricity Industry Center


CISCO