Large-Scale Energy Storage Opportunities for Renewable Energy and Smart Grid

International Battery Association Meeting

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Presented by:
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U. S. Electric Grid

- 157,000 miles of high-voltage (greater than 230 kilovolts) electric transmission lines.
- Over 15,000 generating units
- 143 million customers.

- **Total Electricity Revenues in 2009 - $353 B**

- There are more than 3,100 electric utilities in the United States.
  - 213 stockholder-owned utilities that provide power to about 73% of the customers
  - 2,000 public utilities run by state and local government agencies that provide power to about 15% of the customers
  - 930 electric cooperatives providing power to about 12% of the customers
  - 2,100 nonutility power producers, including both independent power companies and customer-owned distributed energy facilities.

Today's Electricity Infrastructure

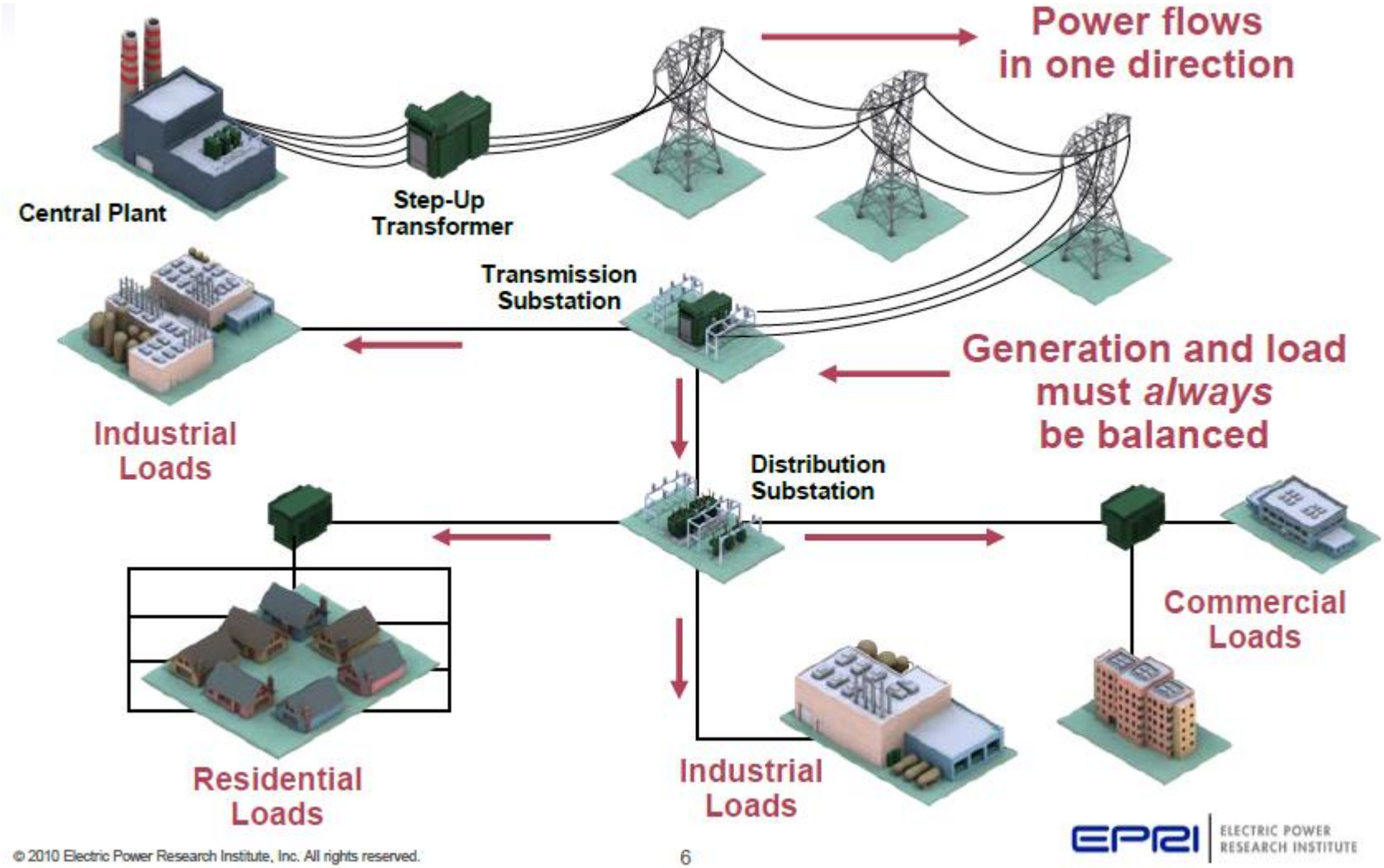

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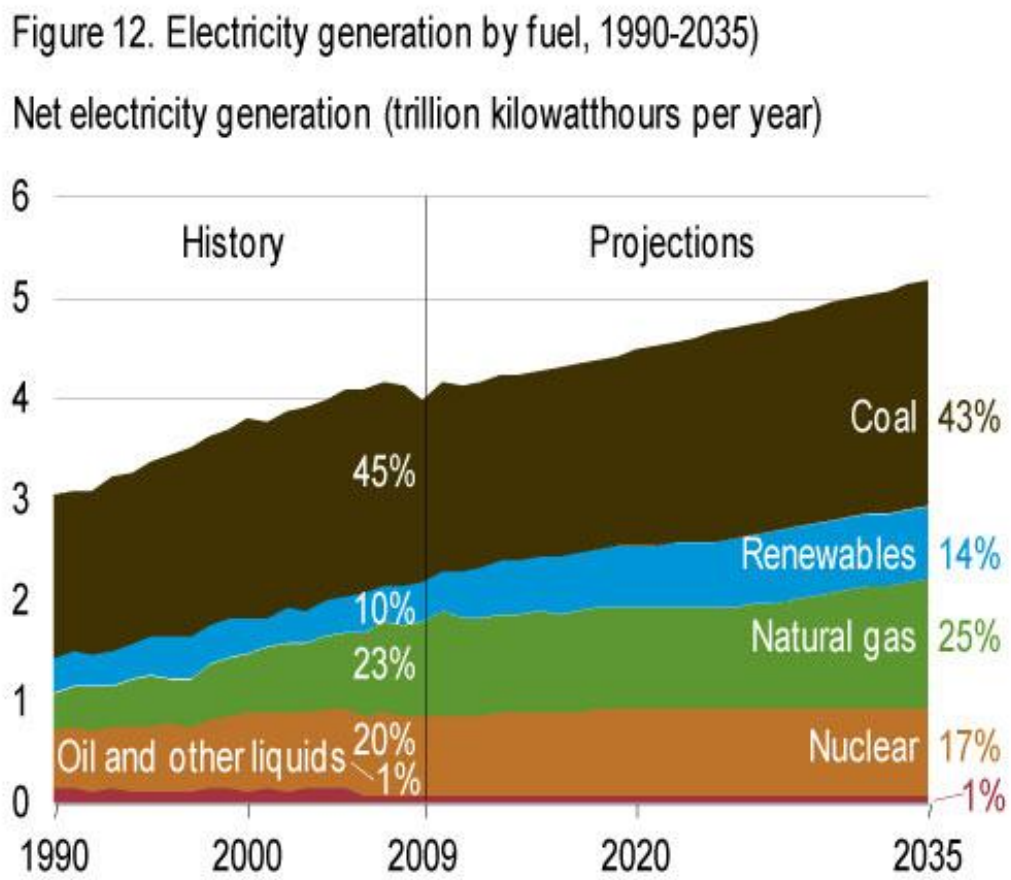
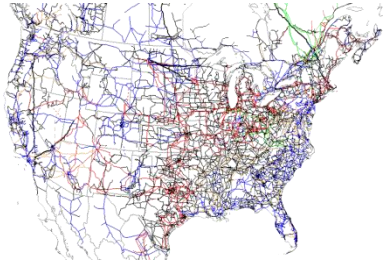
Diagram courtesy of EPRI

Supply Chases Demand



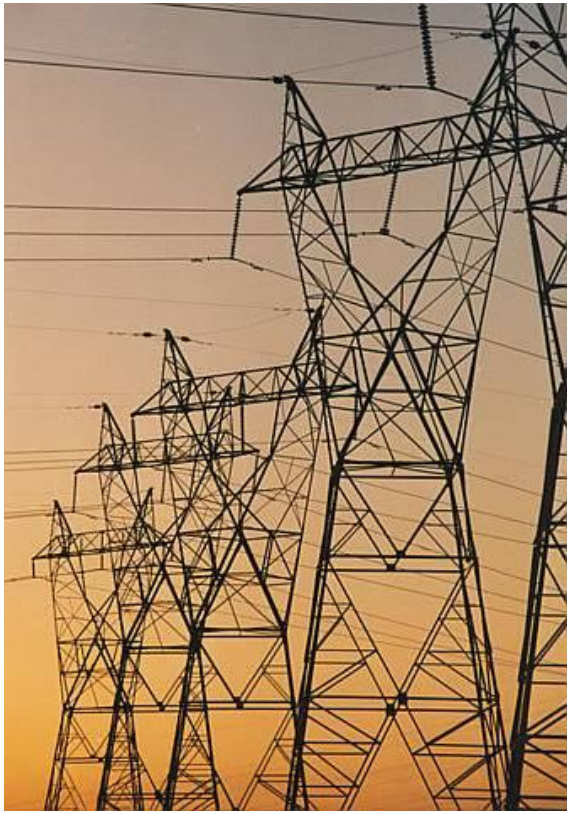


- Grid designed for peak power requirements
- New T&D infrastructure difficult to build
- Renewable Portfolio Standards changing generation mix
- Wind Capacity up to 34 GW

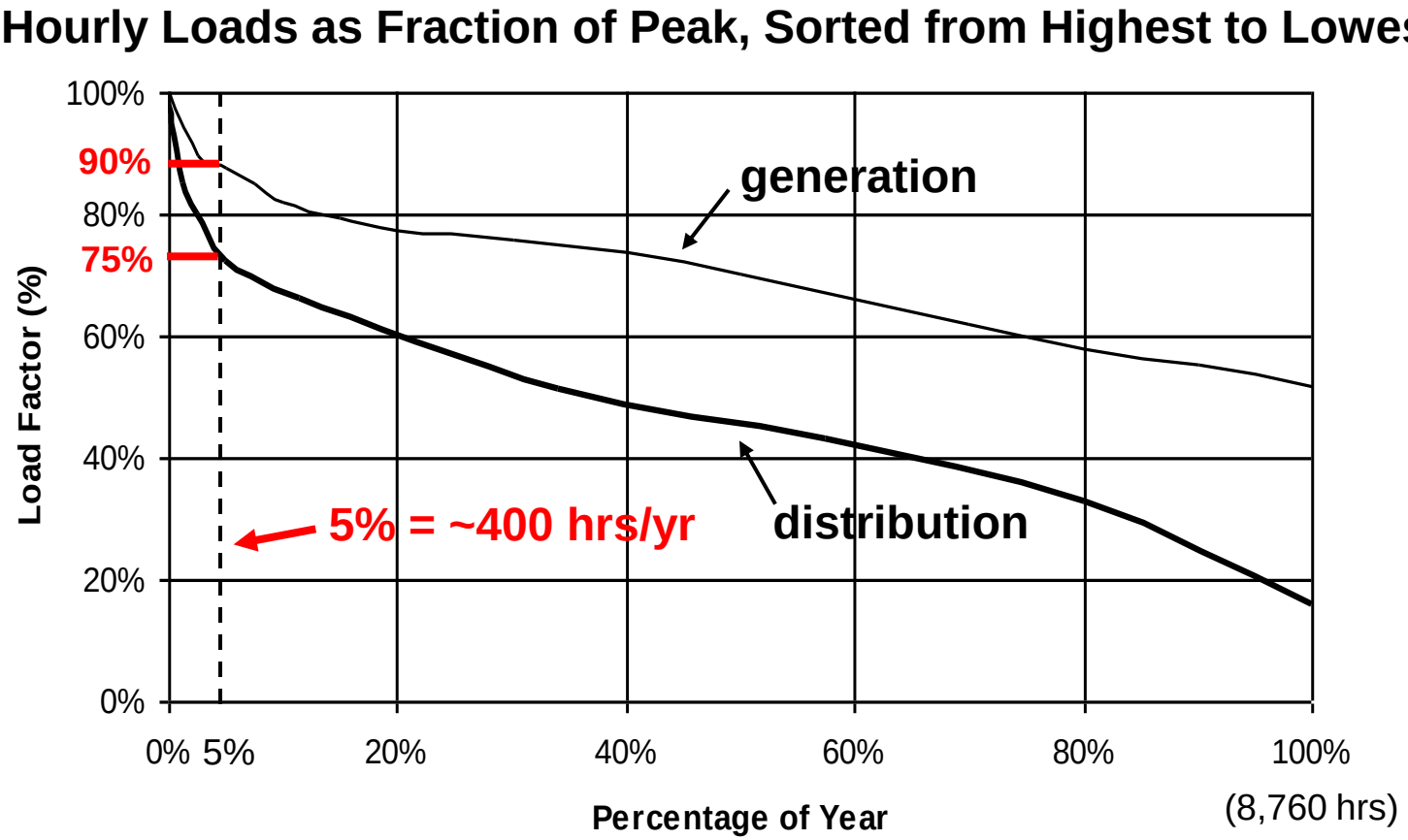
Source: AEO2011 Early Release Overview

What's Changed? Why Energy Storage for Grid Applications Now?

- High cost of managing peak demands
- Increased deployment of renewables
- High cost of Transmission & Distribution infrastucture
- Improve asset utilization
- Investments in "smart grid infrastructure"



Grid Infrastructure Built for Peak – but Peak only used small percentage of the time!!



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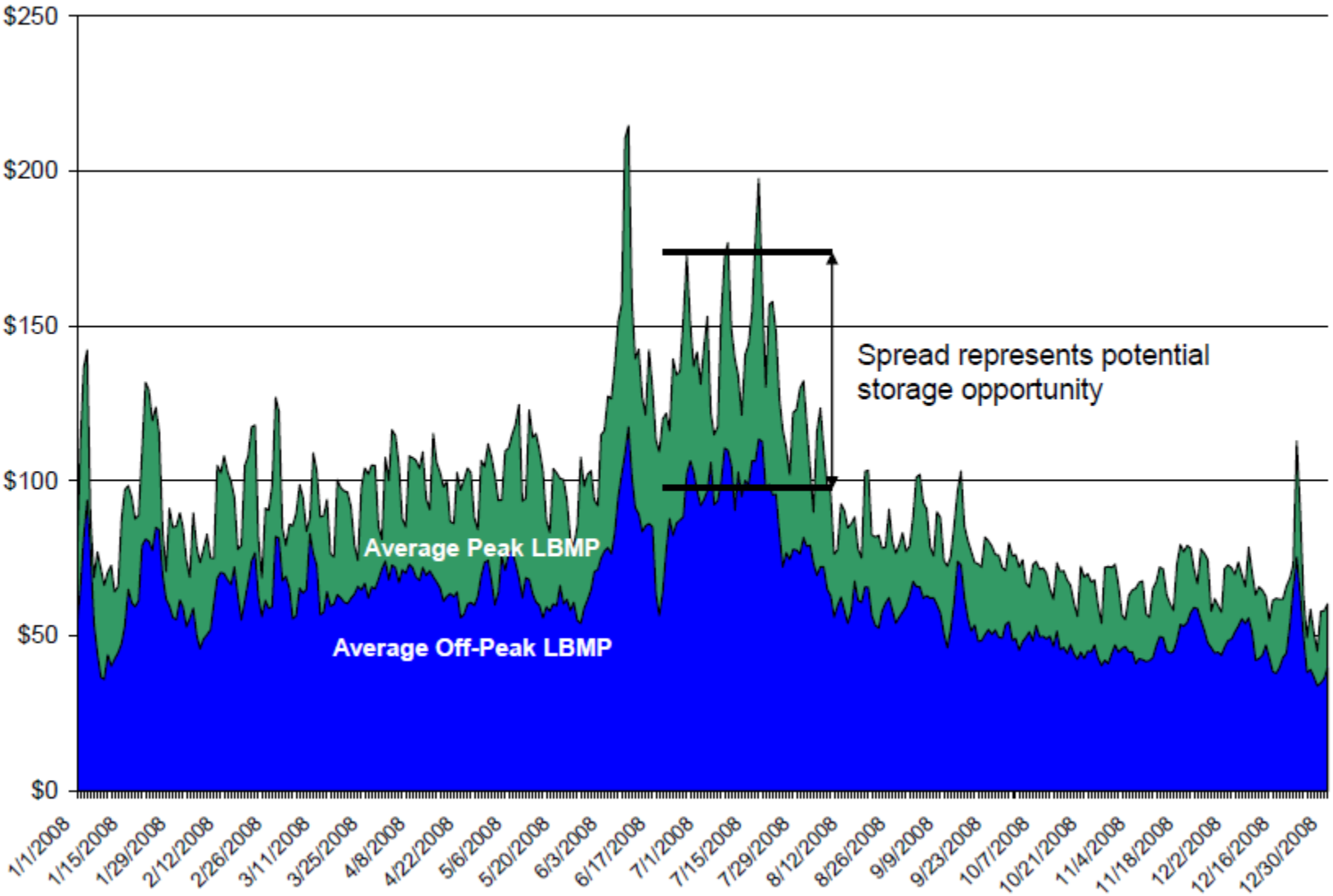
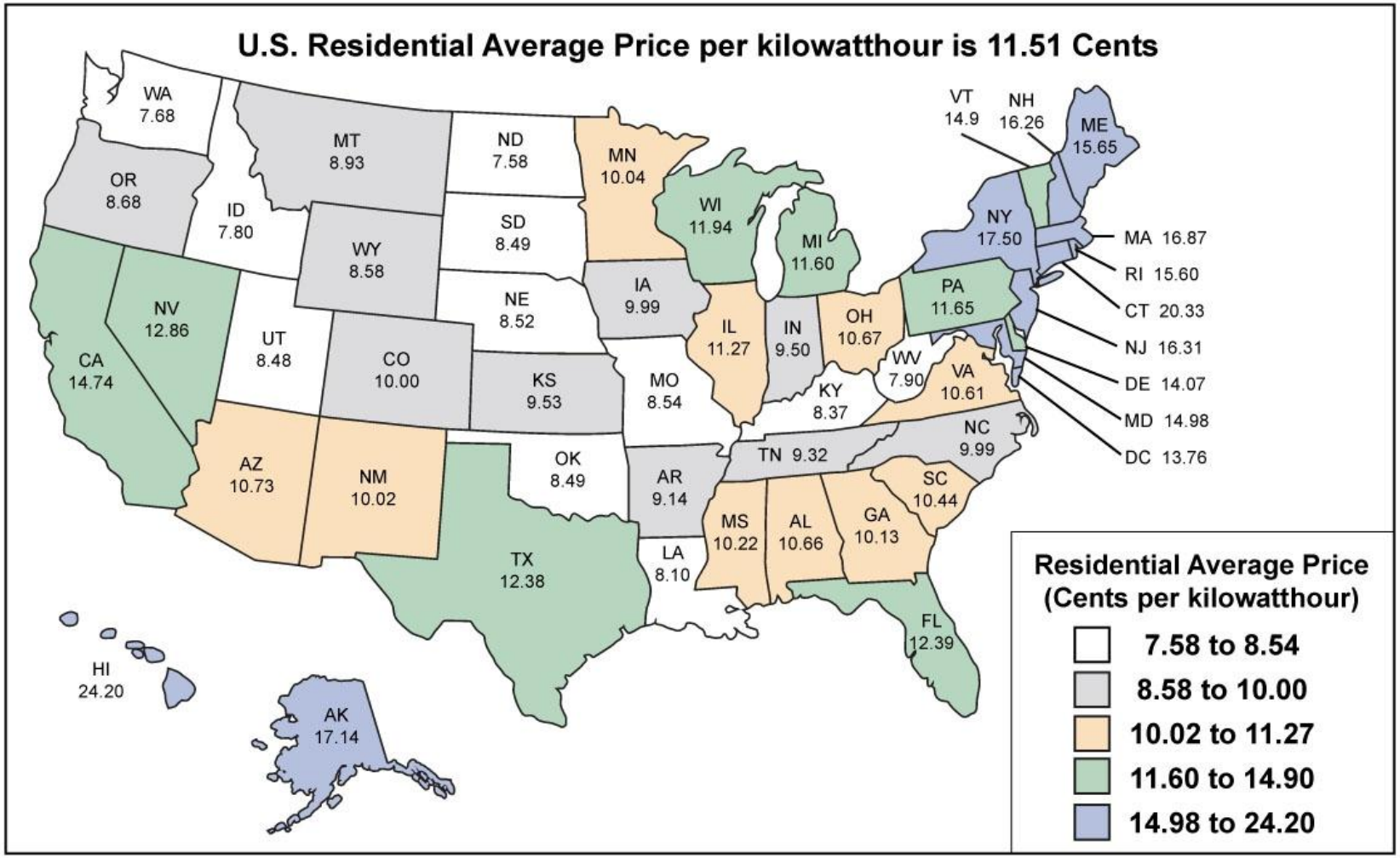
Peak vs Off-Peak Price of Electricity



Energy Storage in the New York Electricity Markets, NYISO, March 2010

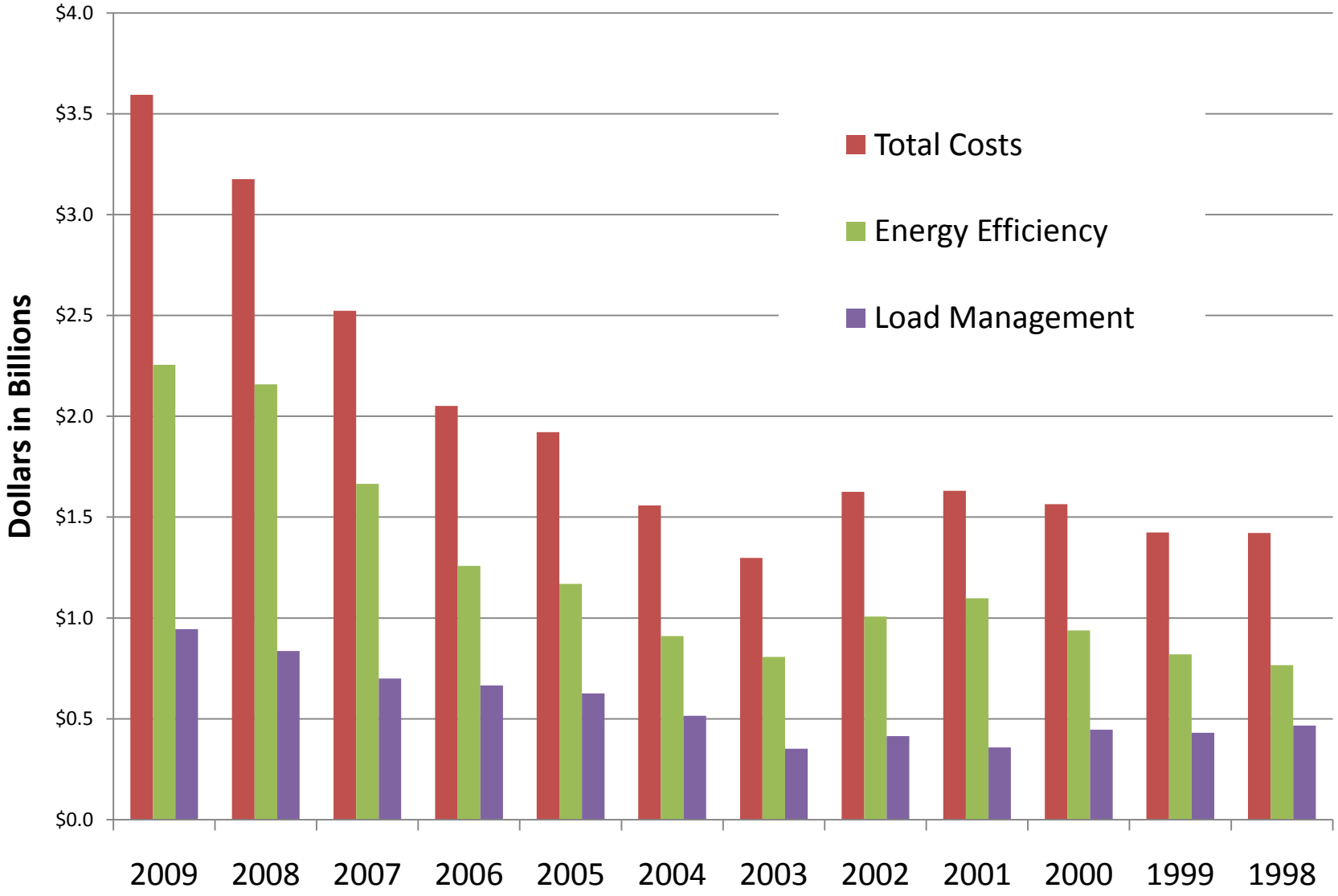
The Value of Energy Storage will vary by Location!!!!



Note: Data are displayed as 5 groups of 10 States and the District of Columbia.

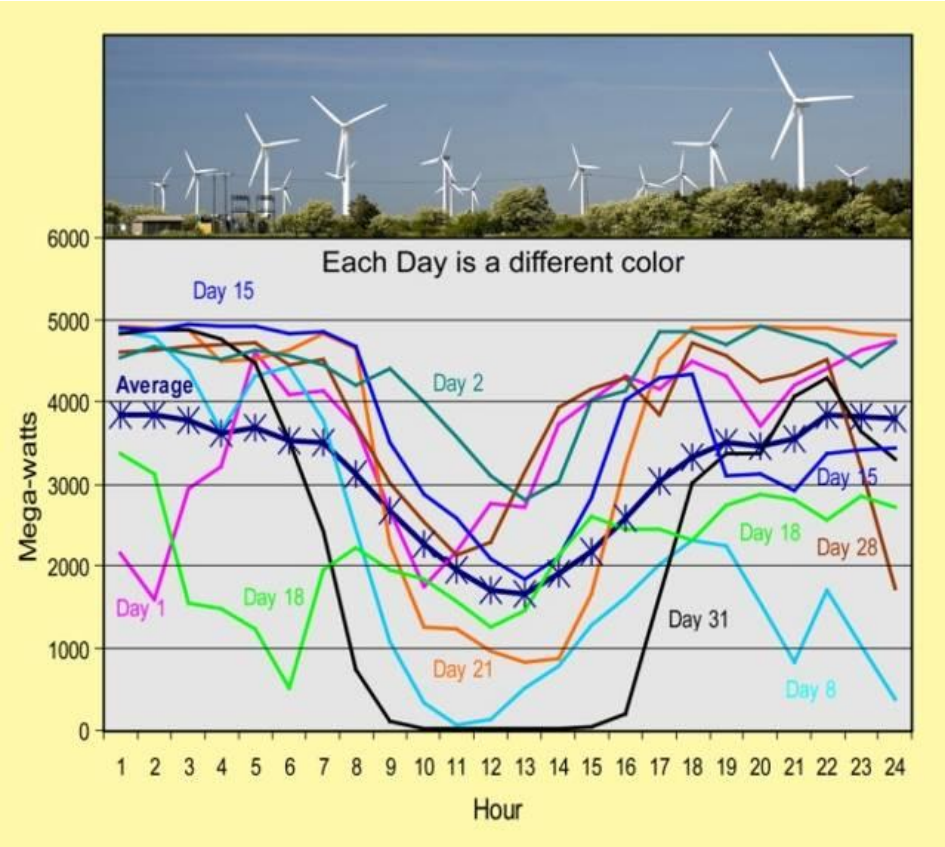
Source: U.S. Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report."

$3.5 Billion Spent in 2009 on Demand-Side Management



Wind Power – Creates Regional Challenge

State Rankings for Wind Power in 2009



- 34.3 GW installed in U.S.
- 3.3 % of U.S. total
- Four states account for 51%
  - Texas, 9.4 GW
  - Iowa, 3.4 GW
  - California, 2.7 GW
  - Washington , 2.0 GW
- Wind accounted for 63% of all new capacity in 2009

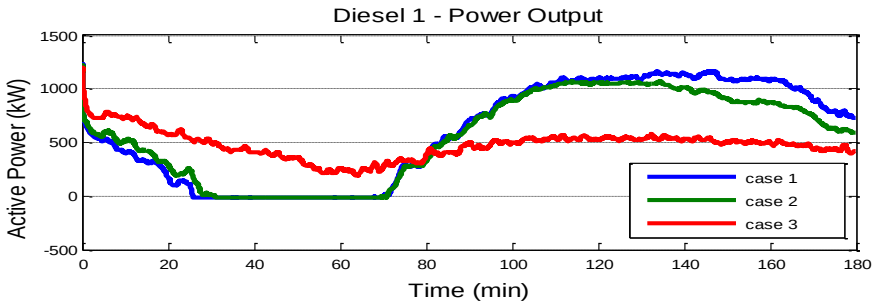
Control Strategies for Distributed Energy Resources to Maximize the Use of Wind Power in Rural Microgrids

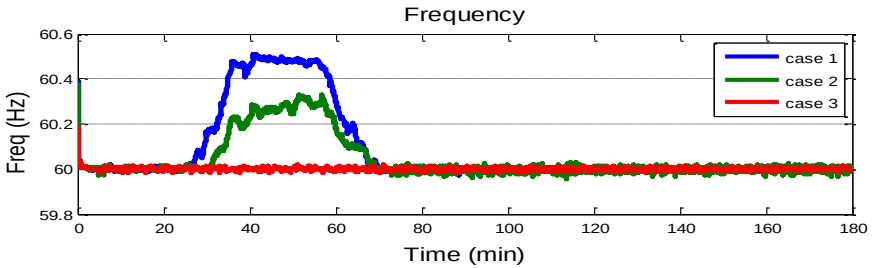
- Three Scenarios Evaluated
  1. Wind + Diesel
  2. Wind + Diesel + Demand Response
  3. Diesel + Wind + Demand Response + Storage

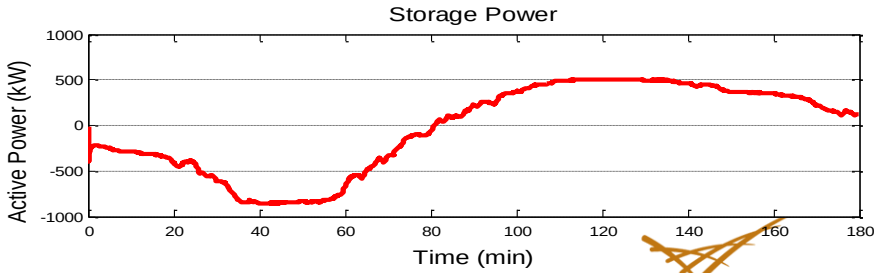
Conclusions

DR and storage can both contribute substantially to the improvement

- frequency performance
- reduction of diesel generator movements, under high-wind normal operations
- generator contingencies in a low-wind scenario







Courtesy : Shuai Lu, Marcelo A. Elizondo, Nader Samaan, Karanjit Kalsi, Ebony Mayhorn, Ruisheng Diao, Chunlian Jin, Yu Zhang, Pacific Northwest National Laboratory

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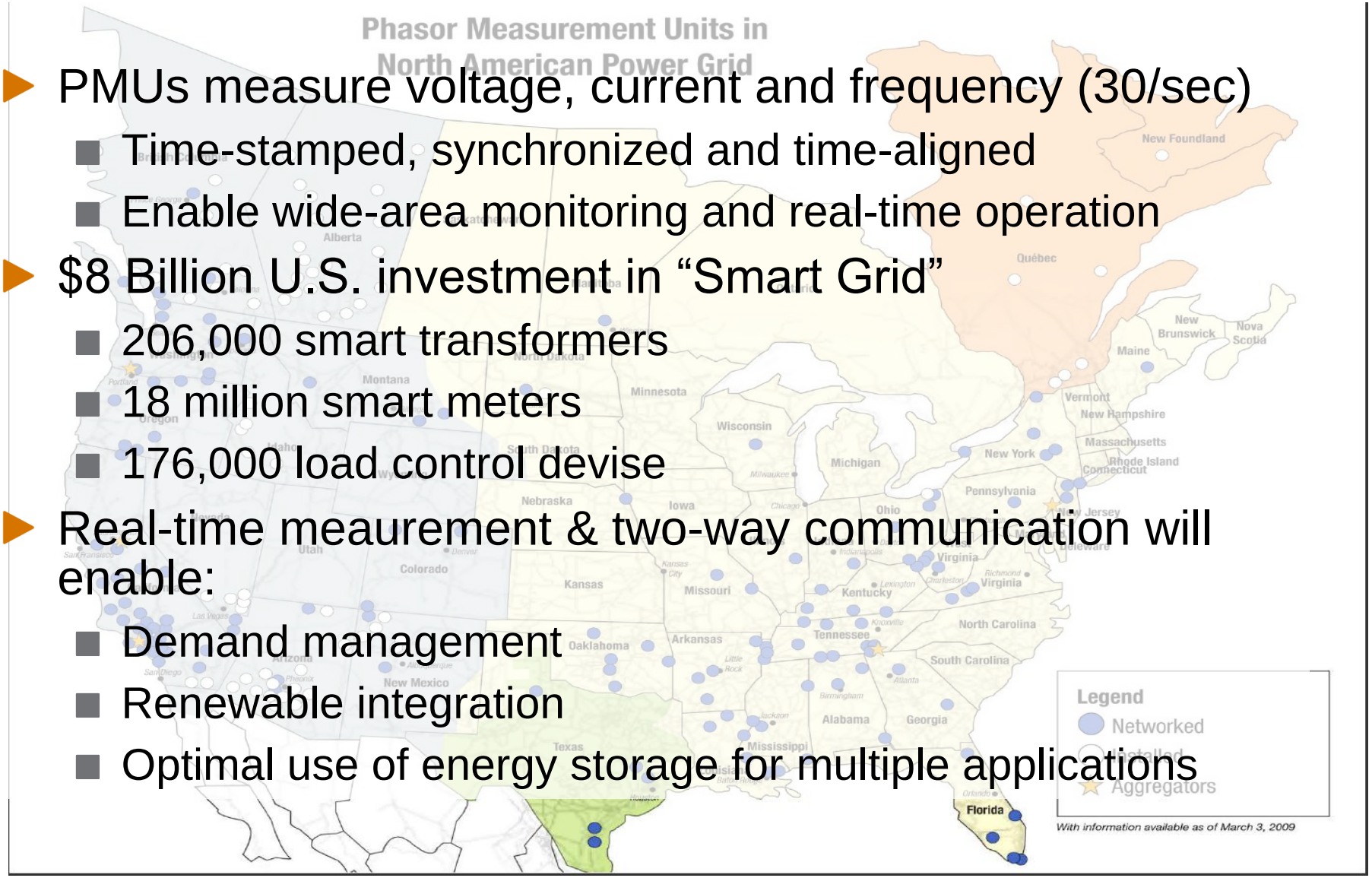
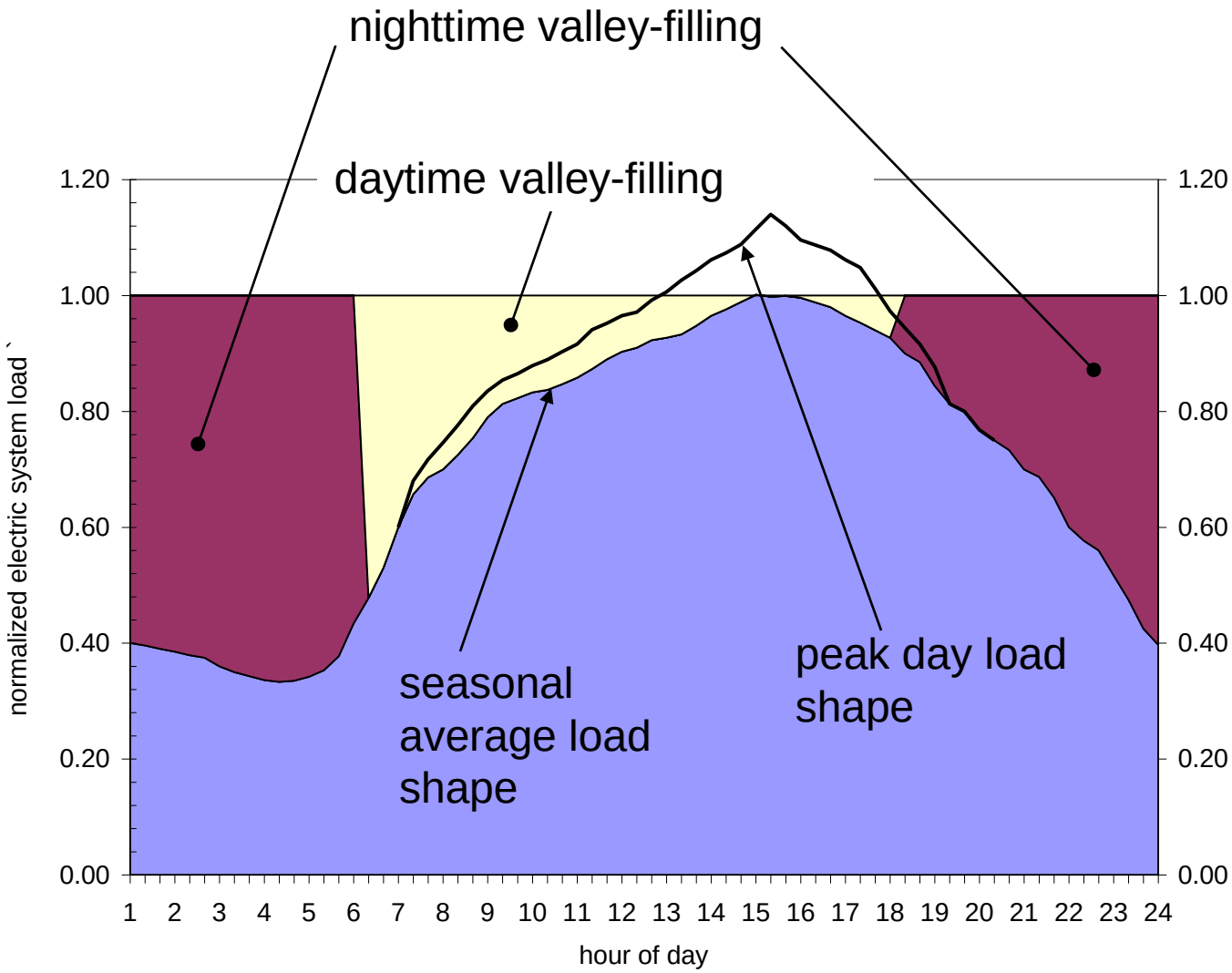
Future Grid – Measurement & Communication

- PMUs measure voltage, current and frequency (30/sec)
  - Time-stamped, synchronized and time-aligned
  - Enable wide-area monitoring and real-time operation
- $8 Billion U.S. investment in “Smart Grid”
  - 206,000 smart transformers
  - 18 million smart meters
  - 176,000 load control devise
- Real-time meaurement & two-way communication will enable:
  - Demand management
  - Renewable integration
  - Optimal use of energy storage for multiple applications



How Many PHEV Can You Put On Today's Grid?

- Use the average day in the peak season
- Determine size of valley in MWh
- Constrain valley by excluding
  - Hydro
  - All other renewables
  - Nuclear
  - Peaking plants



Regional Load Profile

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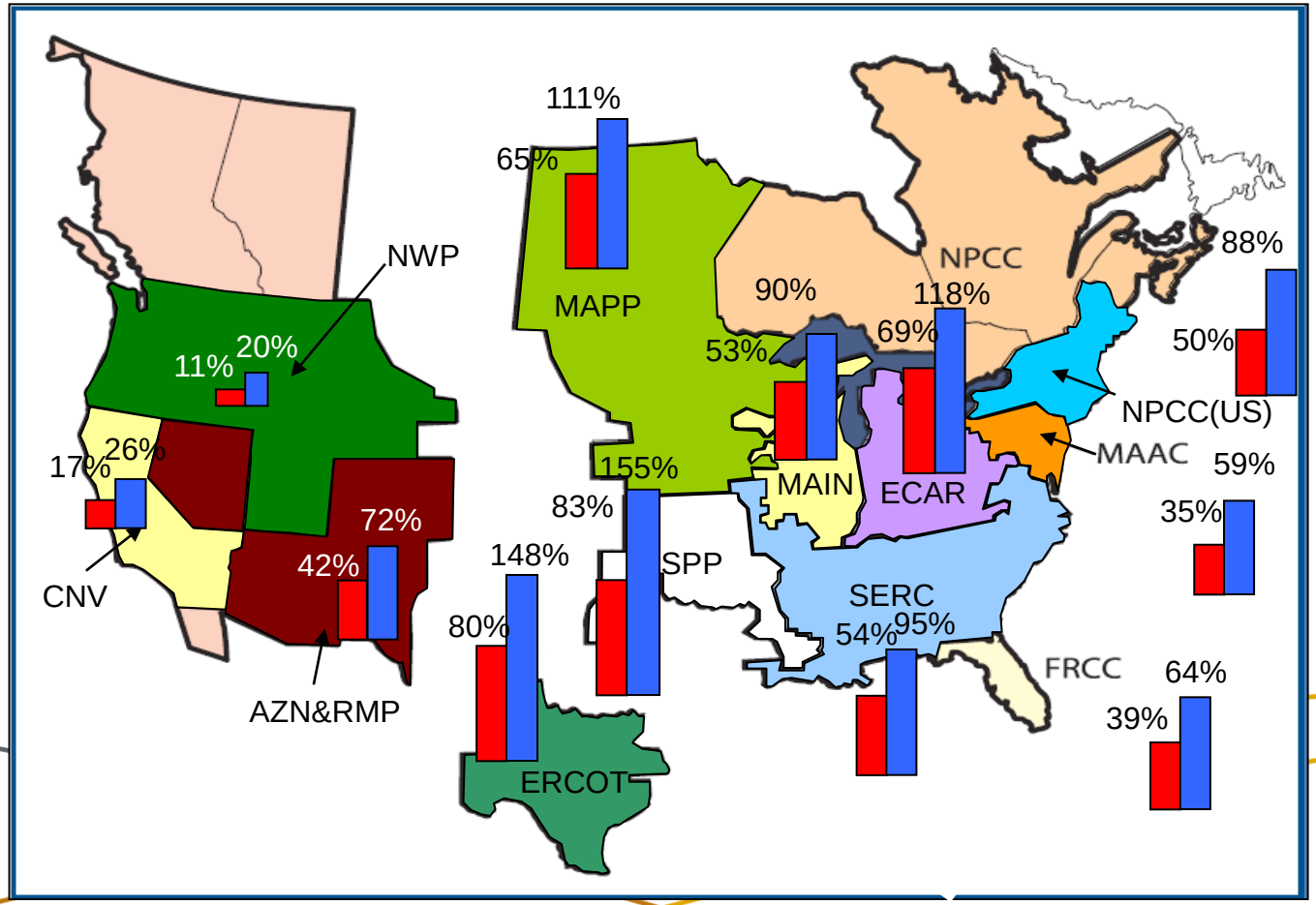
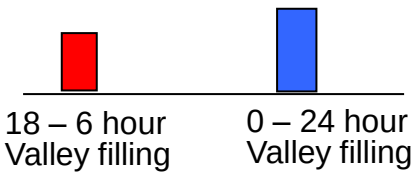
Potential for Fueling the Regional LDV Fleet with Available Electric Capacity ?

Midwest and Eastern regions: high available capacity
Western region: limited available capacity because of large hydro share





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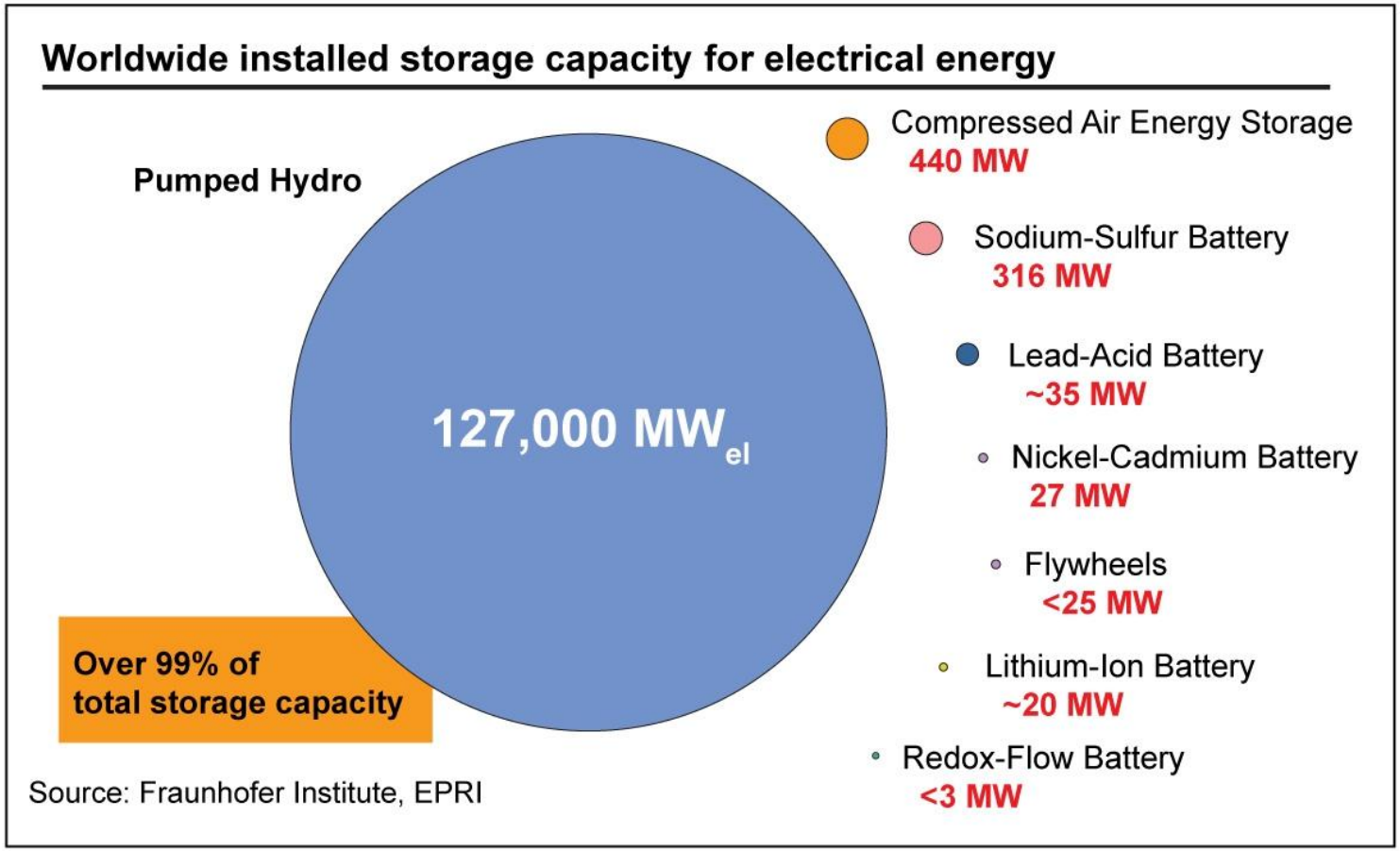
Worldwide Installed Storage Capacity for Electrical Energy Storage



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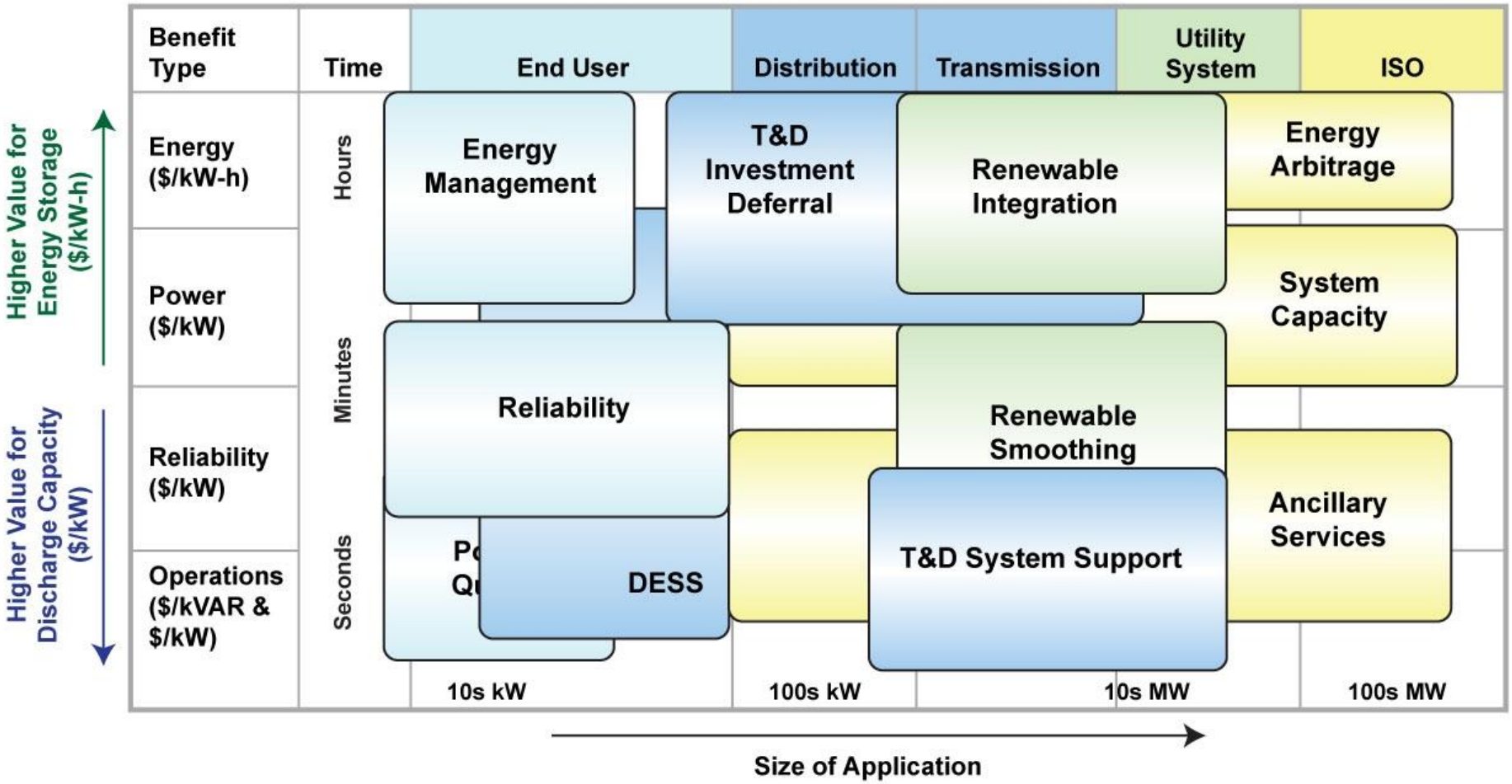
Grid Energy Storage Application



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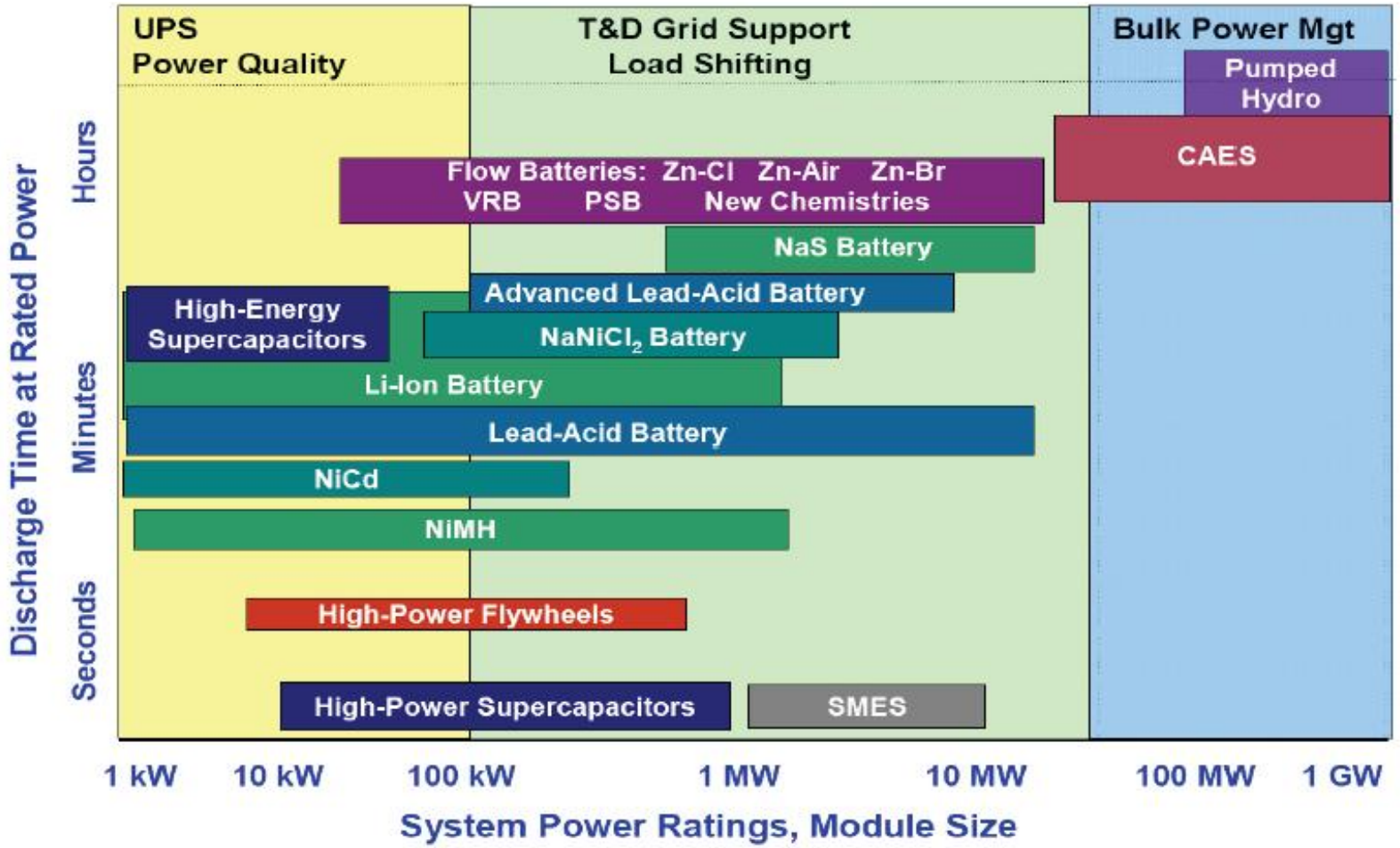
Energy Storage Options



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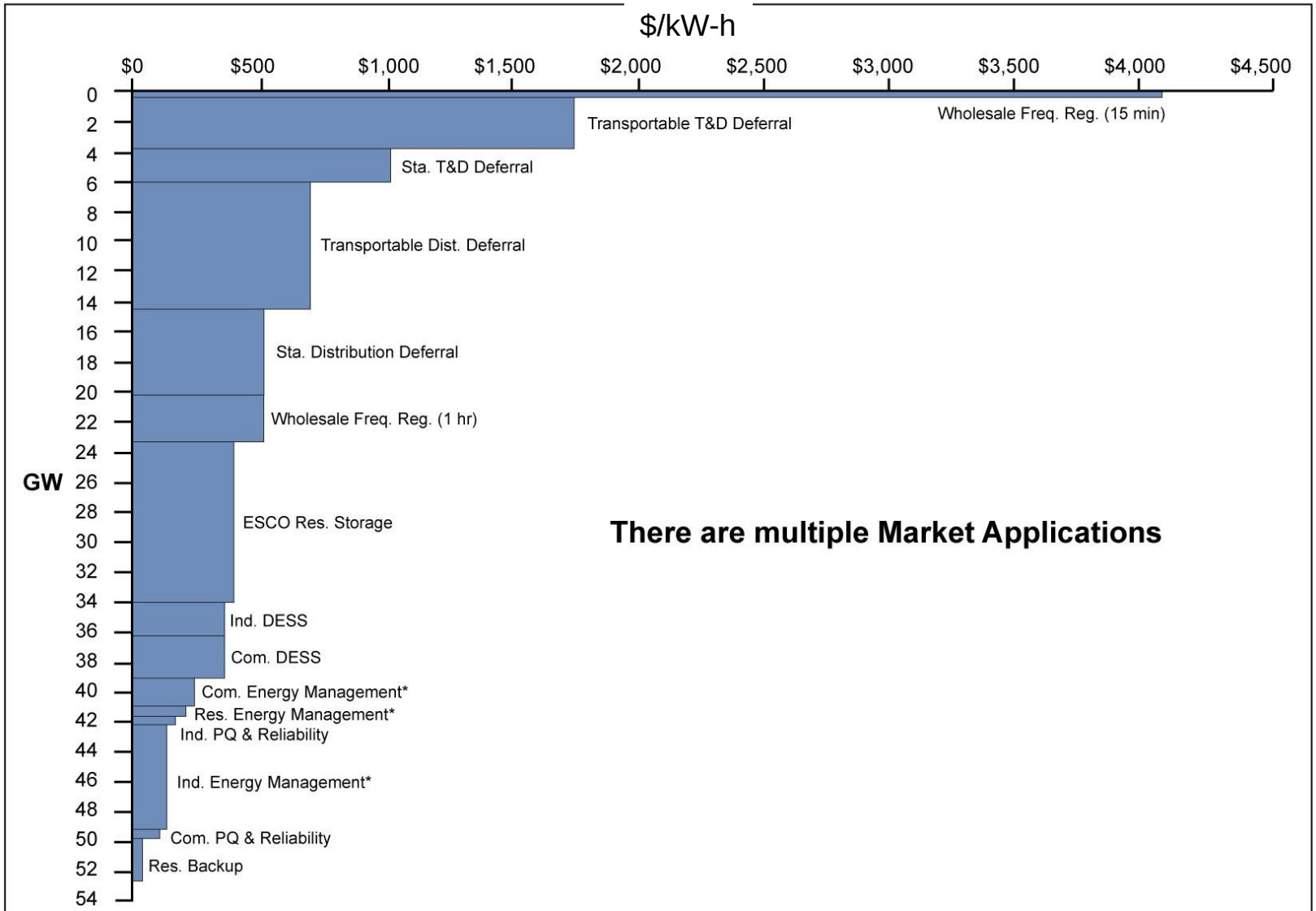
Target Market Size and Value Analysis



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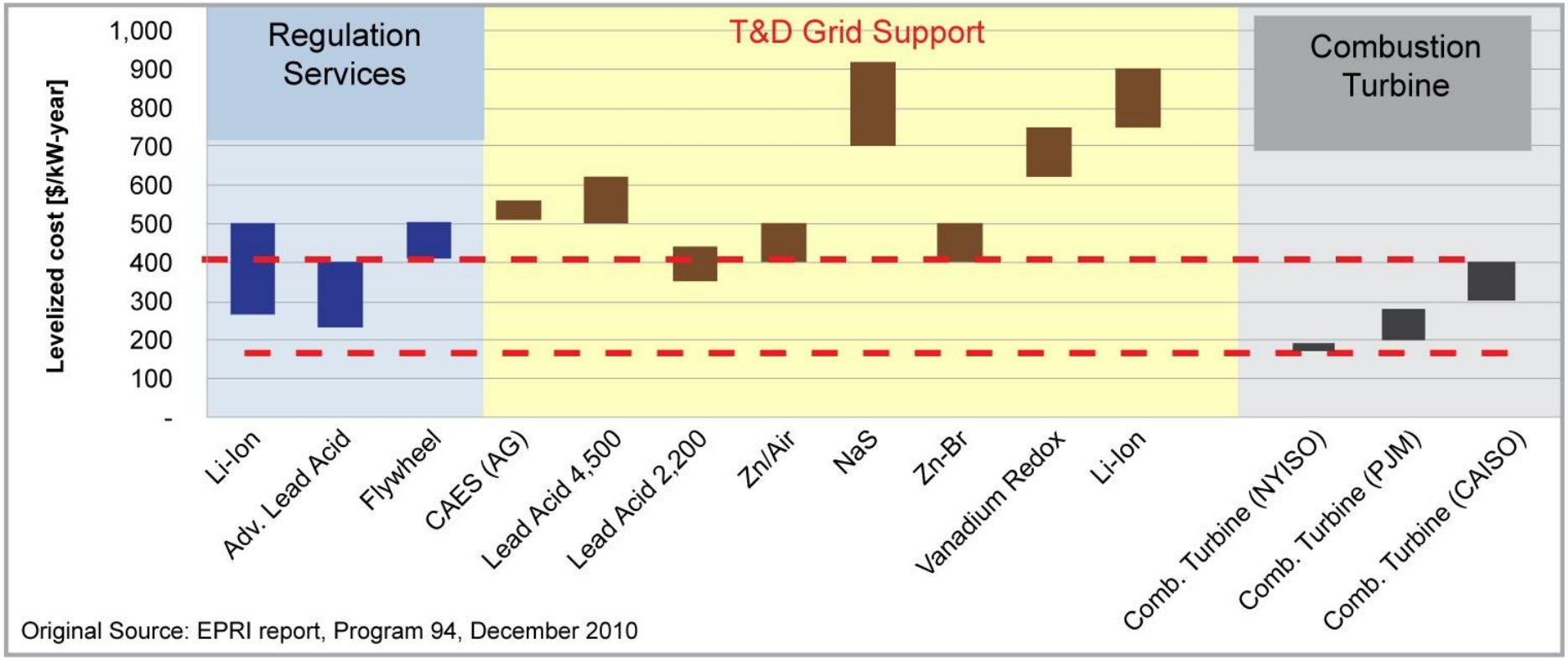
Levelized Total Cost of Energy Storage Technologies Relative to Combustion Turbine



- ***Some storage technologies are beginning to become competitive in selected Regulation Markets***
- ***Cost of many technologies still too high!!!!!!***

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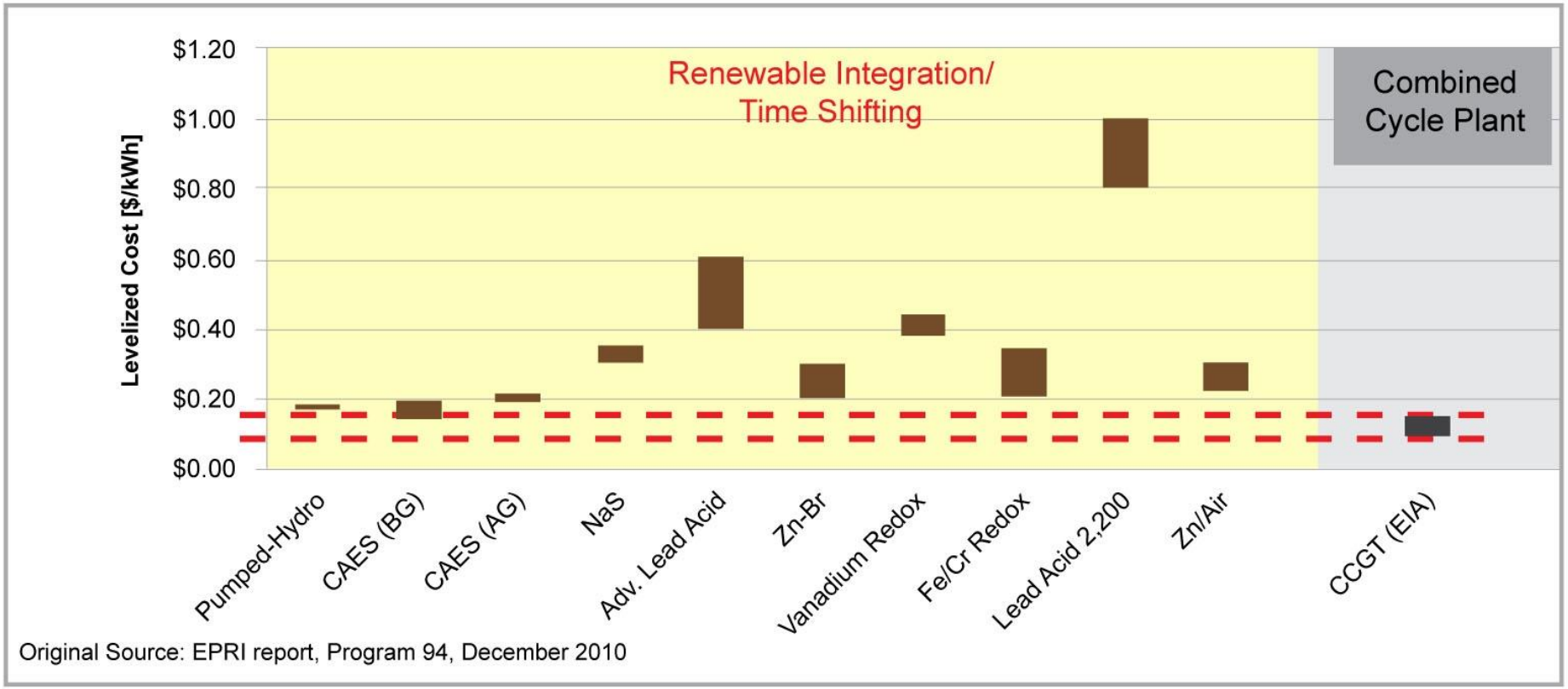

- Storage (levelized) costs of energy products >2~3 times higher, for broad market penetration

ARRA Funded Demonstration Projects
$185 M DOE Funded

Portfolio of DOE ARPA-E Projects

UNIVERSITY/ LAB

USC UNIVERSITY OF SOUTHERN CALIFORNIA

Rechargeable Fe-Air Battery

BERKELEY LAB

Advanced Flow Battery

CUNY The City University of New York

Rechargable $Zn\text{-}MnO_2$ Battery

SMALL BUSINESS

PRIMUS POWER Smart Grid Storage

New Flow Battery Electrode

FLUIDIC ENERGY

High Power Metal-air Storage

Proton ENERGY SYSTEMS

Neutral Water Fuel Cell

Beacon POWER

Long Duration Flywheel

GENERAL COMPRESSION expanding clean power

Fuel-Free Isothermal Compression

CORPORATION

United Technologies Research Center

Advanced Flow Battery

GENERAL ATOMICS AND AFFILIATED COMPANIES

Soluble Lead Flow Battery

ABB

2G-HTS SMES

BOEING

High-Energy Flywheel

Focus: Transformational approaches to energy storage to enable low cost

< 100/kW and < 100kW-h

Grid Energy Storage Summary

- Energy Storage Market is on the order of 14 GW if energy storage systems can be installed at about $750/kWh
  - Still must compete against energy efficiency, demand response, CCGT
- 5GW niche markets at $1400/kWh and multiple benefit can realized.
- High value applications include:
  - Regulation, commercial and industrial power quality and reliability
  - Stationary and transportable systems for grid support and T&D deferral
- Many Energy Storage technologies are too expensive
- R&D needs to focus on those issues that increase performance/reduce cost (materials, lifetime, durability)

Questions?

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