

Storing Electricity for Our Future

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Electricity Storage is a Transformational Opportunity

National Academy of Engineering named the electrical grid the greatest engineering achievement of the 20th century – the largest and most complex machine ever made.



Today

Supply



Instant
response



Demand

Electricity Storage Changes Everything

Supply



Demand



Ambri Overview



Company History

- Spun out of MIT in 2010
- Currently 22 employees in Cambridge, MA
- Based on 40 years of research by Professor Donald Sadoway in extreme electrochemical processes (e.g., aluminum smelting)
- Formerly Liquid Metal Battery Corporation



Core Development Principles

- Primary focus → low cost
- Simple to manufacture
- Use earth abundant materials



Ambri Differentiators

- Fast response & high energy: flexibly address a wide range of applications
- High efficiency, long lifespan, reliable
- Safe and silent
- No moving parts



Target Applications

- Integrate variable renewable resources like wind and solar
- Relieve grid congestion
- Avoid or defer investments in generation, transmission and distribution
- Enable end-users to optimize rates



Funding

- Private investors include Khosla Ventures, Bill Gates and Total
- Enabling grants from the Deshpande Center, the Chesonis Family Foundation, Lightspeed, US DOE ARPA-E and Total

TIME

2012

Professor Sadoway named Time's 100 most influential people in the world



2012

Mass High Tech "Startup to Watch"



2010

David Bradwell named MIT Technology Review's 35 innovators under 35

Ambri Origins



**Commercialization
2014 and Beyond**

Concept Envisioned.

Sadoway's 40 years of inspiring work on metallurgy and chemistry revealed potential of energy storage at grand scale

Concept Advanced.

Bradwell research (MS 2006, PhD 2010)

Operating Battery Cells.

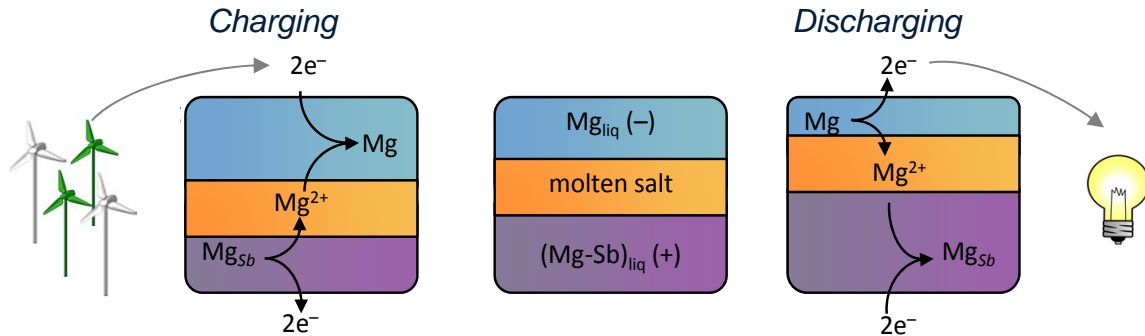
- Research funding from Deshpande Center, Chesonis Family Foundation, Total and ARPA-E
- Performance breakthroughs

Company Formed.

- Founded in 2010
- Funding from Khosla Ventures, Bill Gates and Total
- Team: 22 FTEs currently and expanding
- Building working cells in operating lab and managing to a development plan
- Identifying commercialization acceleration opportunities

The Liquid Metal Battery Concept

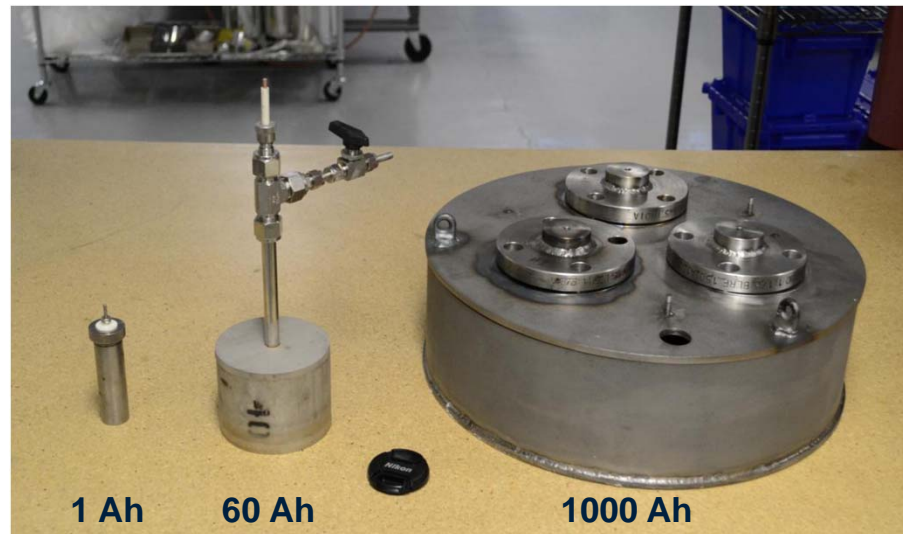
Battery Schematic



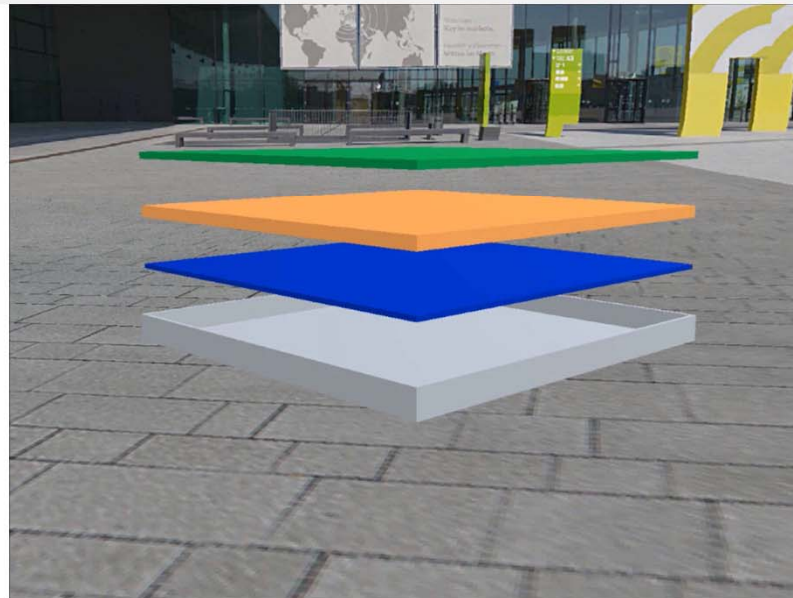
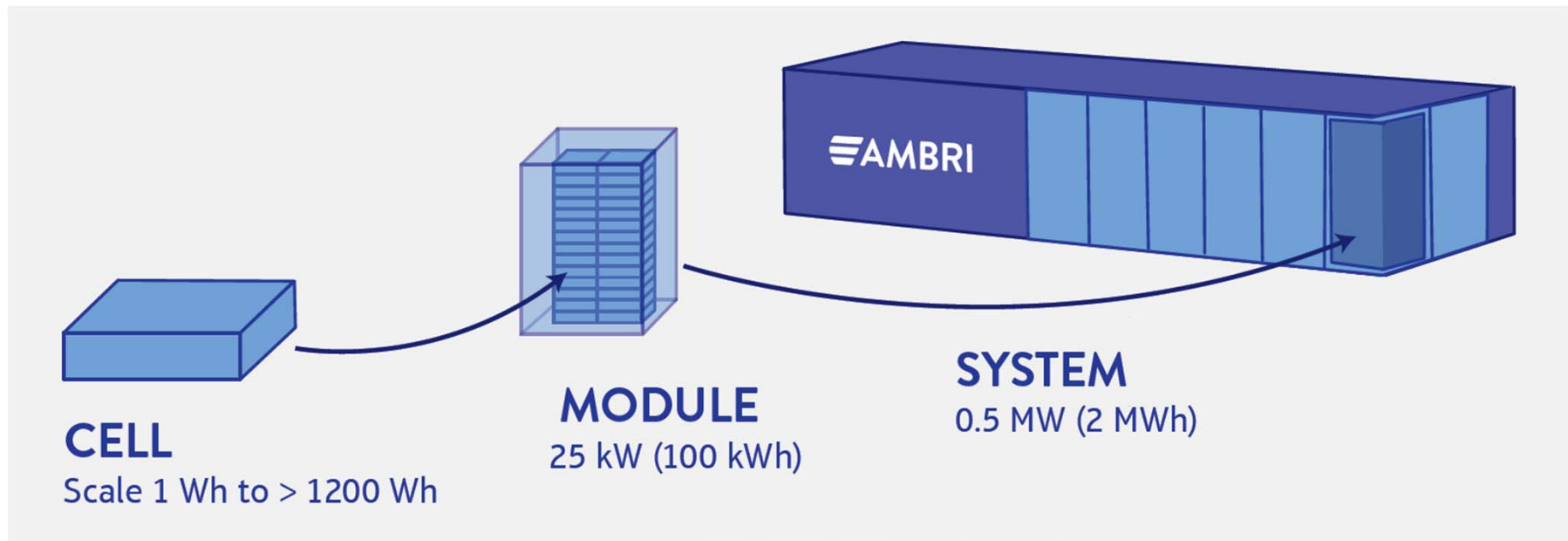
Characteristics

- Three liquid layers
- Self-separating (like oil and water)
- High temperature operation

Technology scale-up

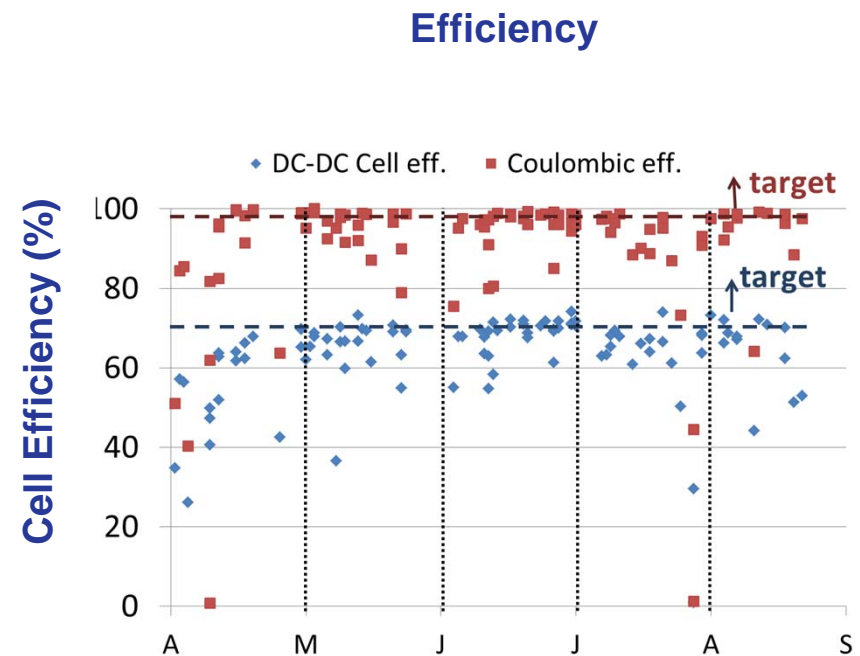
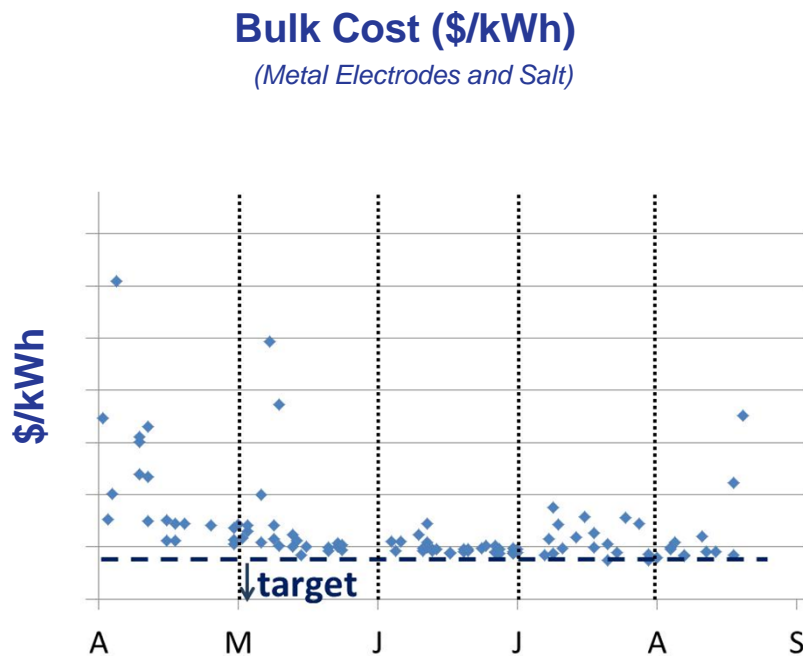


From Cells to Systems



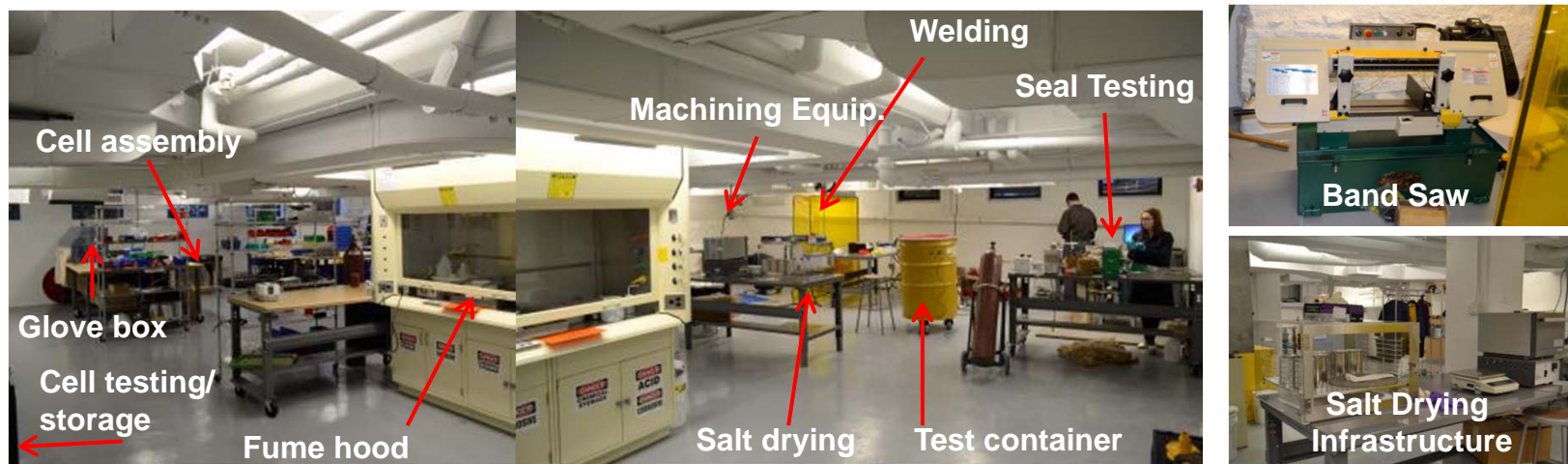
Technology Progress

The Ambri team cycled dozens of cells, demonstrating cost reductions and efficiency improvements.



The Ambri Laboratory

→ Main Laboratory



→ Cell Testing Equipment

100 A Battery Test Stand for Medium Cells



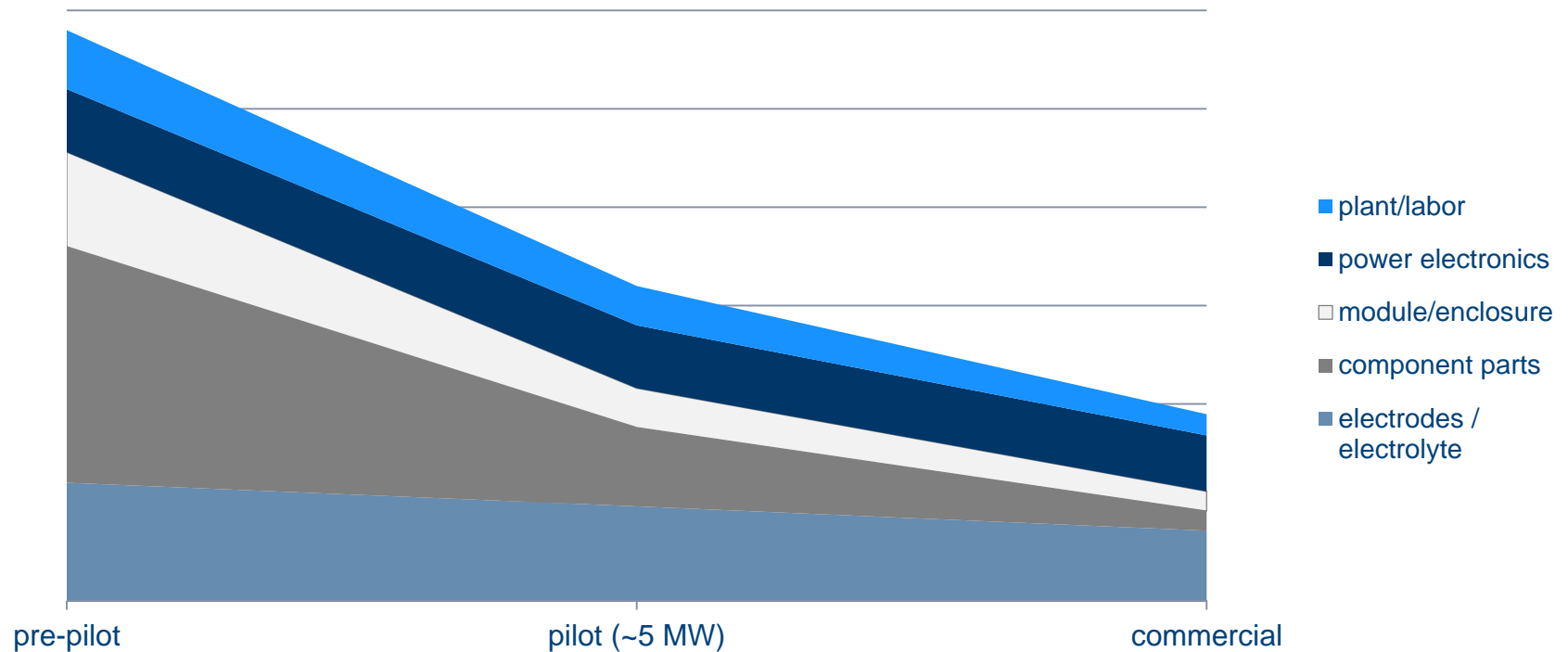
500 A Battery Test Stands for Large Cells



Ambri Unit Costs Will Decrease

Ambri has fast scale-up potential with projectable cost reductions.

- 10 MW annual production per plant would enable unit scale economies
- Likely able to utilize existing industrial metal working facilities – heating, stamping, assembly and welding are very familiar processes
- Envisioning dozens/hundreds of manufacturing sites world wide – ***globally serving local markets built locally***
- Minimal specialty equipment required – no clean room, no robotics required, open assembly



Ambri Differentiators

✓ Low cost

- made of earth-abundant materials and designed for simple manufacturing

✓ Fast response

- able to be dispatched in milliseconds in response to system signals

✓ High power & high energy

- able to provide *both* ancillary services and energy applications

✓ Silent, sealed and safe

- straightforward siting and permitting

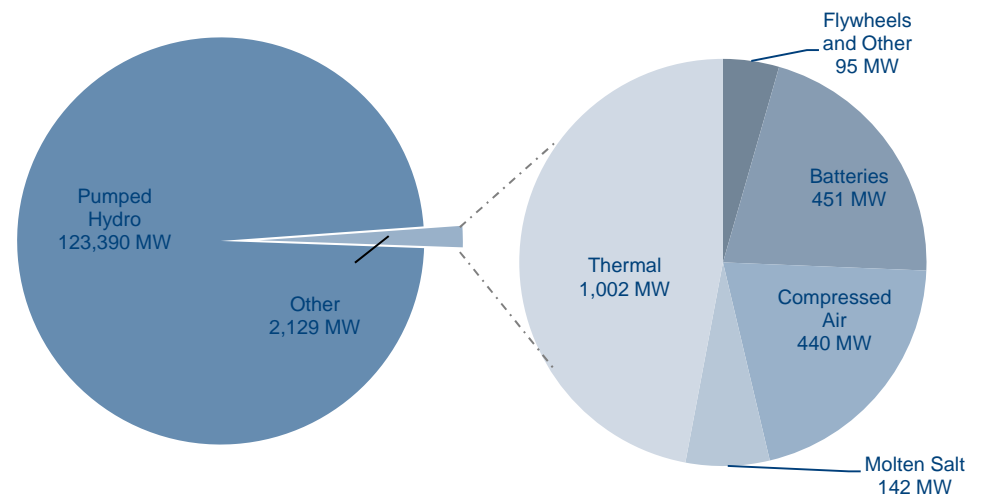
✓ Long lifespan

- will last for 10s of years with minimal maintenance costs and low capacity fade rate

Estimated Installed Capacity of Energy Storage in Global Grid (2011)

Total: 125,520 MW

Total Minus Pumped Hydro: 2,129 MW



Source: DOE

The Opportunity is Large, Many Potential Customers

Wholesale market opportunities

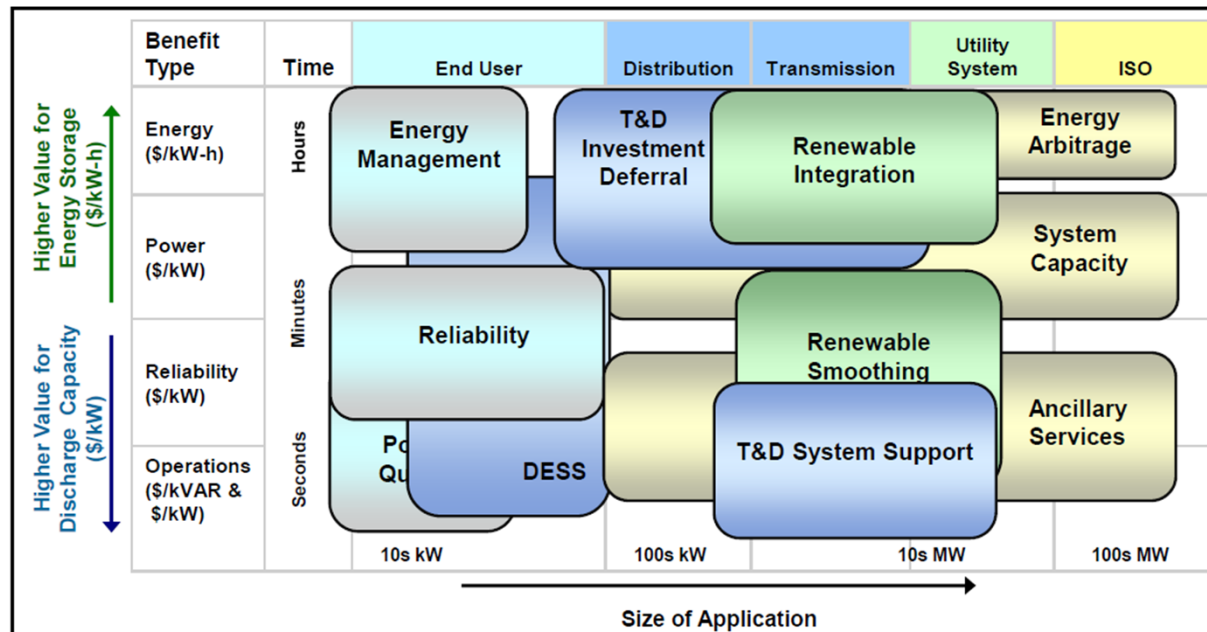
- Day ahead and real-time energy
- Capacity
- Ancillary services (frequency regulation, spinning and non-spinning reserves)
- Voltage/VAR control (reactive power)

Utility Value Proposition

- Integrate and smooth renewable resources
- Avoid transmission and distribution investments
- Meet peak demand
- Ensure reliable system operations

Retail Value Proposition (end customer)

- Avoid demand charges
- Optimize time of use rates
- Optimize energy purchasing strategies
- Provide uninterruptible power supply

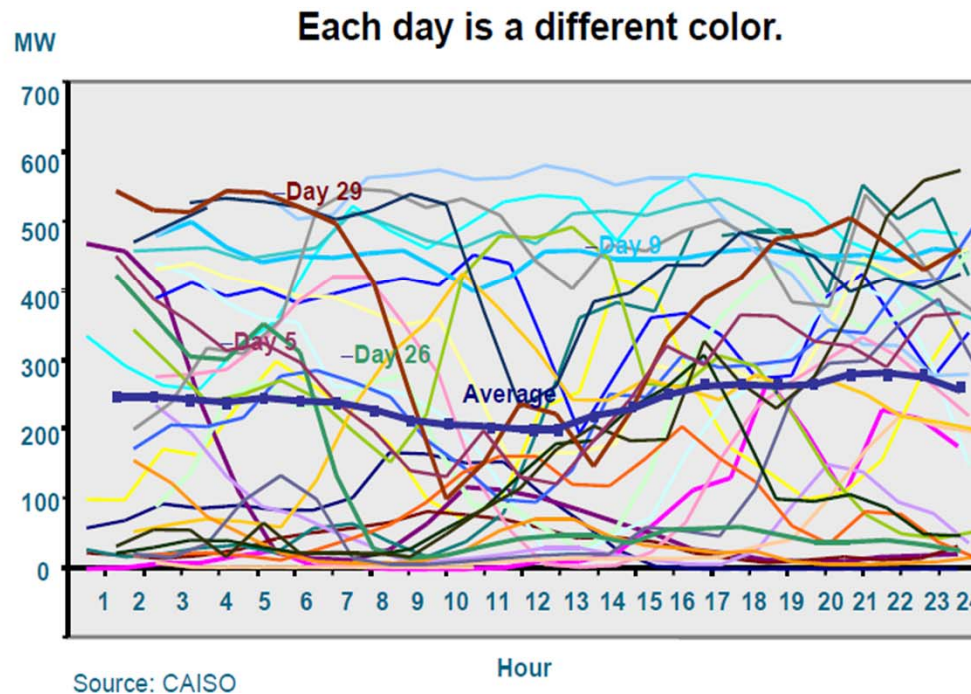


Source: EPRI.

Intermittent Resources Create Opportunity for Storage

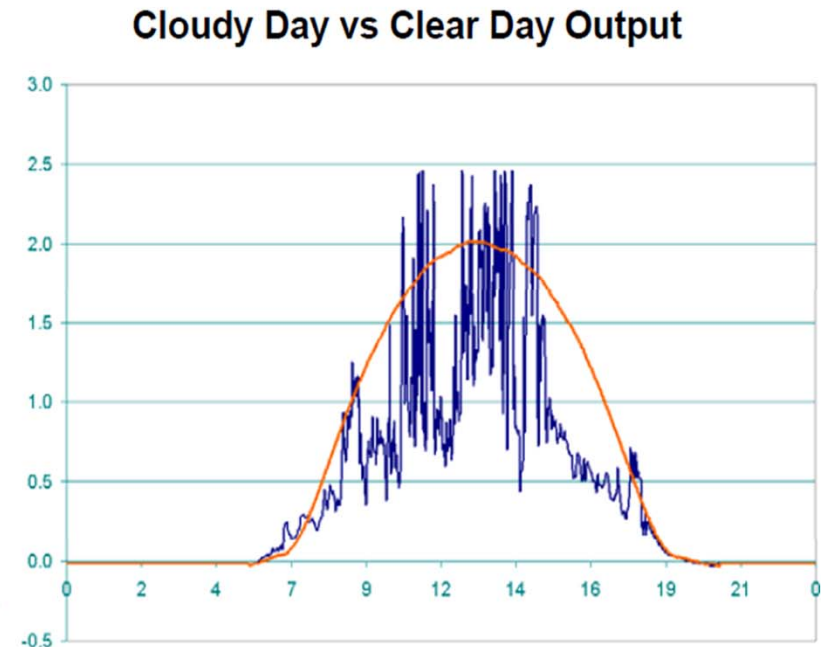
Increasing use of variable renewable resources creates new and extremely challenging conditions for electrical system operators – *cost effective, reliable electricity storage is well suited to meet this challenge.*

Wind



Source: CAISO; PG&E Presentation at ESA 2011

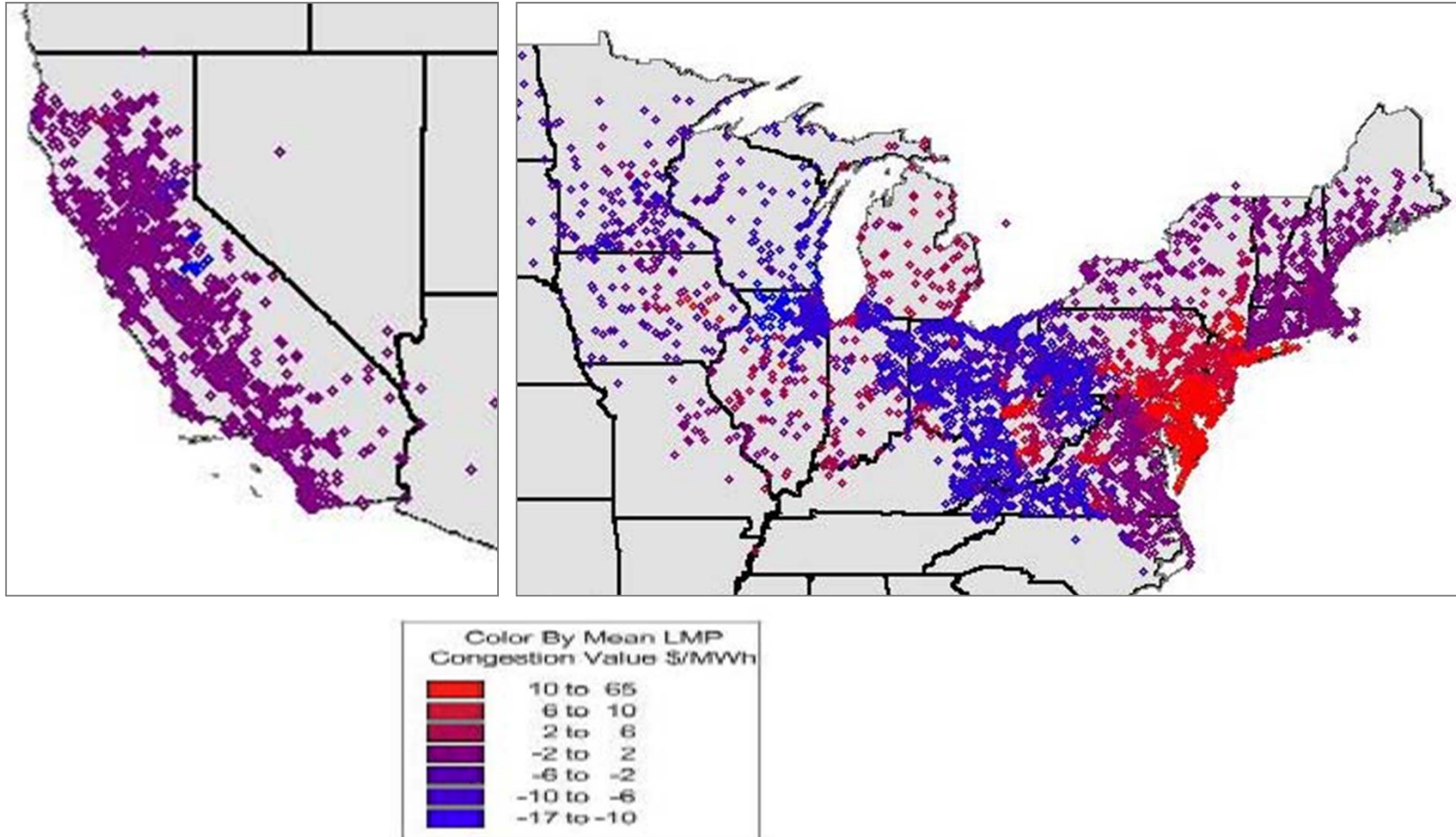
PV Solar



Congestion Creates Opportunity for Storage

Congestion creates substantial price variability in wholesale markets -- *cost effective, reliable electricity storage is well suited to reduce congestion.*

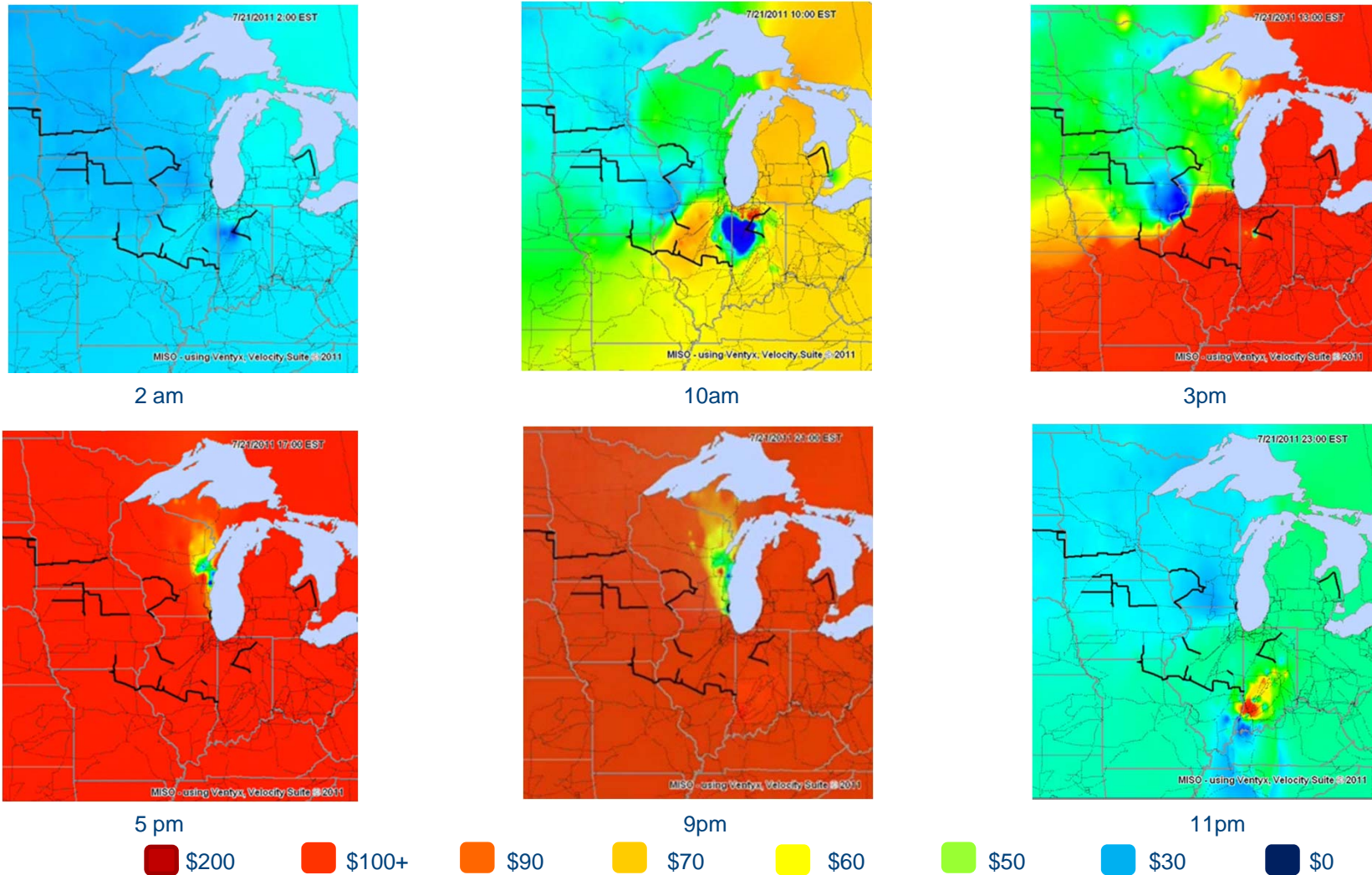
Day Ahead On-Peak Average Monthly Congestion - July 2011



Source: FERC, www.ferc.gov/oversight, updated August 12, 2011

Energy Arbitrage Opportunities Wholesale Markets

MISO LMP electricity prices over 24 hours



Source: MISO Analysis by Ryan Westphal. July 21, 2011, http://www.EnergyCollection.us/Companies/MidwestISO/MISO_LMP_7-21-2011.wmv

Electricity Needs are Large and Growing

- Consumed unevenly around the world and growing substantially
- Near-zero time lag between consumption and production
- Worldwide generation, transmission and distribution investments are projected to be approximately **\$17 trillion** between 2011-2030
- **20% or more of electricity needs will be better served with cost effective electricity storage**



Ambri 3-year plan

2012

- Commercial sized cells operating
- Initial power electronics and battery management systems determined
- Market and regulatory assessments underway
- Exploration and refinement of manufacturing options

2013

- Stacks of cells operating as prototype batteries with power electronics
- Market and regulatory prioritization and partnerships identified
- Manufacturing partnerships developed
- Determination of further investment needs (if any)

2014

- Initial battery installations
- Implemented:
 - Manufacturing partnership(s)
 - Marketing and sales partnership(s)
 - Regulatory monitoring and influence plans
- Global growth plans detailed

Thank you for your interest

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