Nevada Institute for Renewable Energy Commercialization

Renewable Energy and the Role of Energy Storage

Presented to:

IEEE Power and Energy Society General Meeting

July 26, 2011

Jim Croce
President and CEO

Presentation Agenda

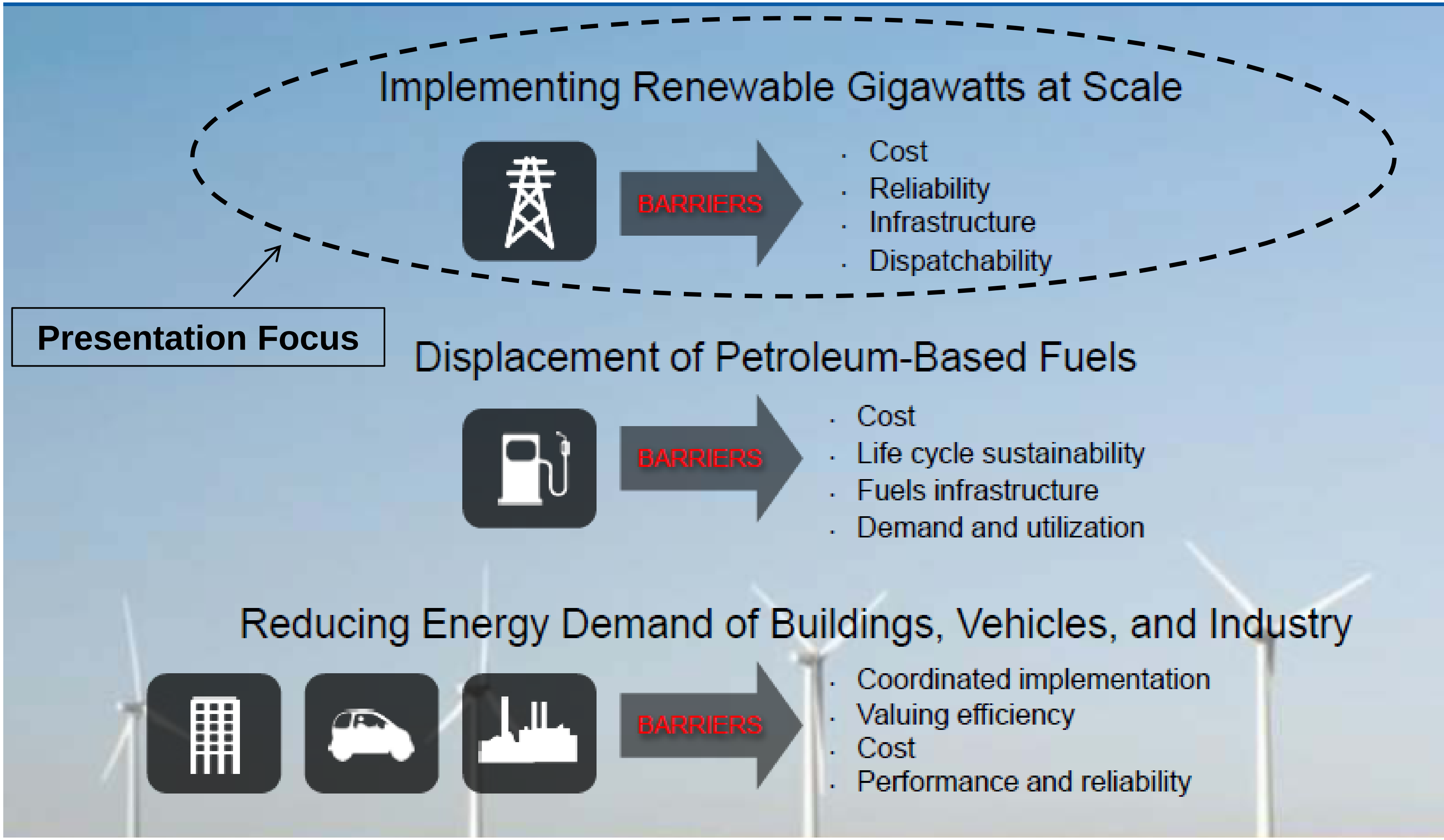
1. Overview of energy storage applications

2. Renewable energy integration challenges

3. Energy storage industry status and implementation challenges

4. Summary and Conclusions

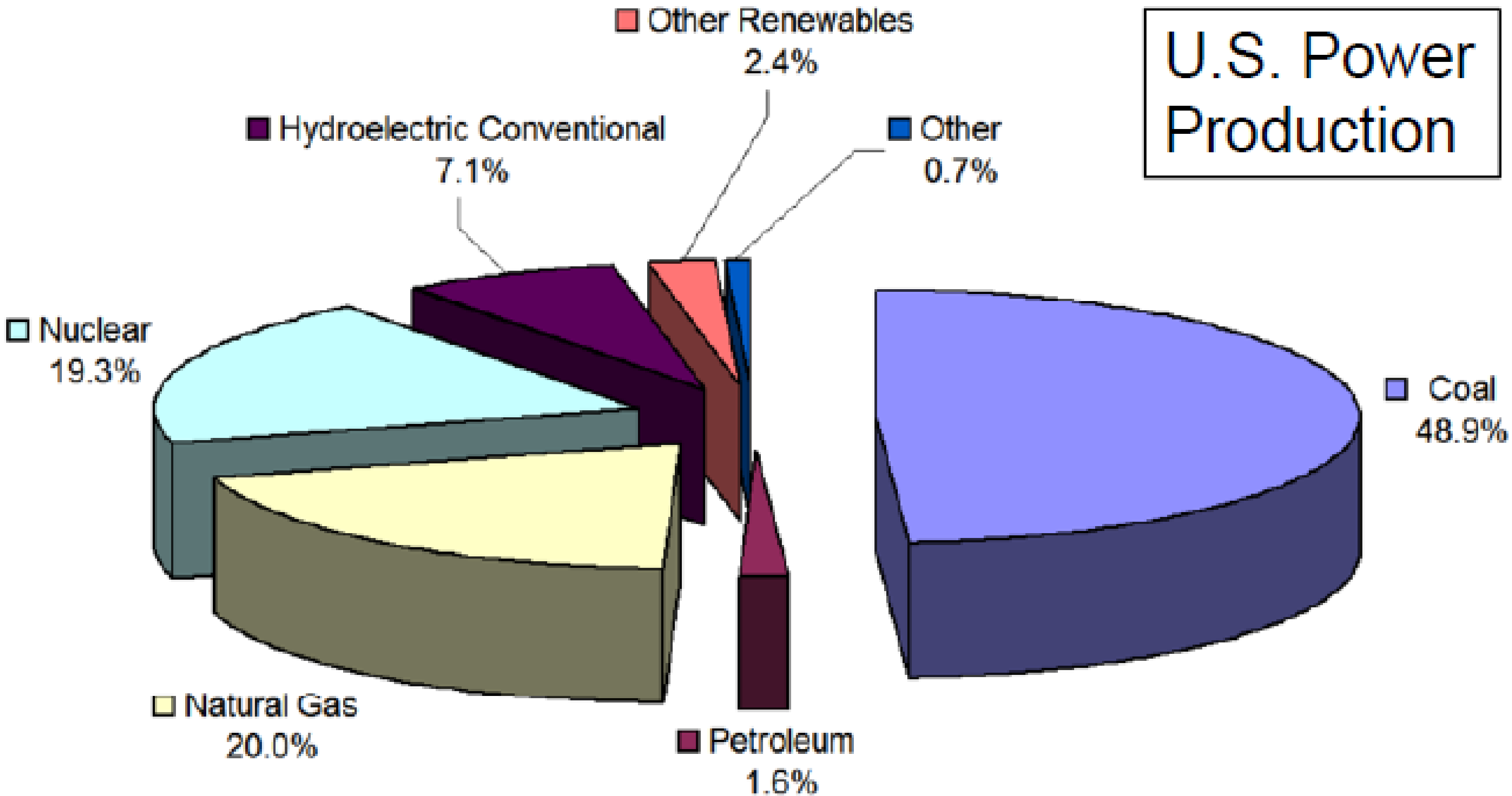
Key Energy Technology Challenges



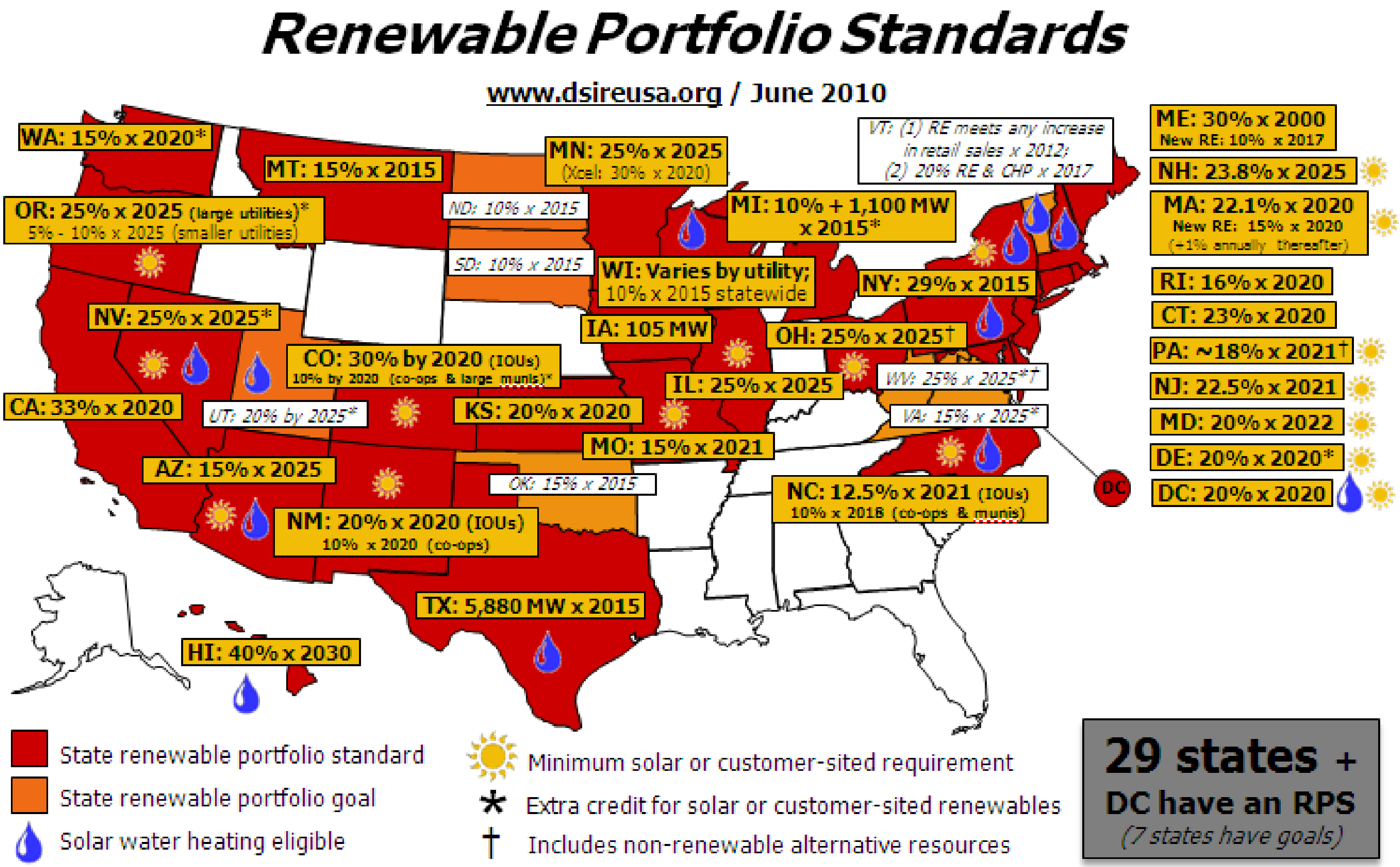
-- Energy storage has an enabling role in all sectors --

DOE NREL, April, 2009

Renewable Energy:
Still a Small Fraction of Total US Production

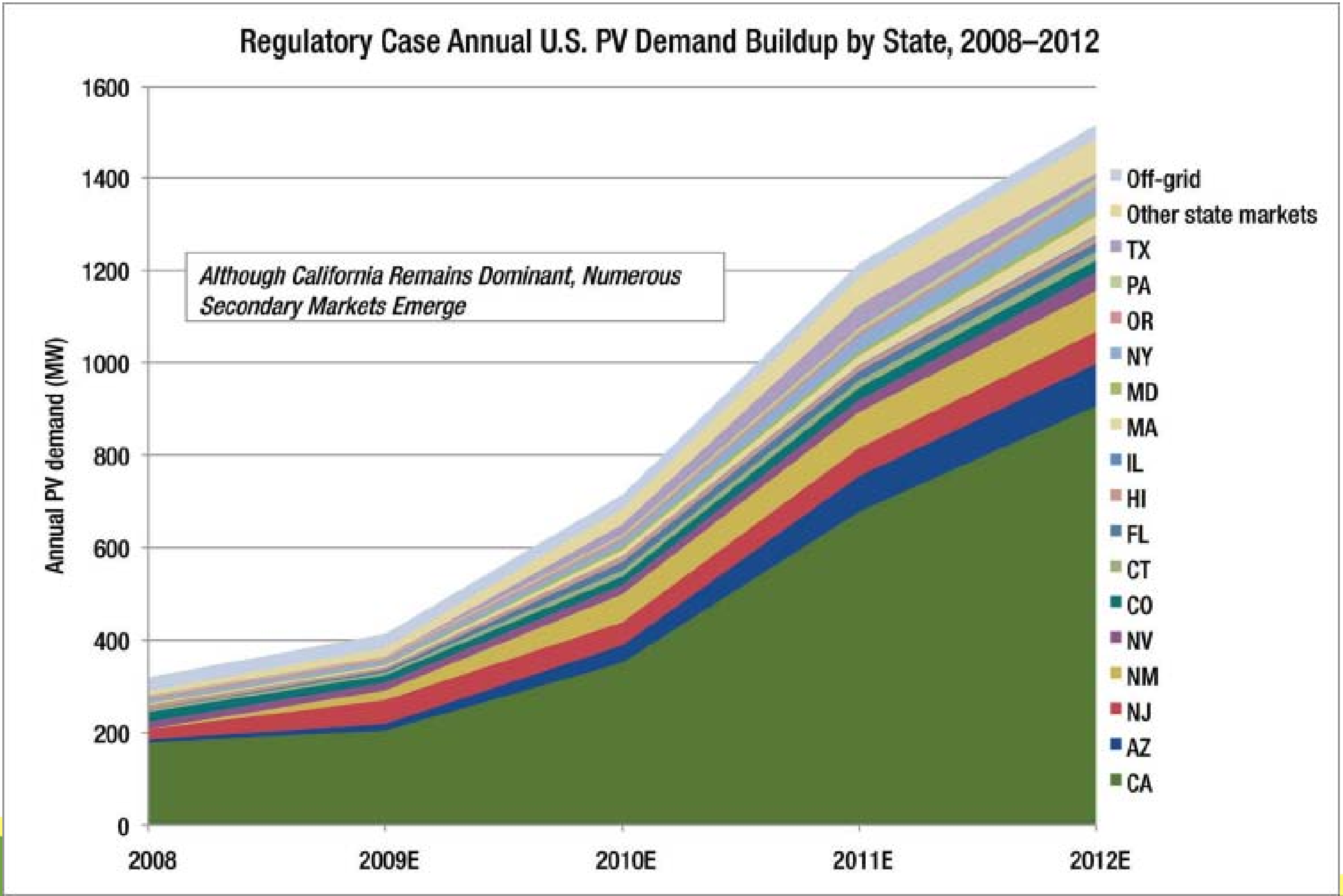


State RPS Incentives Provides Strong Impetus for Growth



Forecasted Growth in U. S. PV Demand

Source: GTM Research



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Bonneville Power: Harbinger of the Future?

BPA power lines at Oregon¿s Biglow Canyon facility   Photograph: Sam Churchill

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The Dalles dam on the Columbia River has been affected by extra snow-melt

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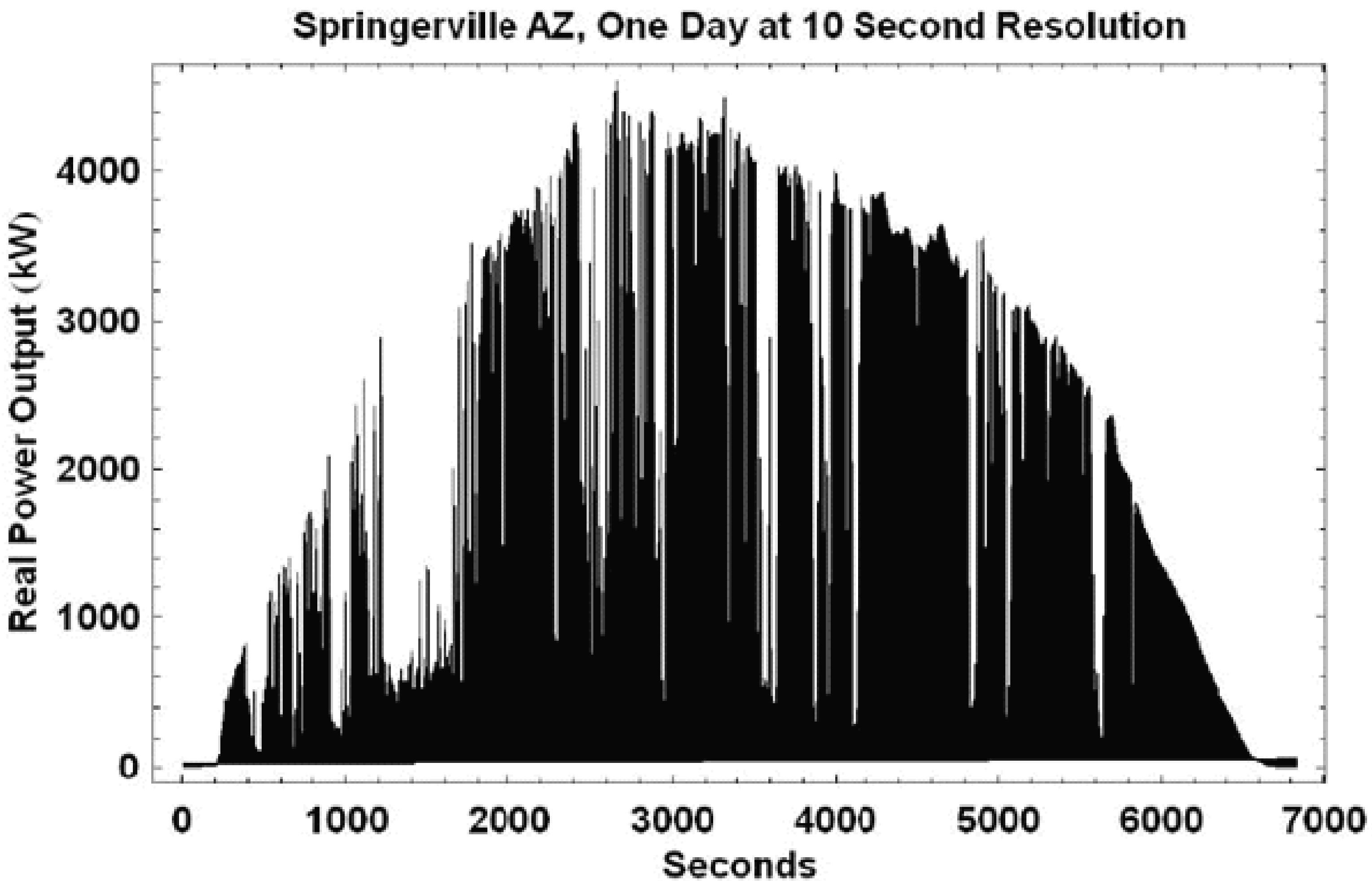
Spill at Bonneville Dam.   Photograph: Bonneville Power Administration

+ **Wind Curtailments**

Renewable Energy Integration Impacts

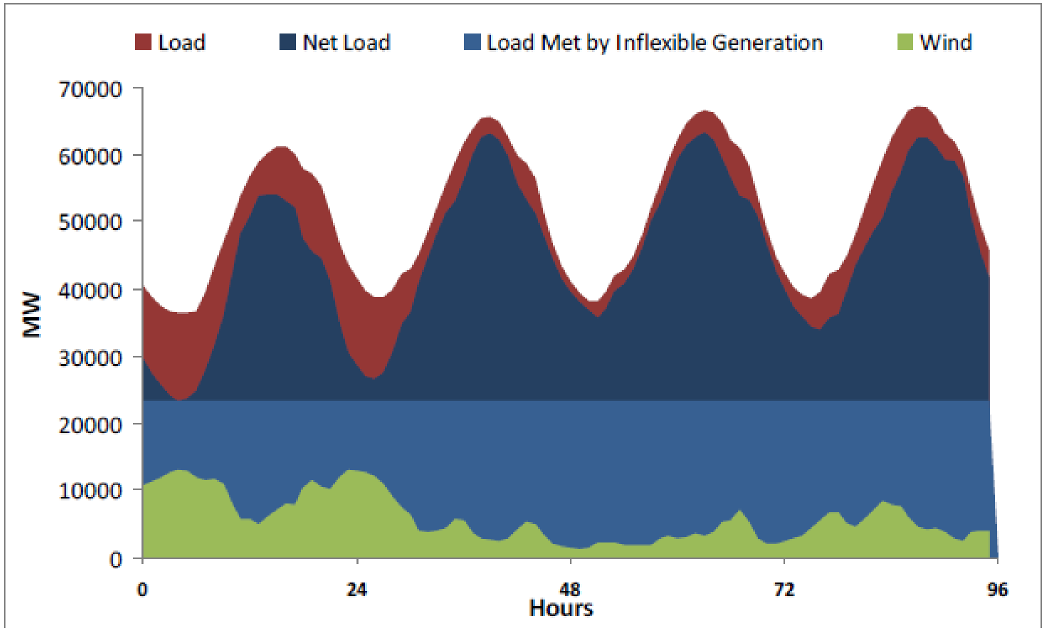
- Regulation services – resulting from the need for short-term ramping (seconds to minutes)
- Load following – resulting from the need for hourly ramping
- Resource uncertainty – resulting from having a suboptimal mix of units online because of errors in forecasting. Referred to as "unit commitment" or "scheduling cost"; involves costs associated with committing (turning on) too few or too many slow-starting, but lower operational-cost units.

Example - PV Intermittency
4.6 MW System

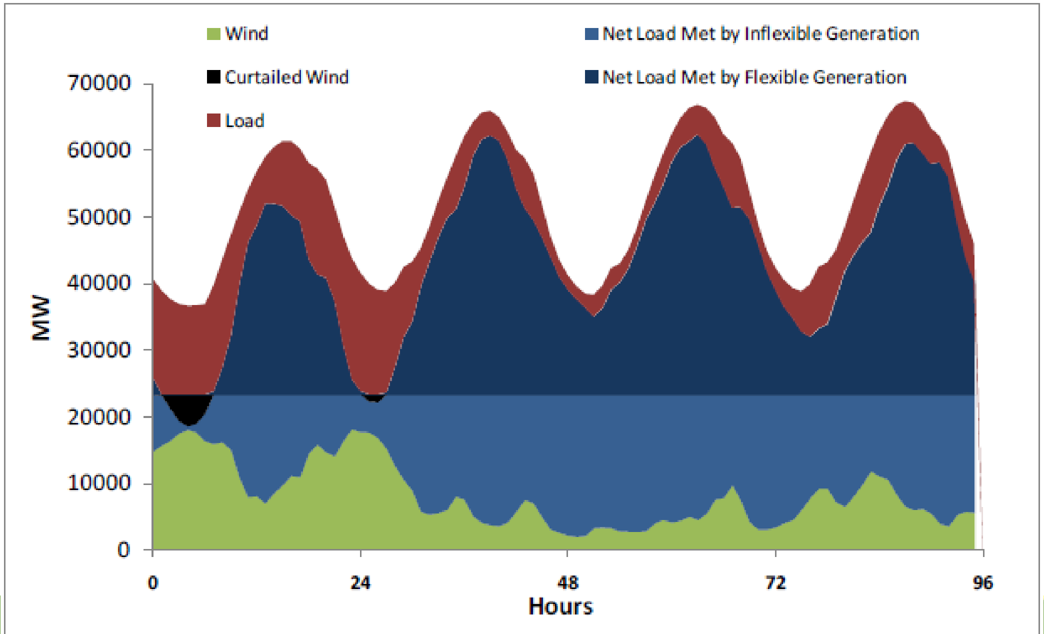


Carnegie Melon, CEIC, 08-04

Impact of Increasing Renewable Generation



Dispatch with low VG penetration (wind providing 8.5% of load)



Dispatch with higher VG penetration (wind providing 16% of load)

DOE NREL, January, 2010

Cost of Renewable Energy Integration

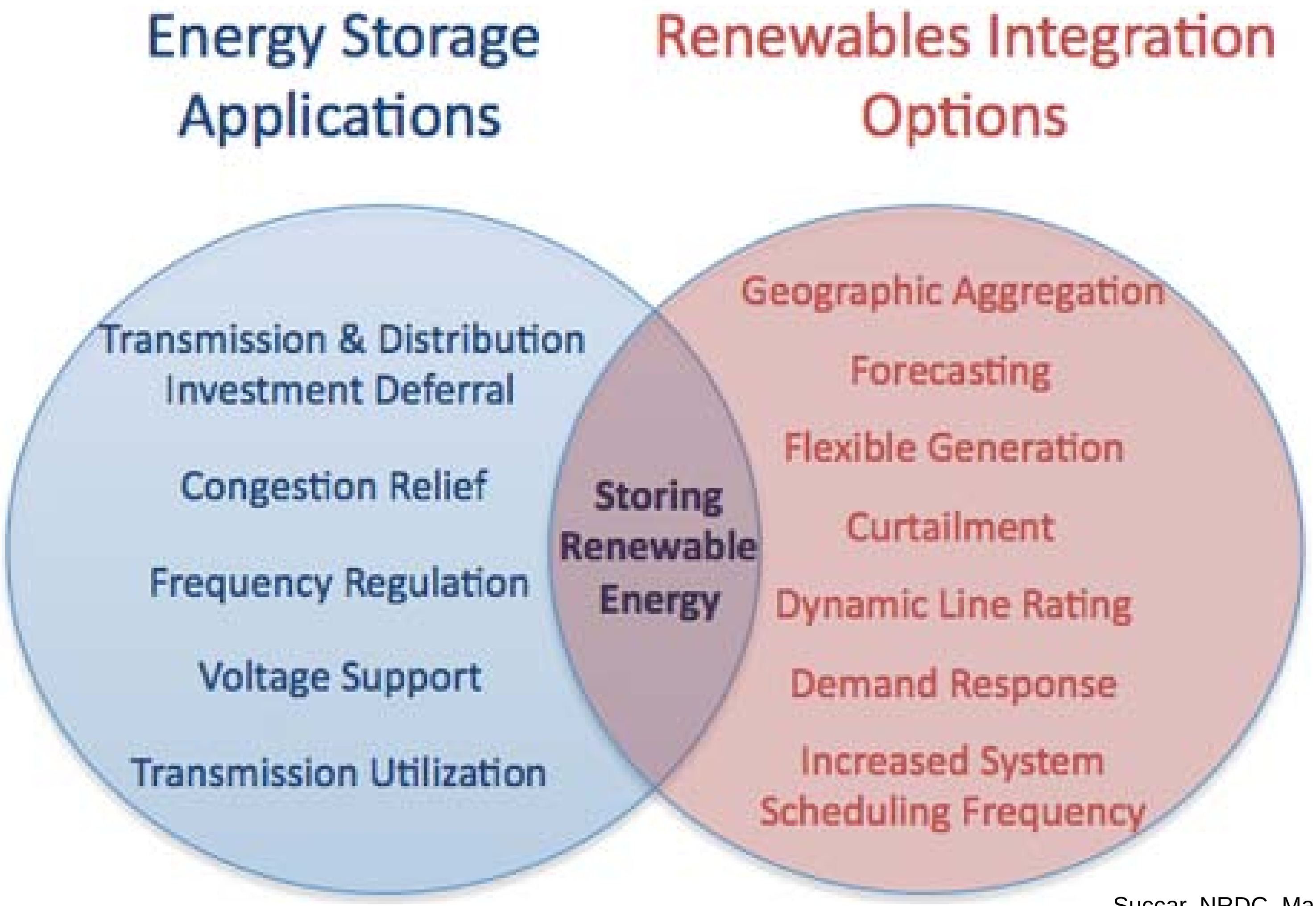
Table 4.1. Summary of Recent Wind Integration Cost Studies (DeCesaro et al. 2009)

Date	Study	Wind Capacity Penetration (%)	Regulation Cost ($/MWh)	Load-Following Cost ($/MWh)	Unit Commitment Cost ($/MWh)	Other ($/MWh)	**Tot Oper. Cost Impact ($/MWh)**
2003	Xcel-UWIG	3.5	0	0.41	1.44	Na	**1.85**
2003	WE Energies	29	1.02	0.15	1.75	Na	**2.92**
2004	Xcel-MNDOC	15	0.23	na	4.37	Na	**4.6**
2005	PacifiCorp-2004	11	0	1.48	3.16	Na	**4.64**
2006	Calif. (multi-year)[a]	4	0.45	trace	trace	Na	**0.45**
2006	Xcel-PSCo[b]	15	0.2	na	3.32	1.45	**4.97**
2006	MN-MISO[c]	36	na	na	na	na	**4.41**
2007	Puget Sound Energy	12	na	na	na	na	**6.94**
2007	Arizona Pub. Service	15	0.37	2.65	1.06	na	**4.08**
2007	Avista Utilities[d]	30	1.43	4.4	3	na	**8.84**
2007	Idaho Power	20	na	na	na	na	**7.92**
2007	PacifiCorp-2007	18	na	1.1	4	na	**5.1**
2008	Xcel-PSCo[e]	20	na	na	na	na	**8.56**

[a] Regulation costs represent 3-year average.
[b] The Xcel/PSCO study also examine the cost of gas supply scheduling. Wind increases the uncertainty of gas requirements and may increase costs of gas supply contracts.
[c] Highest over 3-year evaluation period. 30.7% capacity penetration corresponding to 25% energy penetration
[d] Unit commitment includes cost of wind forecast error.
[e] This integration cost reflects a $10/MMBtu natural gas scenario. This cost is much higher than the integration cost calculated for Xcel-PSCo in 2006, in large measure due to the higher natural gas price: had the gas price from the 2006 study been used in the 2008 study, the integration cost would drop from $8.56/MWh to $5.13/MWh.

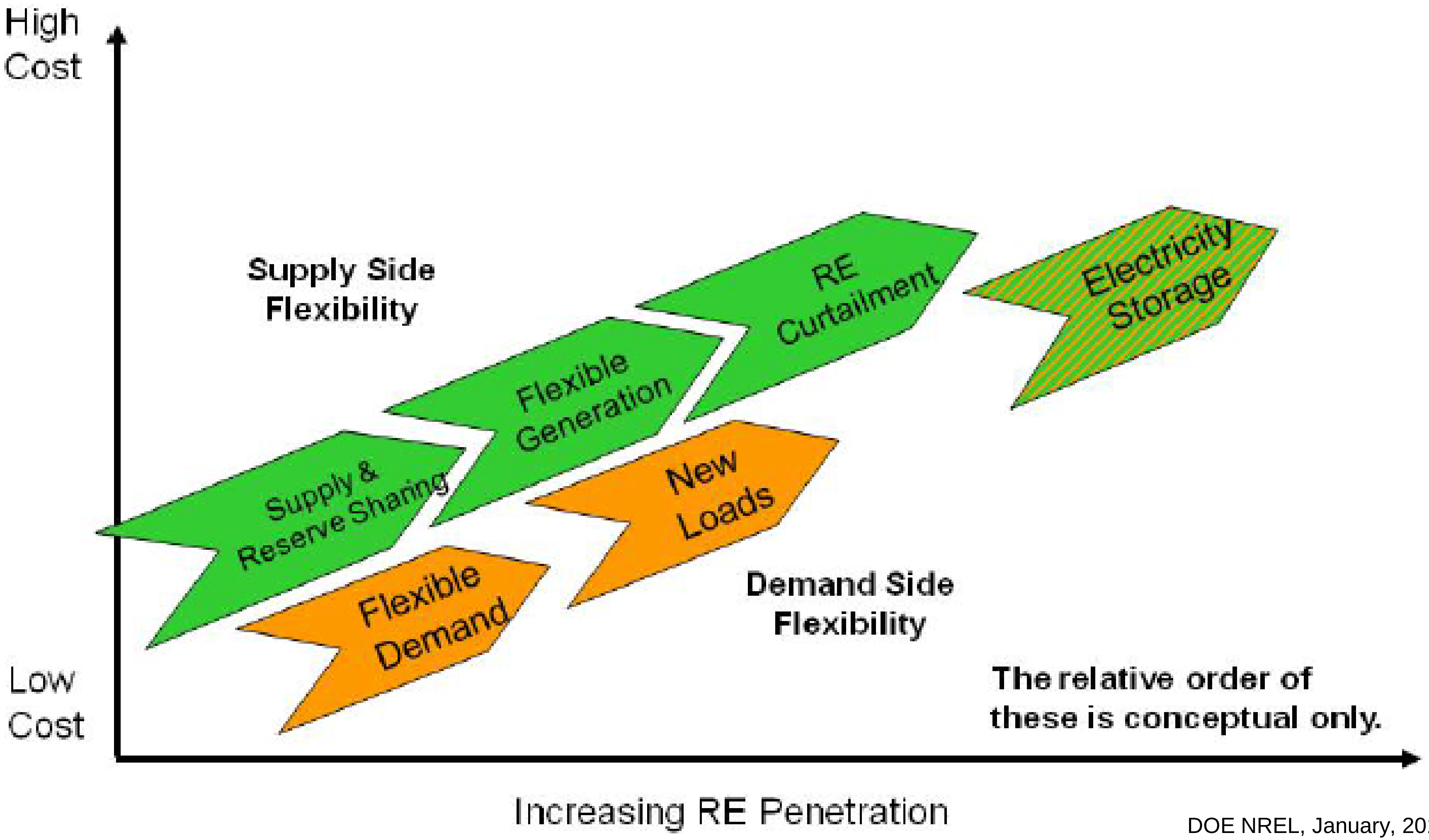
DOE NREL, January, 2010

Many Energy Storage Applications …
Many Renewables Integration Options



Succar, NRDC, March, 2011

Relative Costs of RE Integration Strategies



DOE NREL, January, 2010

Multiple Benefits of Energy Storage for Integrating Renewables

- Provides regulation services – precisely match generation to load (sec-by-sec)
- Provides load following – adjusts to shifts in wind and solar over mins to hrs
- Provides ramping – adjusts to shifts in wind and solar over multiple hours

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- Provides operating reserves, without adding energy to the grid (and emissions), reducing the need for partially loaded thermal generators
- Zero emissions at point of operation
- Uses no water
- Quiet operation

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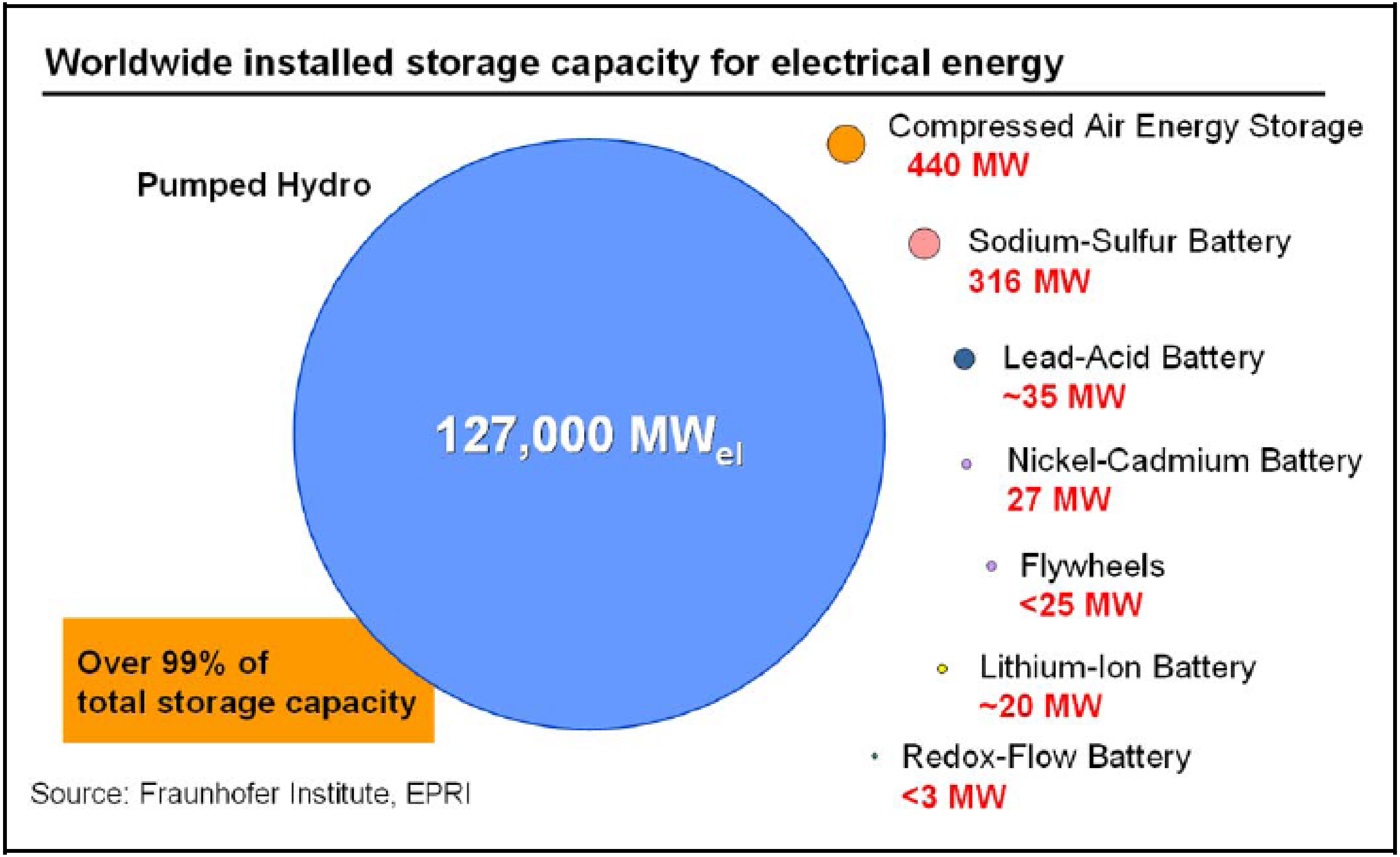
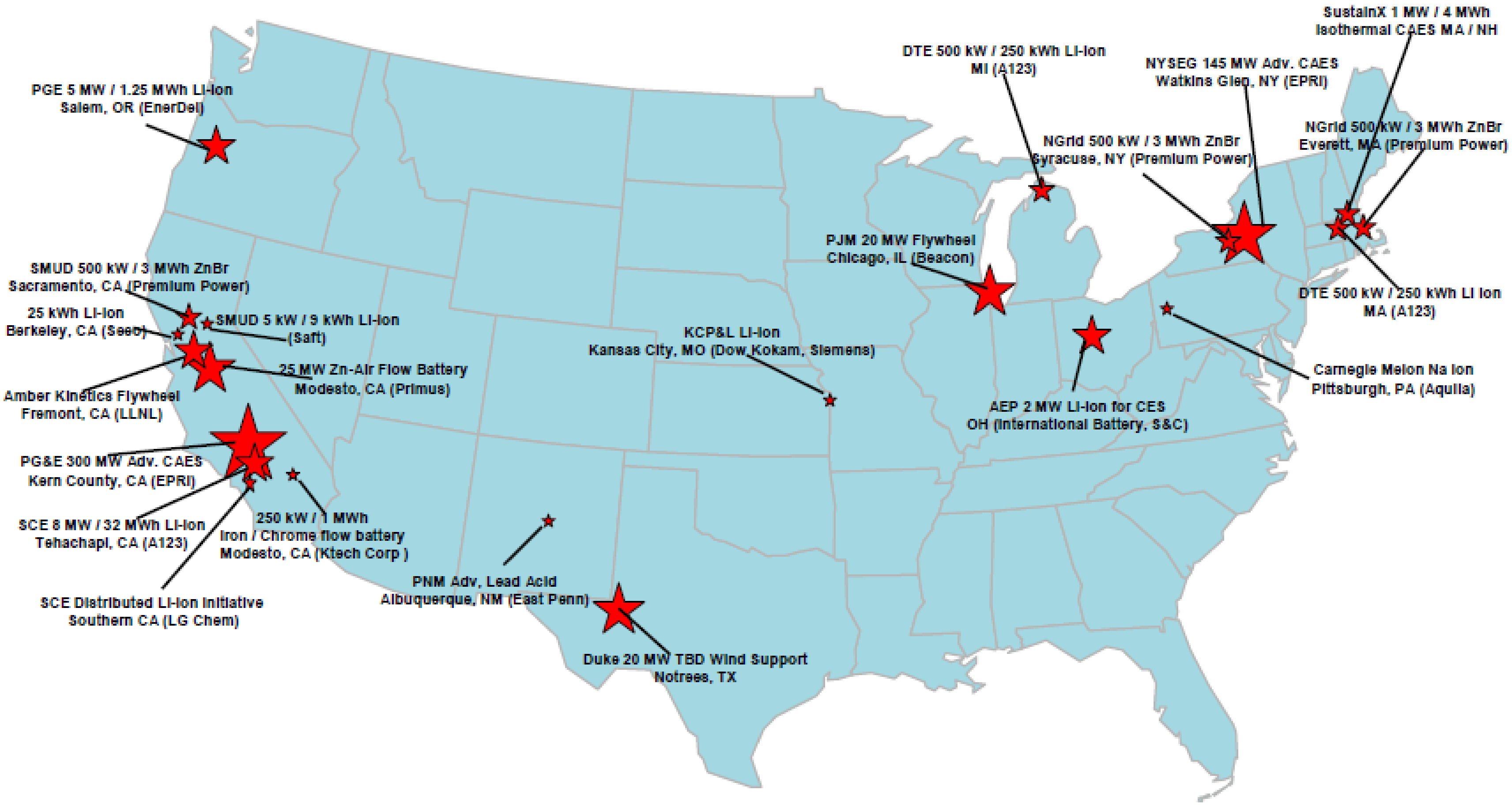
Installed Energy Storage Capacity – Dominated by Pumped Hydro



Growing List of Non-Hydro Demonstrations

What Utilities Are Doing in Energy Storage

(AARA Funded Utility-Scale Projects)



EPRI, December, 2010

What Impedes Large Scale Energy Storage?

- Massive capital requirements to scale
- Unproven business models
  - Benefits often accrue to parties other than those making the investments
  - Highly fragmented, regional markets
- Incumbents not incentivized to invest (without significant federal support)
- Under-investment in federal R & D
- Regulatory uncertainty

Significant Regulatory Uncertainty / Issues

- Generation, transmission, distribution or end- user asset?
  - Who owns, operates, maintains
  - Who's taking the risk…Who's reaping the benefits?
  - Cost recovery
- Who has Jurisdiction of storage system installation and operation? (e.g. State vs. Federal)
  - Approval
  - Operation
  - Rate case, Tariffs
- Bi-directional flow does not fit into conventional regulatory model

Regulatory Enablers – California Leads the Way

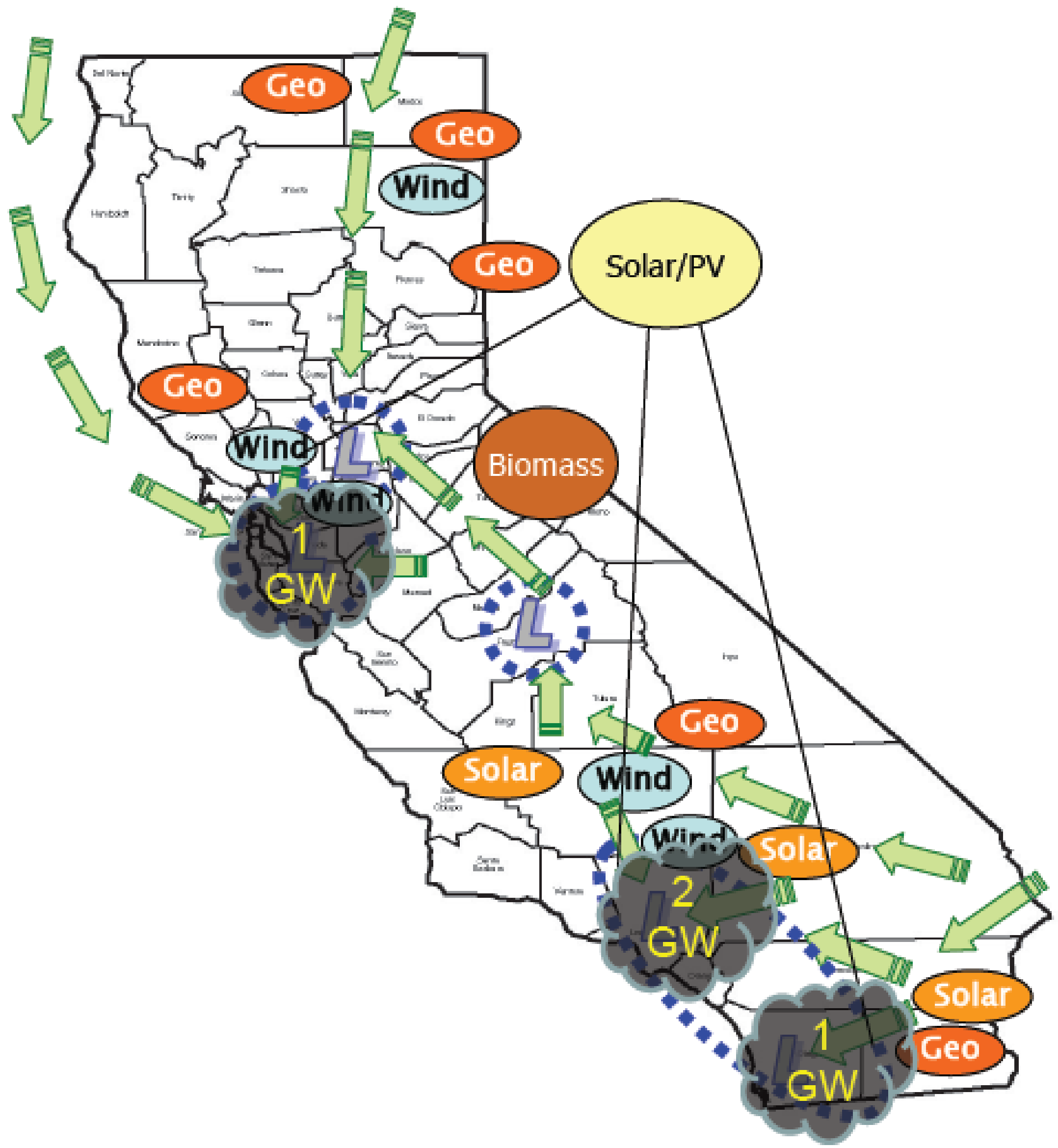
Why California?

Energy storage is fundamental to many key California policy initiatives that are shaping the storage market today

- Its BIG: 13% of US GDP, 8th largest economy in the world (if it were a country), ahead of Canada and Spain
- 'Foundational' Legislation
  - Energy Storage Procurement Targets: (AB 2514)
  - RPS Legislation (SB 722, introduced)
  - Self-Generation Incentive Program: SGIP (SB 412)
  - Smart Grid Systems (SB 17)
  - Global Warming Solutions Act of 2006 (AB 32)
  - Solar Energy System Incentives: CSI (SB 1)
- Pro-storage policy makers in Legislature and at key agencies: California Public Utility Commission, Energy Commission & California Air Resources Board
- Incentives available for customer sited applications via SGIP and possibly PLS too
- Non-Generator Participation in Ancillary Services Stakeholder Process—California Independent System Operator (CAISO)
- Many CA storage projects currently underway

Source: Strategen

How Much Storage is Needed in CA?



California 2020 Vision

(33% Renewables)

Storage Target (conservative):
5% Peak = 4 GW

Storage Attributes:
No Emissions, Water, Noise

Displaces 4 GW Transmission & Distribution

Provides 4 GW RA Capacity

Provides 8 GW Dispatchable Ramping, Load Following, and Regulation

Provides 4 GW Over Generation Protection

Provides 4 GW Voltage Support

Need to refocus CA Transmission, Distribution and Generation Planning.

Summary

1. The renewable energy industry will continue to experience rapid growth to meet state policy (RPS) goals
   - Limiting factor is operational impact on the electric grid (integration issues)

2. Energy storage is viewed by many as a “must-have” to solve renewable integration challenges

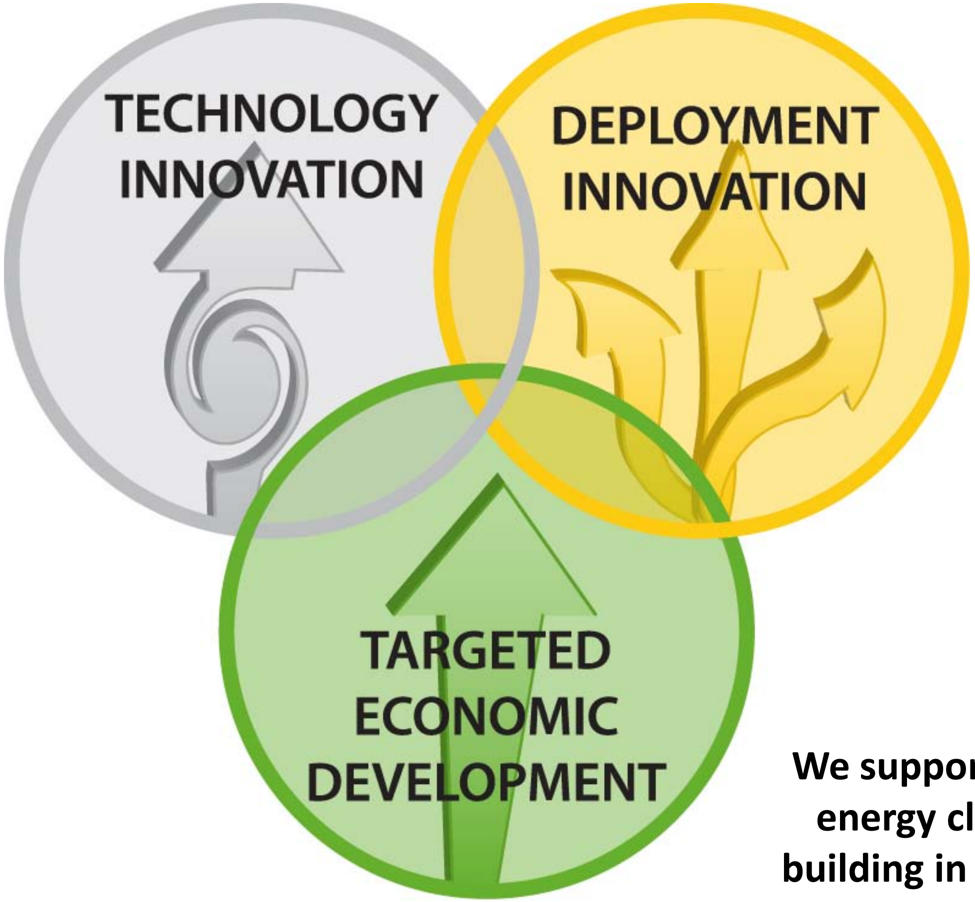
3. Given many solutions to mitigate renewable integration issues, bulk electricity storage faces strong competition over the foreseeable future – costs must continue to decrease

4. Growth in storage market will largely depend upon the pace of required regulatory changes to monetize benefits among disparate stakeholders

NIREC Business Focus

NIREC is a non-profit corporation whose mission is to accelerate clean energy innovations from the laboratory to the market

We mentor clean energy companies *nationwide*



We enable RE project development in the *western U.S.*

We support clean energy cluster-building in *Nevada*

NIREC - Regional and National Partnerships

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Thank You.