PNNL's Analytics Activities for the DOE Energy Storage Systems Program

Program Review
Energy Storage Systems Program (ESS)

San Diego, CA
October 19-20, 2011

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Special thanks for the support of this effort by Dr. Imre Gyuk

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PNNL EES RD&D strategy

Collaboration with industries, universities

EES RD&D

Grid analytics, cost analysis, code and standards
- Roles of storage in US grids
- Value, locations, targets
- Cost and performance requirements

EES Technologies

- Novel redox flow batteries
- New gen Na-batteries
- Low cost, long life Li-ion,
- New concepts, emerging technologies

Materials/chemistries

- Ionic conductors
- Mixed conductors
- Novel structures (e.g. nano-)
- Redox chemistries,…

Crosscutting science

Computer Modeling
- Mass/charge transport
- Electrochemical
- Flow, thermal, …

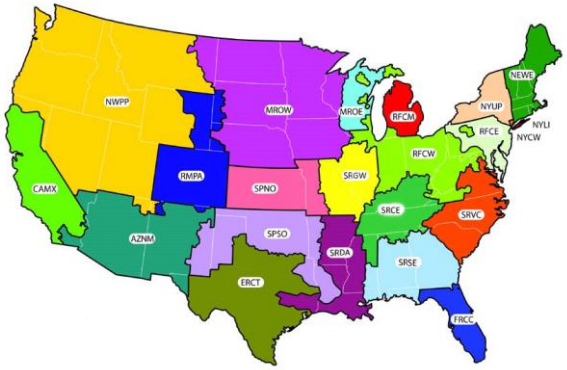
Advanced diagnostic study, NMR, TEM, etc.
- Basic chemistry
- Materials structure
- Physical properties

Electrochemical study
- Electrochemical activity
- Reaction kinetics
- Performance/chemistry/structure

Goal, Approach, Coordination

- Goal: Explore the following questions
  - How much energy storage does the nation need?
  - What kind of storage?
  - Where to place it?
  - What are cost and performance characteristics to be competitive in various markets?
  - What are the barriers for the prudent deployment of storage?
- Approach:
  1. National assessment of energy storage addresses
     - How much storage does the US need?
     - Cost and performance targets
  2. Component cost modeling addresses
     - Guidance and prioritization for R&D agenda
  3. Standardization for performance testing addresses
     - Lack of product differentiation and comparison
  4. Legislative/regulatory landscape relevant for economic viability of storage addresses
     - Regulatory and market design, barriers
- Coordination with other national labs and DOE Offices and DOE advisory panels

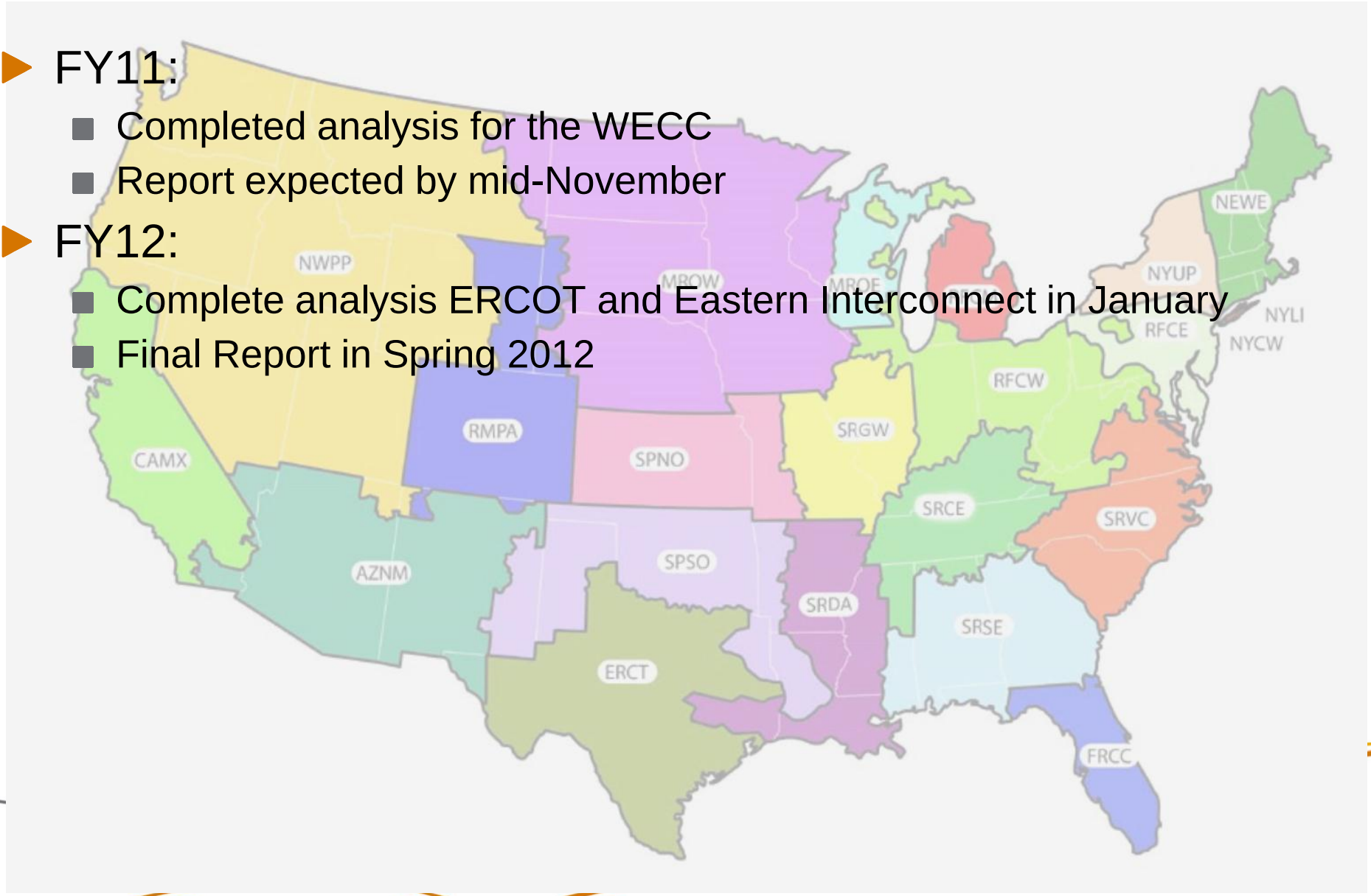
National Assessment



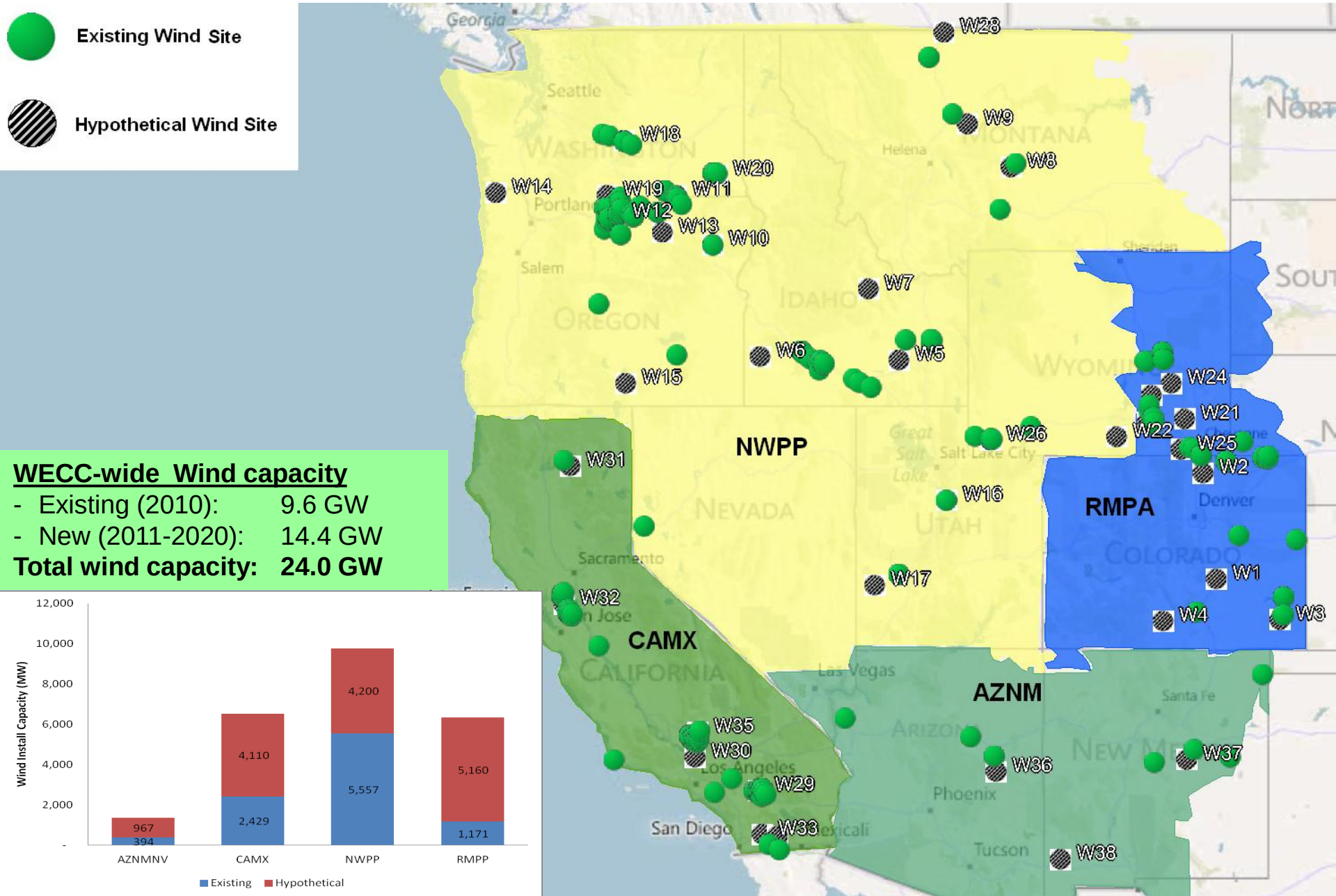
- Scope
  - Determine the market size for 22 US regions for
    - Balancing services
    - Arbitrage
  - Determine cost-performance characteristics to compete against conventional technologies
- Assumptions
  - 2020 grid (typical projections for utility and transmission planners)
  - Current laws of states' RPS by 2020
  - 20% PRS for states with no RPS legislation
  - many other assumptions
- Outcome and Products
  - Estimation of potential incremental market sizes for balancing services
  - Estimation of potential for arbitrage services
  - Life-cycle cost comparisons for various storage types and competing technology alternatives

Accomplishments: National Assessment

- FY11:
  - Completed analysis for the WECC
  - Report expected by mid-November
- FY12:
  - Complete analysis ERCOT and Eastern Interconnect in January
  - Final Report in Spring 2012



Assessment for WECC for a 2020 Grid Scenario

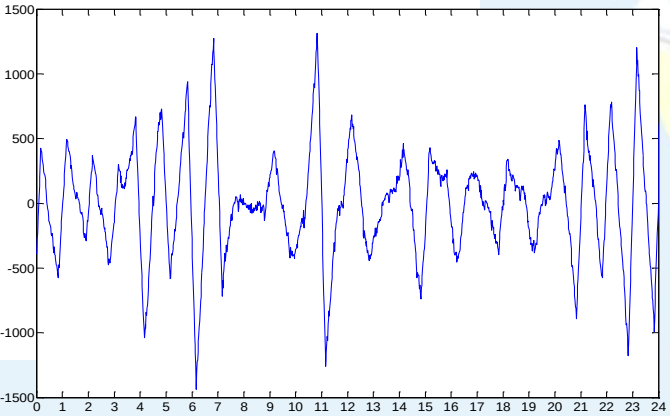


WECC-wide Wind capacity

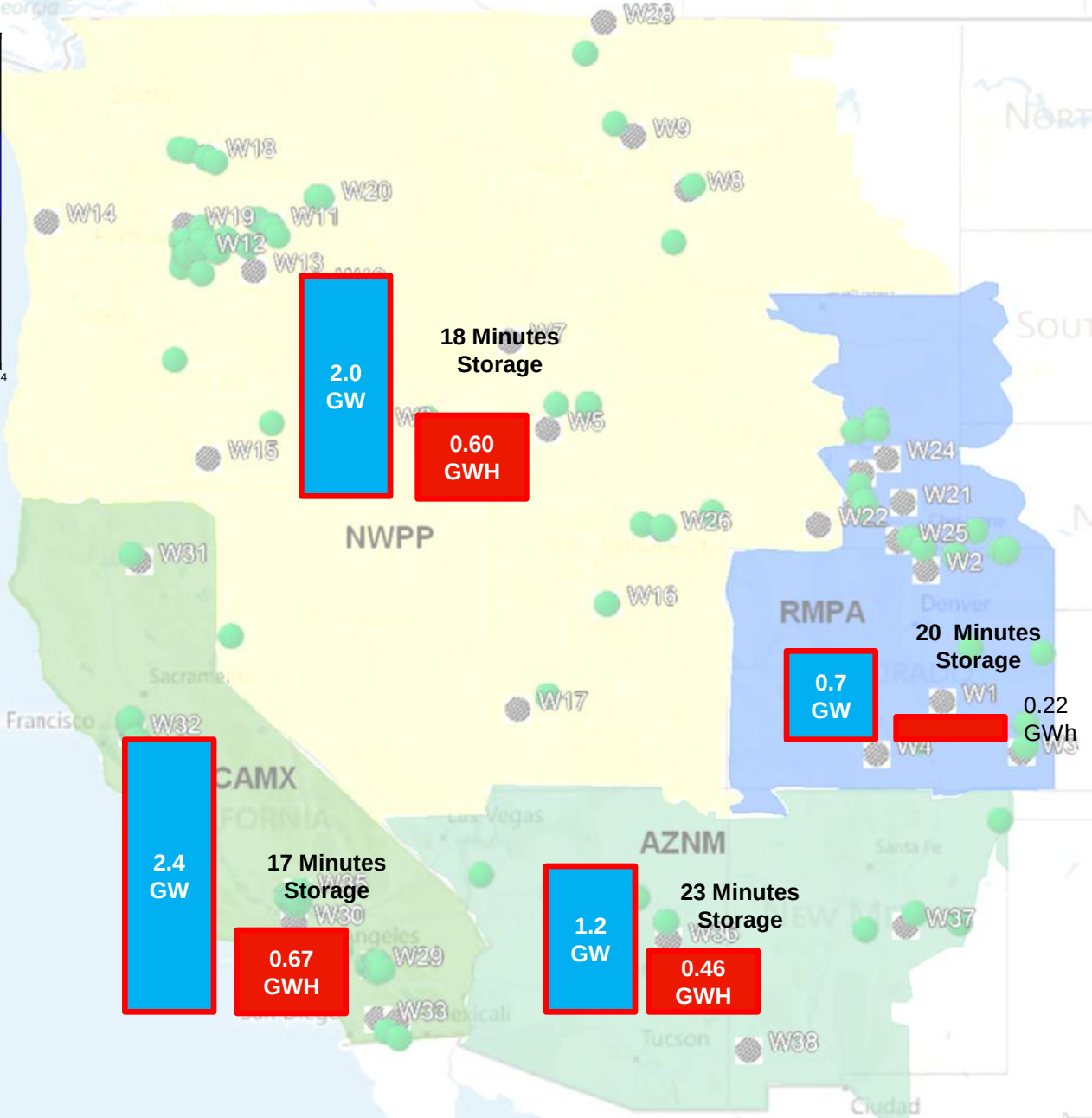
- Existing (2010): 9.6 GW
- New (2011-2020): 14.4 GW

Total wind capacity: 24.0 GW

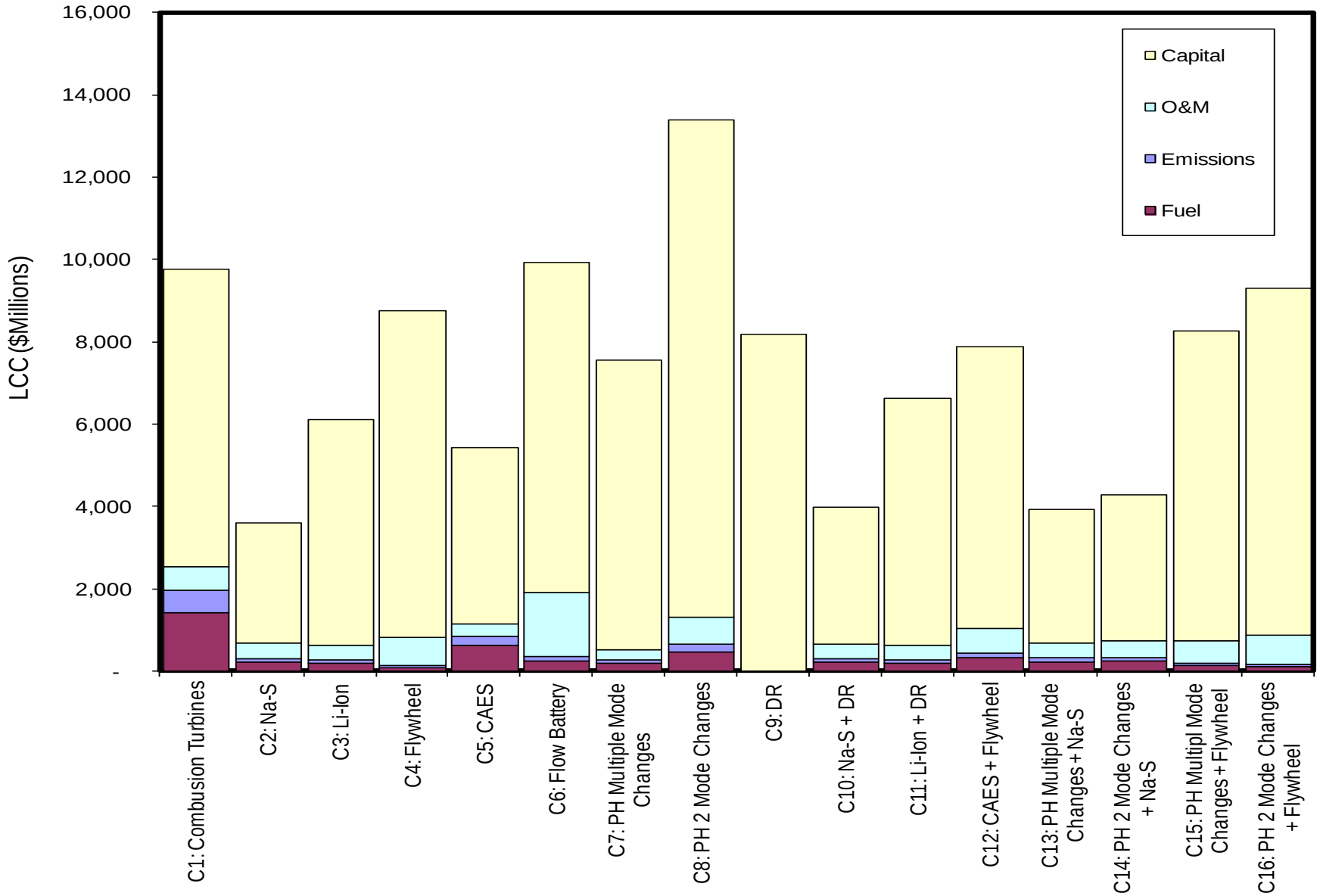
Incremental Intra-hour Balancing Requirements for WECC for a 2020 Grid Scenario



Incremental
Intra-hour balancing requirements

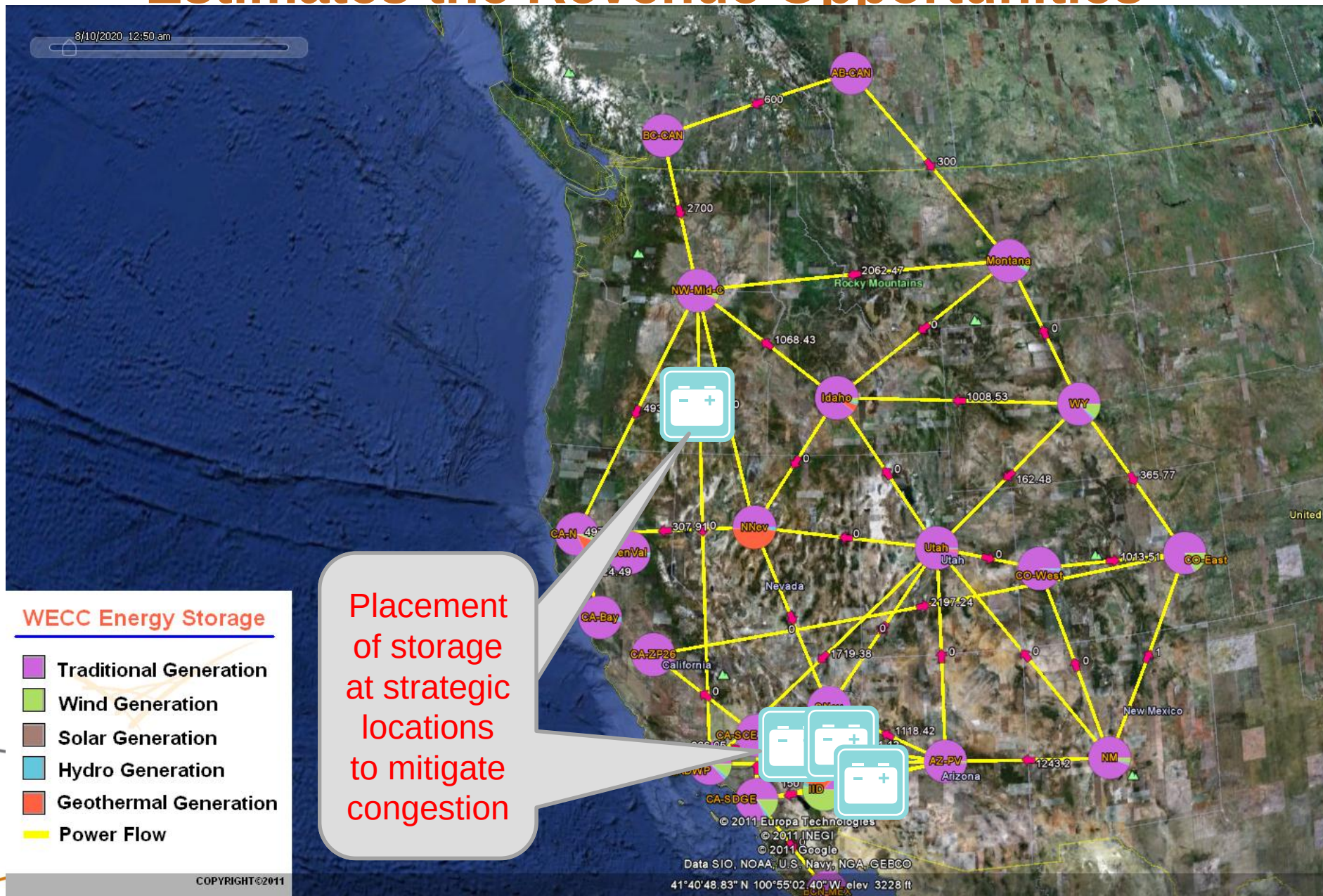


LCC Results for 16 Technology Options Meeting Intra-hour Balancing Requirements

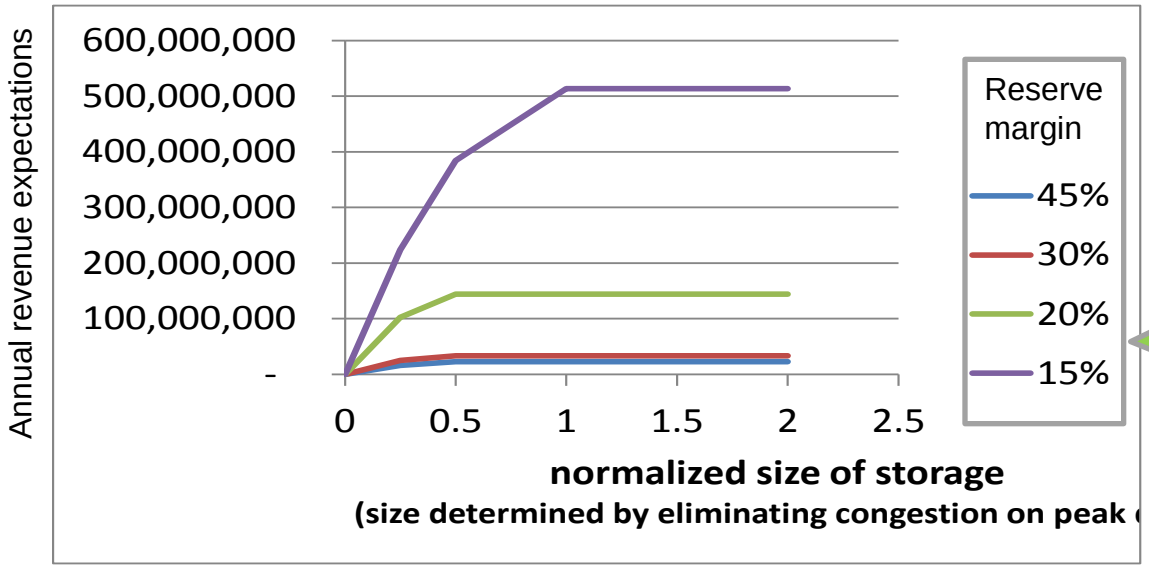


Opportunity for Arbitrage

Detailed Production Cost Modeling Estimates the Revenue Opportunities

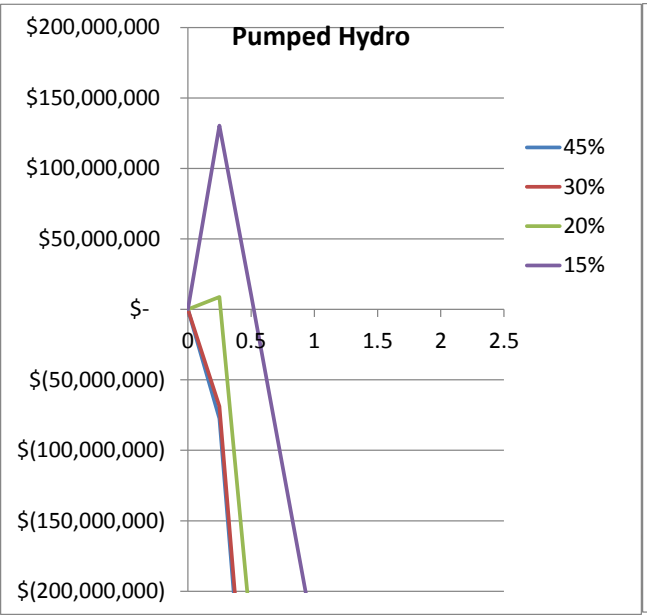


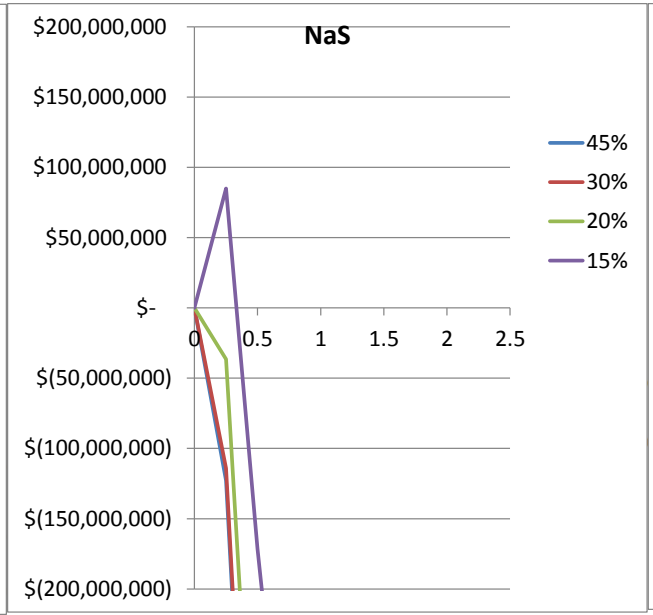
Arbitrage Opportunities in California

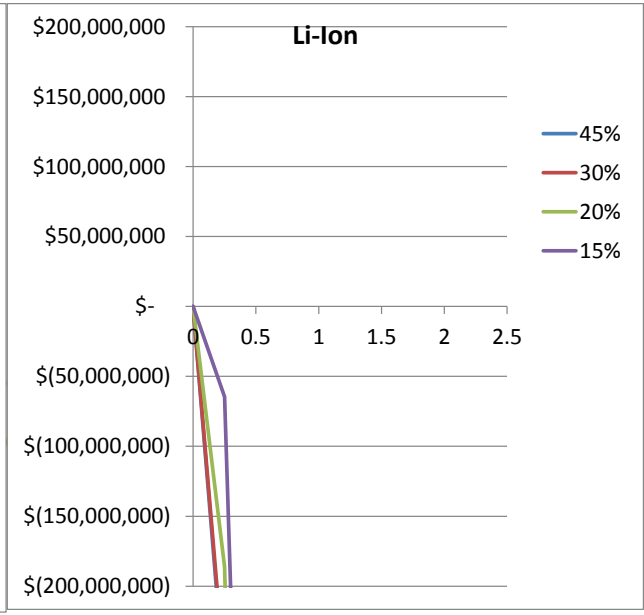


- Revenue expectations are strongly dependent on reserve margins
- Diminishing returns with increasing storage

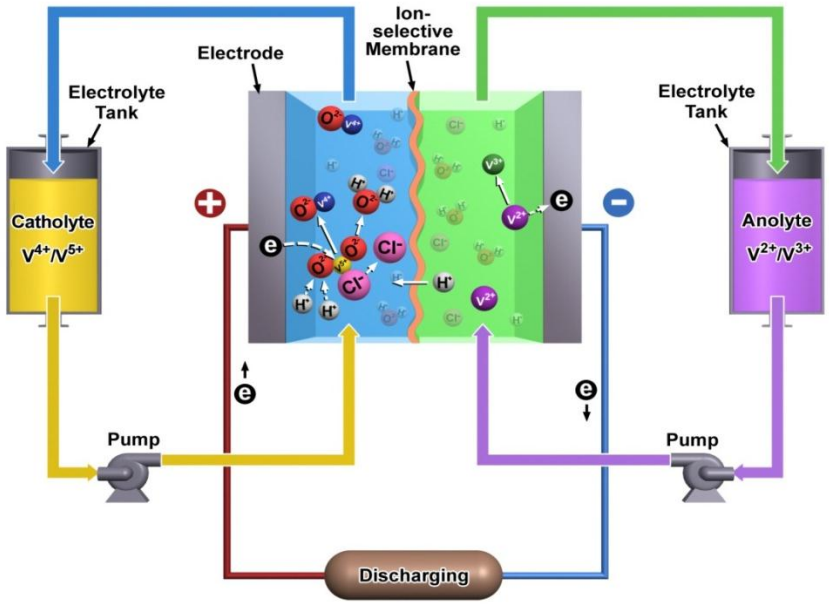
Annualization of cost as a function of storage size and reserve margin

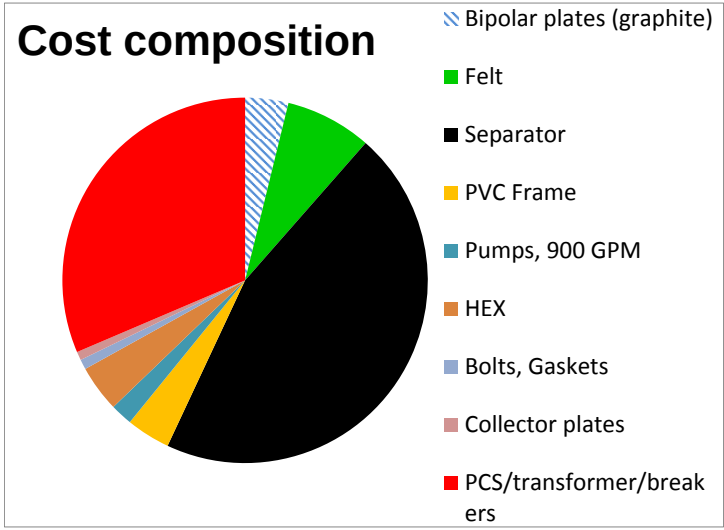






Detailed Component Cost Modeling Redox Flow Battery (PNNL)





FY11 Outcomes and Accomplishments:

- First cost model for flow battery completed
- Industry Advisory Board established to review work on cost model and guide future cost model development

FY12 Plan:

- Enhance flow battery model (more detailed treatment of key components)
- Develop cost models for a second battery types
- Develop initial battery degradation model

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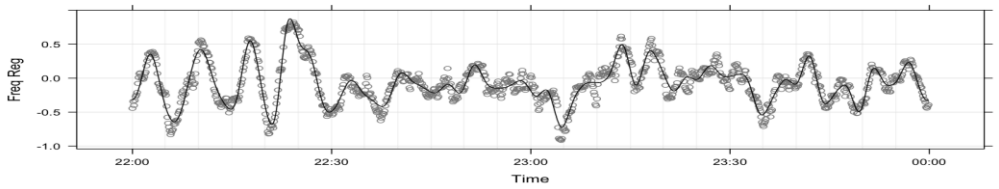
Codes and Standards

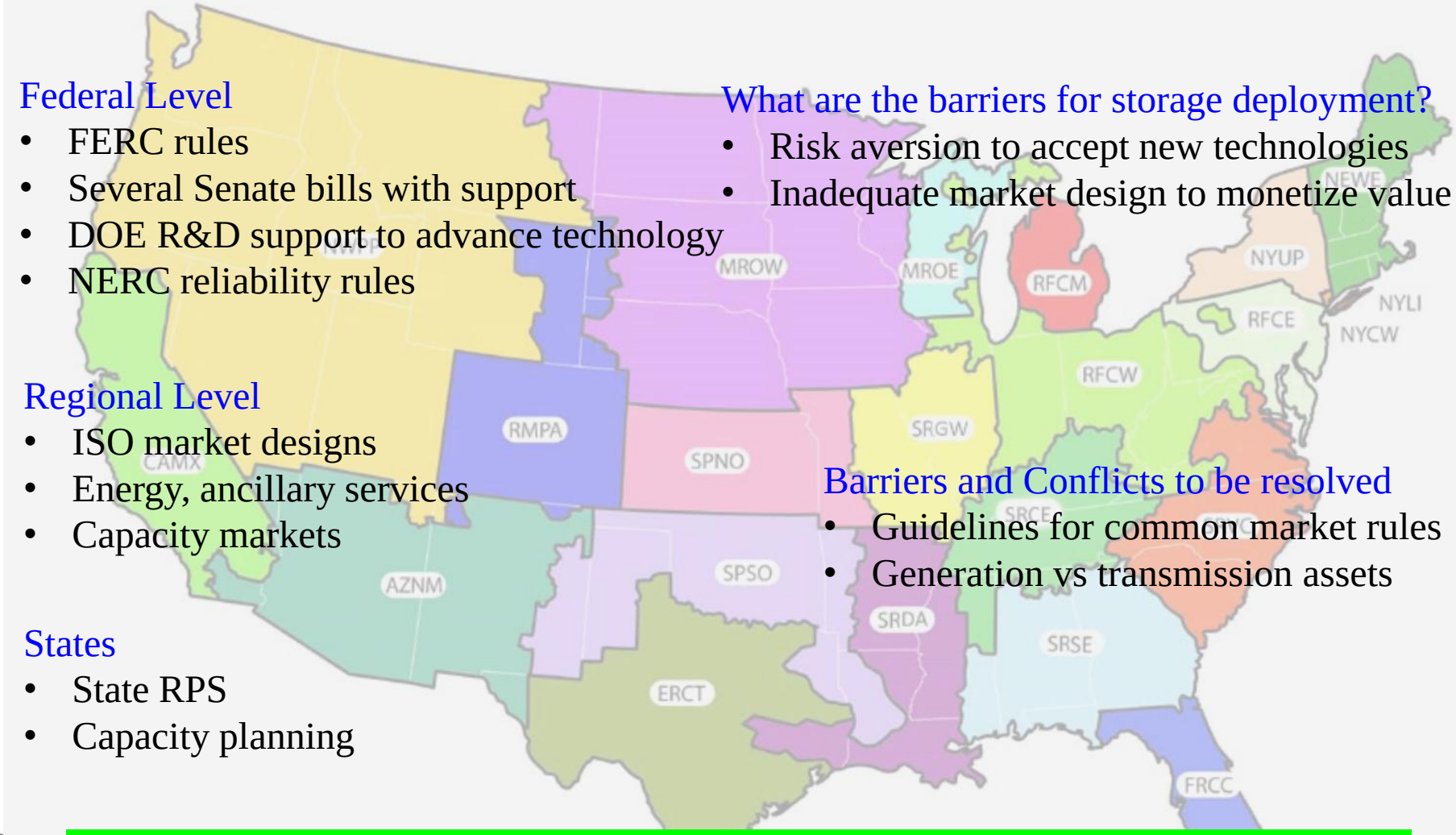
- Several guidelines and standards exists for
  - testing of lead-based batteries
  - Interconnection of distributed resources

  But nothing specific for performance testing of grid-connected storage systems
- Characterized cycles for PJM regulation signals to establish **representative regulation cycles**



- Plan for FY12
  - Initiating developments through IEEE
  - Potentially accelerated process of performance testing protocols that find agreement within the industry

Landscape of Legislation and Regulation Relevant to Energy Storage



Federal Level
- FERC rules
- Several Senate bills with support
- DOE R&D support to advance technology
- NERC reliability rules

Regional Level
- ISO market designs
- Energy, ancillary services
- Capacity markets

States
- State RPS
- Capacity planning

What are the barriers for storage deployment?
- Risk aversion to accept new technologies
- Inadequate market design to monetize value

Barriers and Conflicts to be resolved
- Guidelines for common market rules
- Generation vs transmission assets

Accomplishments FY11: Draft report on legislation and regulatory landscape (partnered with Dr. Michal Moore, Univ. of Calgary)

Plan for FY12: Policy strategies to remove barriers

Summary of Accomplishments and Future Activities

- Accomplishments:
  - National Assessment: WECC portion
  - Component cost modeling for Vanadium Redox Flow Battery
  - Advisory Panel for guidance in cost modeling and standards
  - Initiated discussion within IEEE to performance standards development
  - Report on role of legislation and regulatory frameworks for deployment of energy storage
- Planned activities
  - Complete National Assessment: ERCOT, EIC
  - Coordination with SNL and NREL to leverage other renewable integration efforts
  - Initiate performance standard development, potentially 2-prong approach: 1) accelerated and 2) initiate through IEEE
  - Refine Redox Flow Battery cost modeling and expand model to NaS
  - Develop policy strategies for removing barriers