Energy Storage Opportunities and Challenges

Presentation to NPCC Generating Resources Advisory Committee

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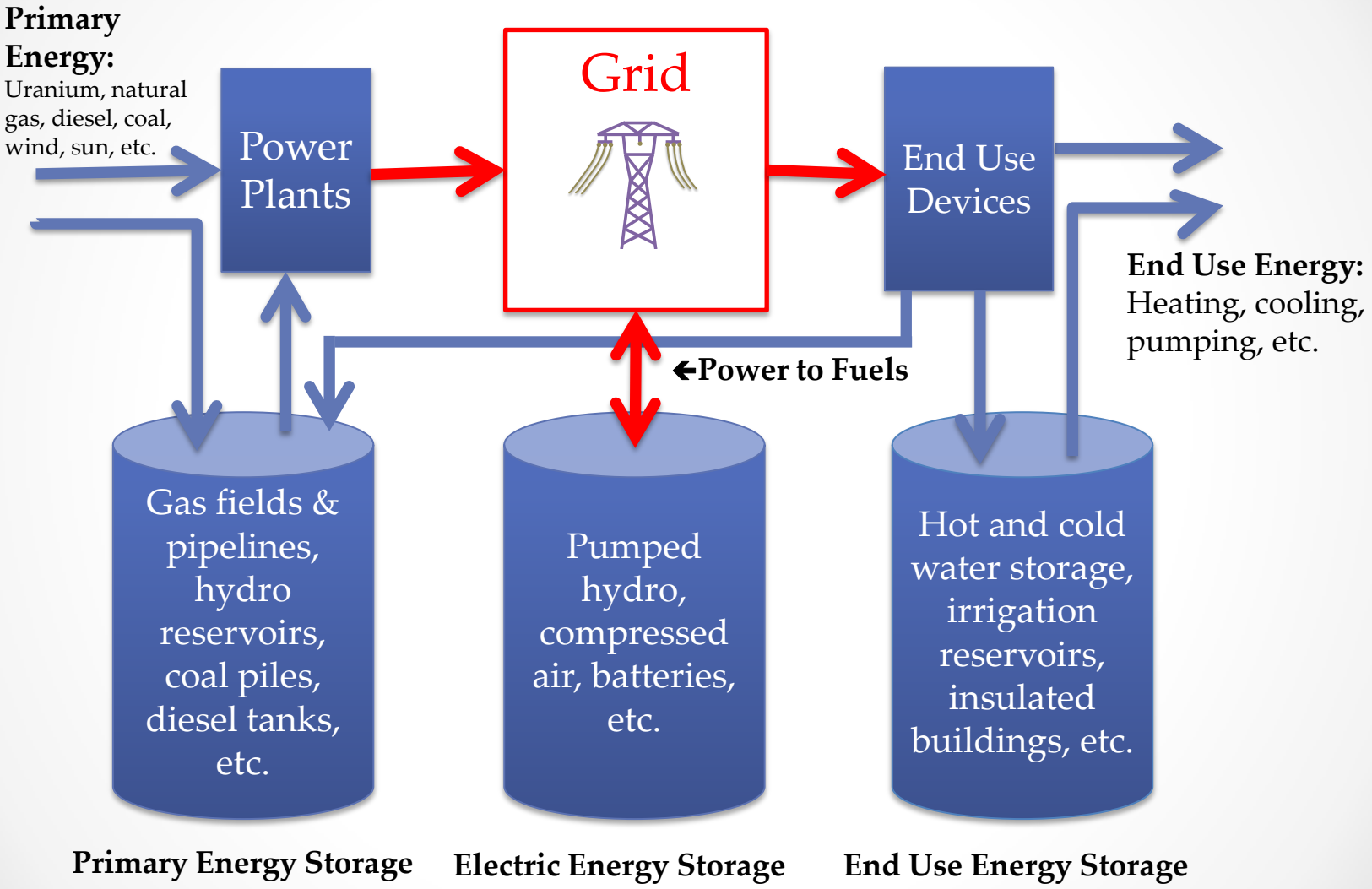
Interest in Energy Storage

- The interest in energy storage seems to be exploding.
  - Papers relating to energy storage proliferating.
  - Research and development at fever pitch– new technologies being developed.
  - Increasing need for flexible resources due to push for renewable energy.
  - Policy and regulatory intervention to facilitate energy storage.

Generalized View of Energy Storage



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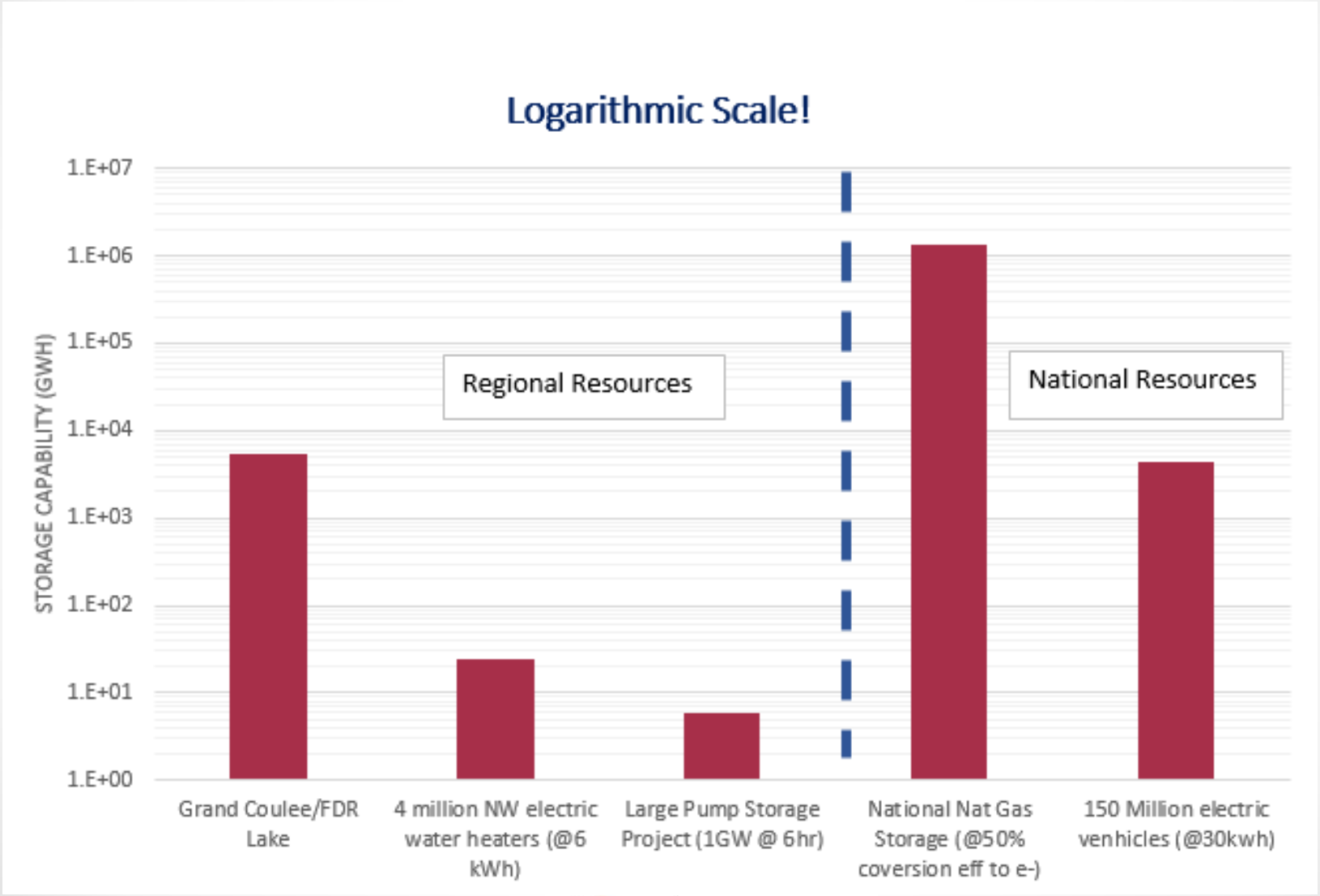
Energy Storage Comparison



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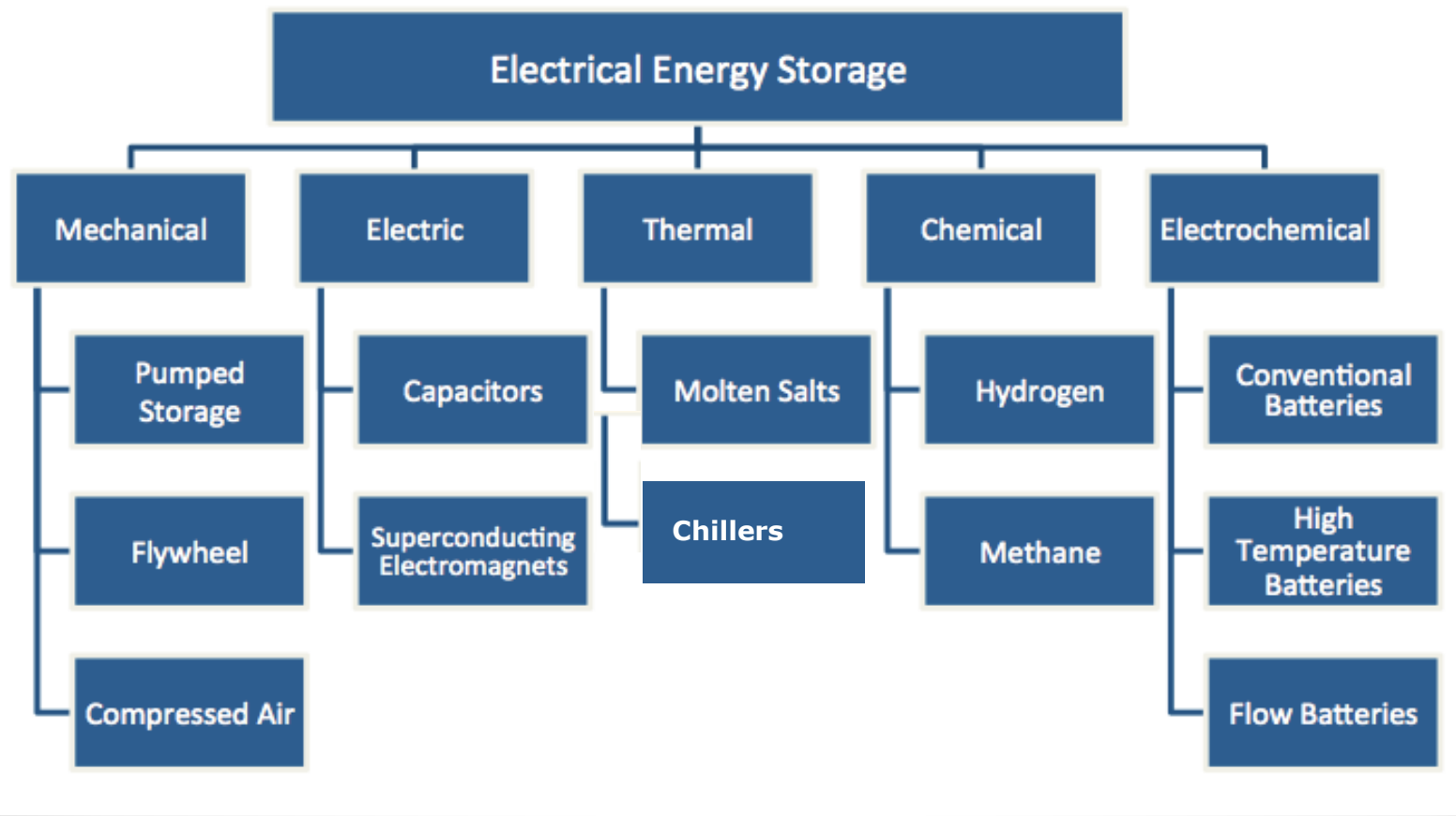
Technologies

- There is a full taxonomy of storage technologies, many of them developing rapidly, but also including some old standards.



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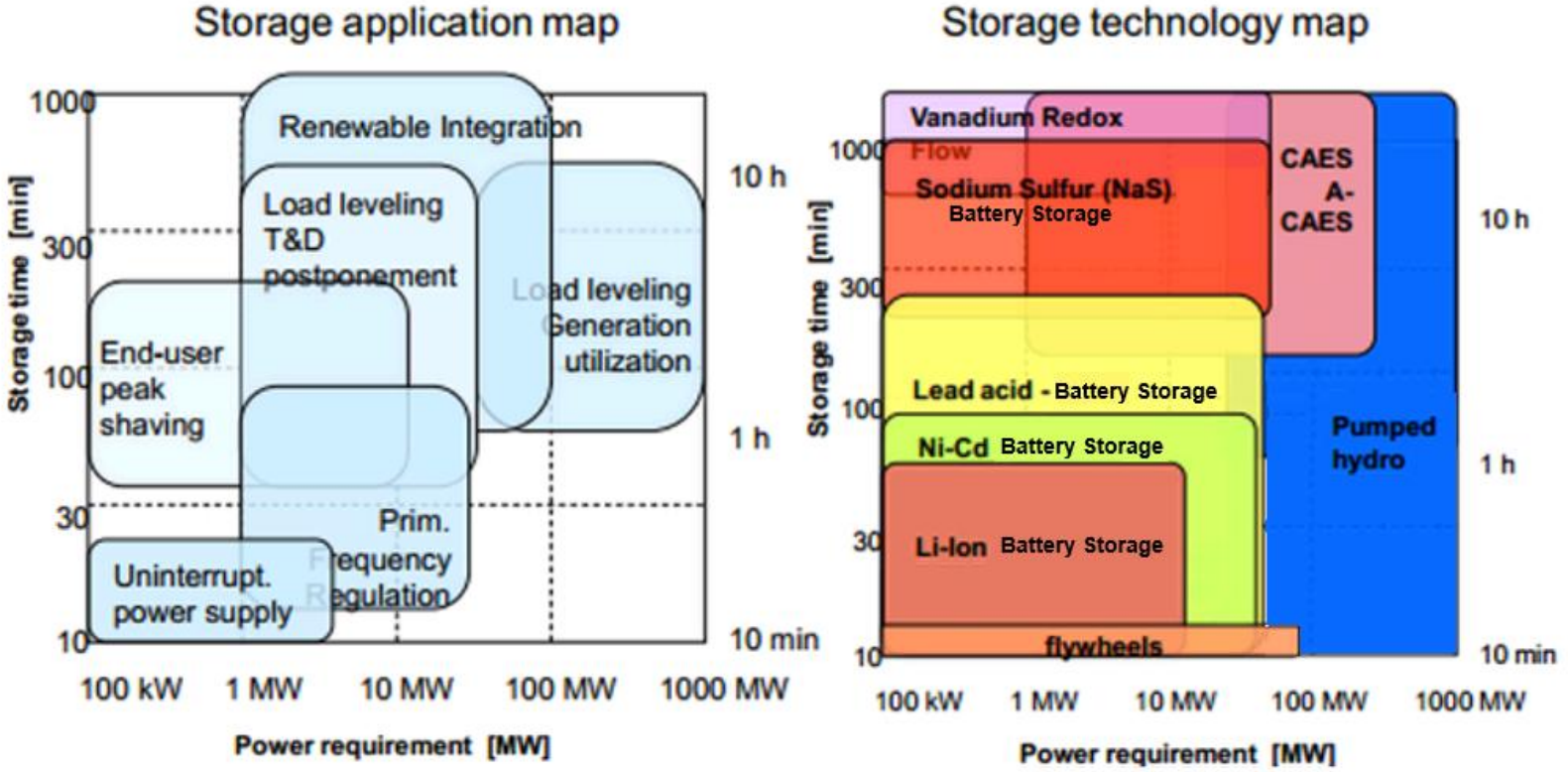
Modeling and Valuation Challenges

- Diurnal price arbitrage in today's markets generally not sufficient to justify storage.
  - Other values need to be considered, especially ancillary services, and niches where other solutions may be prohibitive (e.g., transmission expansion).
  - Some studies show that the value of ancillary services from energy storage may equal or exceed the value of moving bulk energy through time (i.e., arbitrage).
- There are two basic valuation modeling approaches.
  - Historical market prices.
  - Dispatch models.
- Both approaches are challenging and may go beyond available modeling capability.

Matching Capabilities and Needs

- Understanding the need is important to technology selection.



Reproduced from Ecofys *Energy Storage White Paper*– adapted from *Utility Scale Energy Storage Systems*, State Utility Forecasting Group, June 2013

Table of Storage Resources

Caveat:
Specifications are rapidly evolving for many technologies. This data is broadly representational of a few (not all!) technologies and almost certainly out of date by the time you read it.

Technology	Maturity	Cost ($/kW)	Cost ($/kWh)	Efficiency	Cycle Limited	Response Time
Pumped Hydro	Mature	1,500 - 2,700	138 - 338	80-82%	No	Seconds to Minutes
Compressed Air (Underground)	Demo to Mature	960 - 1,250	60 - 150	60-70%	No	Seconds to Minutes
Compressed Air (Aboveground)	Demo to Deploy	1,950 - 2,150	390 - 430	60-70%	No	Seconds to Minutes
Flywheels	Deploy to Mature	1,950 - 2,200	7,800 - 8,800	85-87%	>100,000	Instantaneous
Lead Acid Batteries	Demo to Mature	950 - 5,800	350 - 3,800	75-90%	2,200 - >100,000	Milliseconds
Lithium-ion Batteries	Demo to Mature	1,085 - 4,100	900 - 6,200	87-94%	4,500 - >100,000	Milliseconds
Flow Batteries (Vanadium Redox)	Develop to Demo	3,000 - 3,700	620 - 830	65-75%	>10,000	Milliseconds
Flow Batteries (Zinc Bromide)	Demo to Deploy	1,450 - 2,420	290 - 1,350	60-65%	>10,000	Milliseconds
Sodium Sulfur	Demo to Deploy	3,100 - 4,000	445 - 555	75%	4,500	Milliseconds
Power To Gas	Demo	1,370 - 2,740	NA	30-45%	No	10 Minutes
Capacitors	Develop to Demo	-	-	90-94%[13]	No	Milliseconds
SMES	Develop to Demo	-	-	95%[14]	No	Instantaneous

Reproduced from Ecofys *Energy Storage White Paper*-- Data sourced from Carnegie, et al, *Utility Scale Energy Storage Systems: Benefits, Applications, and Technologies*; State Utility Forecasting Group, June 2013. Costs are expressed in 2010 dollars.

Resource Planning and Energy Storage

- Resource planning has historically focused on meeting peak hour demand.
- New realization that "flexibility" may become a constraining factor.
  - Flexibility is generally thought of as ramping capability and "turn down" capability– the ability to absorb occasionally large amounts of variable generation.
- Challenges remain in defining the supply and need for various types of flexibility.
- Energy storage should be given careful consideration.

Policy Considerations

- Policies may be needed to help with some of the technical, market, and risk barriers faced by energy storage.
  - Broad recognition that full range of power system benefits cannot be realized through existing market incentives.
- Policies can help continue innovation and improvement in competing storage technologies.
- FERC has intervened to help build markets that recognize the value of flexible resources.

Integrating with Utility Operations

- There is much interest in "plug and play" systems that seamlessly integrate energy storage with existing utility systems.
  - *Controllers and management systems need to function independently of the types of storage being controlled.*
  - *Control technology should function even when the applications belong to different actors (grid operator, end-use supplier, consumer).*
- No complete agreement on whether a single communication standard is best given the many potential actors, which may include behind the meter end-users.

Sidelights

- The theory that CTs need to be added with wind is being challenged– CTs get economically displaced when the wind comes up, and their "flexibility" is gone, perhaps when needed most-- Not so for energy storage.
- Energy storage competes with other alternatives, including institutional measures (e.g., energy imbalance market), controlling the renewable resources themselves, and demand management.
- Gas turbine inlet cooling is a commercially available storage opportunity that is somehow missed in most energy storage papers.
- Audi's 6 MW pilot methane production plant in Germany may provide the answer to what happens when the wind doesn't blow and the sun doesn't shine for long periods– renewable fired combustion turbines.

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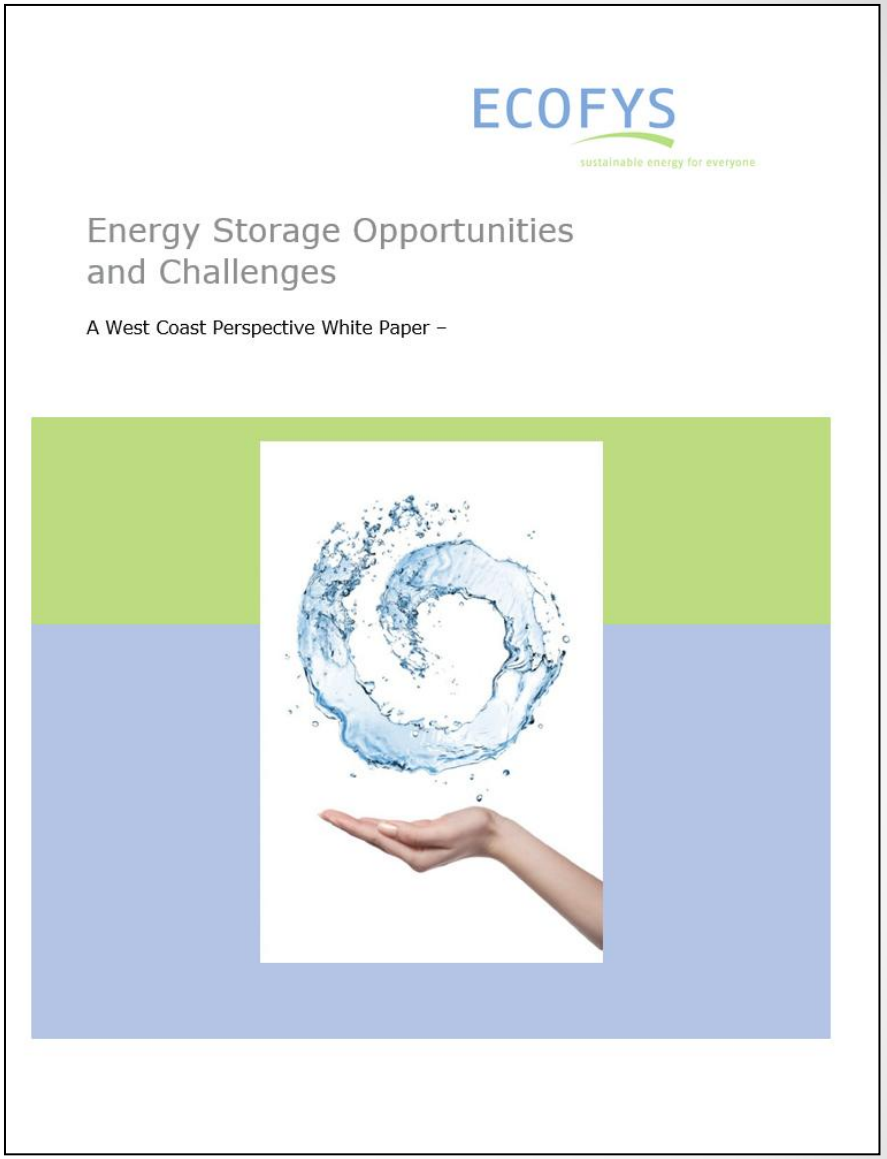
Observations

- Energy storage includes both mature technologies and technologies that appear to have much development potential.
- Complexities in calculating and realizing the value of energy storage provides multiple system benefits that are may not be fully valued, at least partly because of the complexity involved.
- Energy storage deserves to be evaluated on a par with other resources in utility resource plans.
- Challenges to energy storage development suggest continued policy intervention is merited to promote competition among projects and technologies, and to create a foundation for a future largely devoid of fossil fuels.
- Standardized integration with utility system energy management systems may be lagging and merits development.

Want More?

- Ecofys was hired by EDF Renewable Energy to develop a white paper that raises the awareness of energy storage among planners, utility managers, regulators, and legislators.
- An Advisory Panel was established to guide and review the work.
- Four-plus page bibliography!



http://www.ecofys.com/en/news/white-paper-challenges-and-new-opportunities-for-energy-storage/