NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Active Power Control from Wind Power

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Creating Options

Creating the Options: Integrating wind, operating the power system.

Selecting the Options: Optimize the economics, enhance the reliability.

Team

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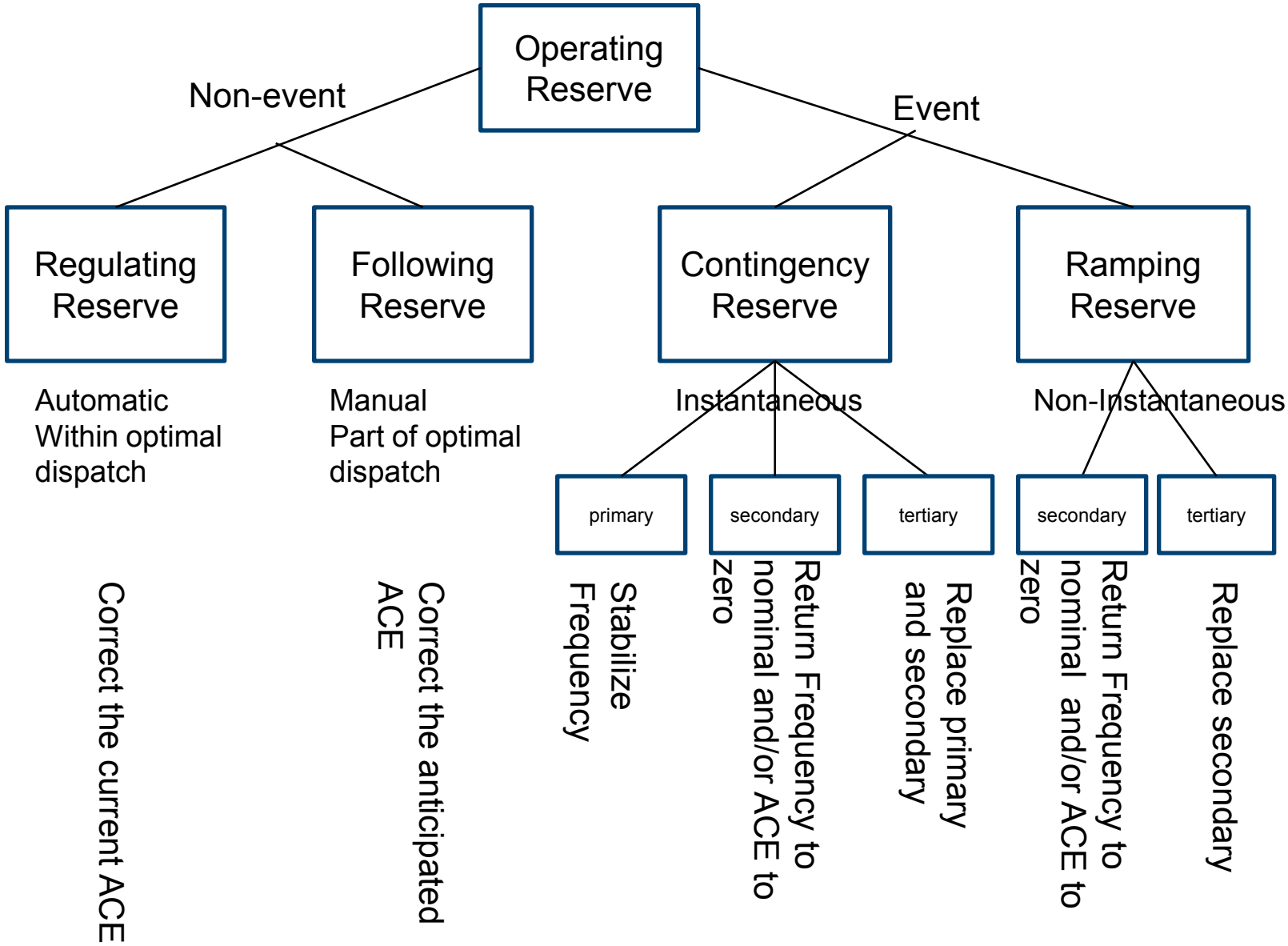
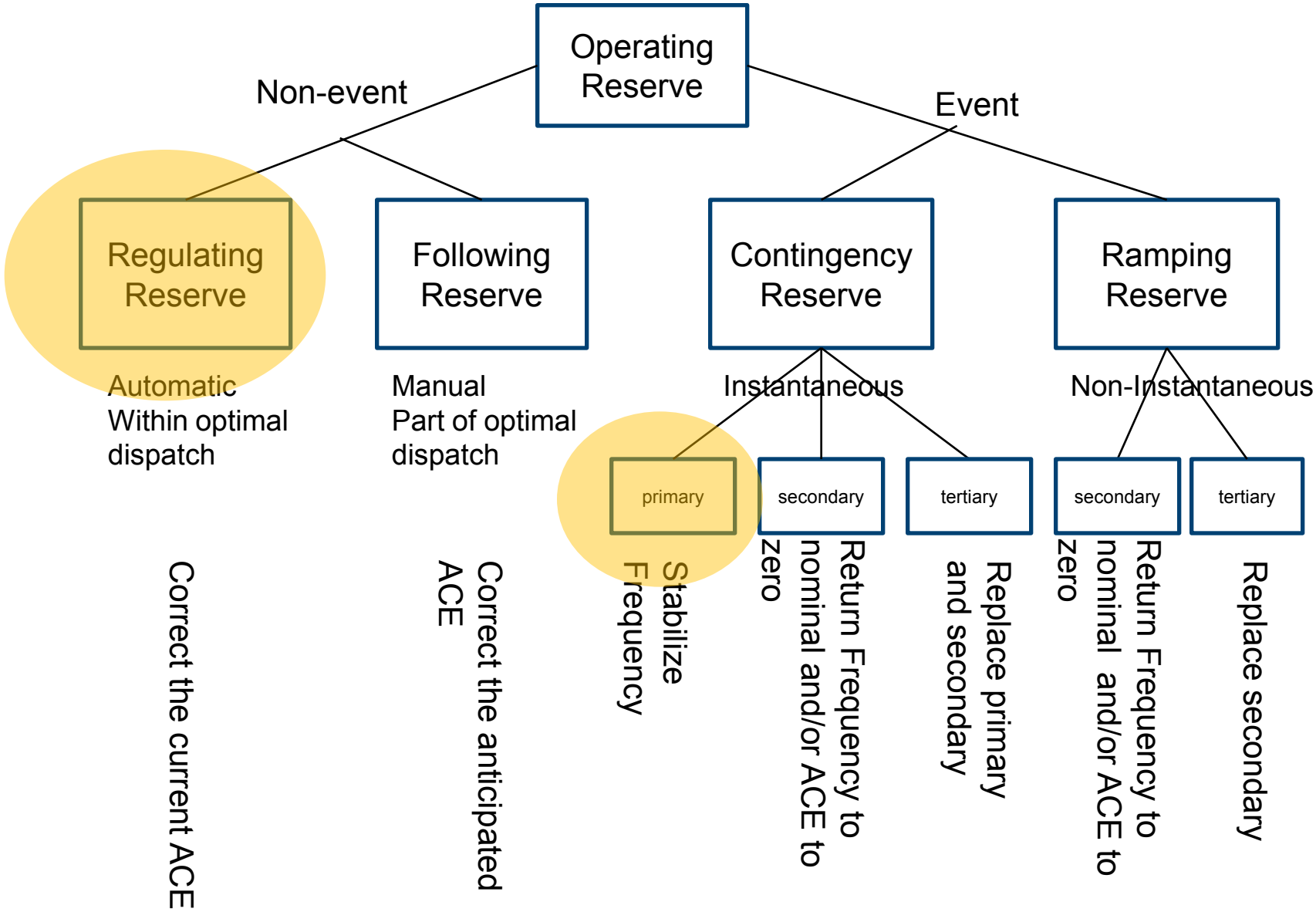
Active Power Operating Reserves



Active Power Operating Reserves



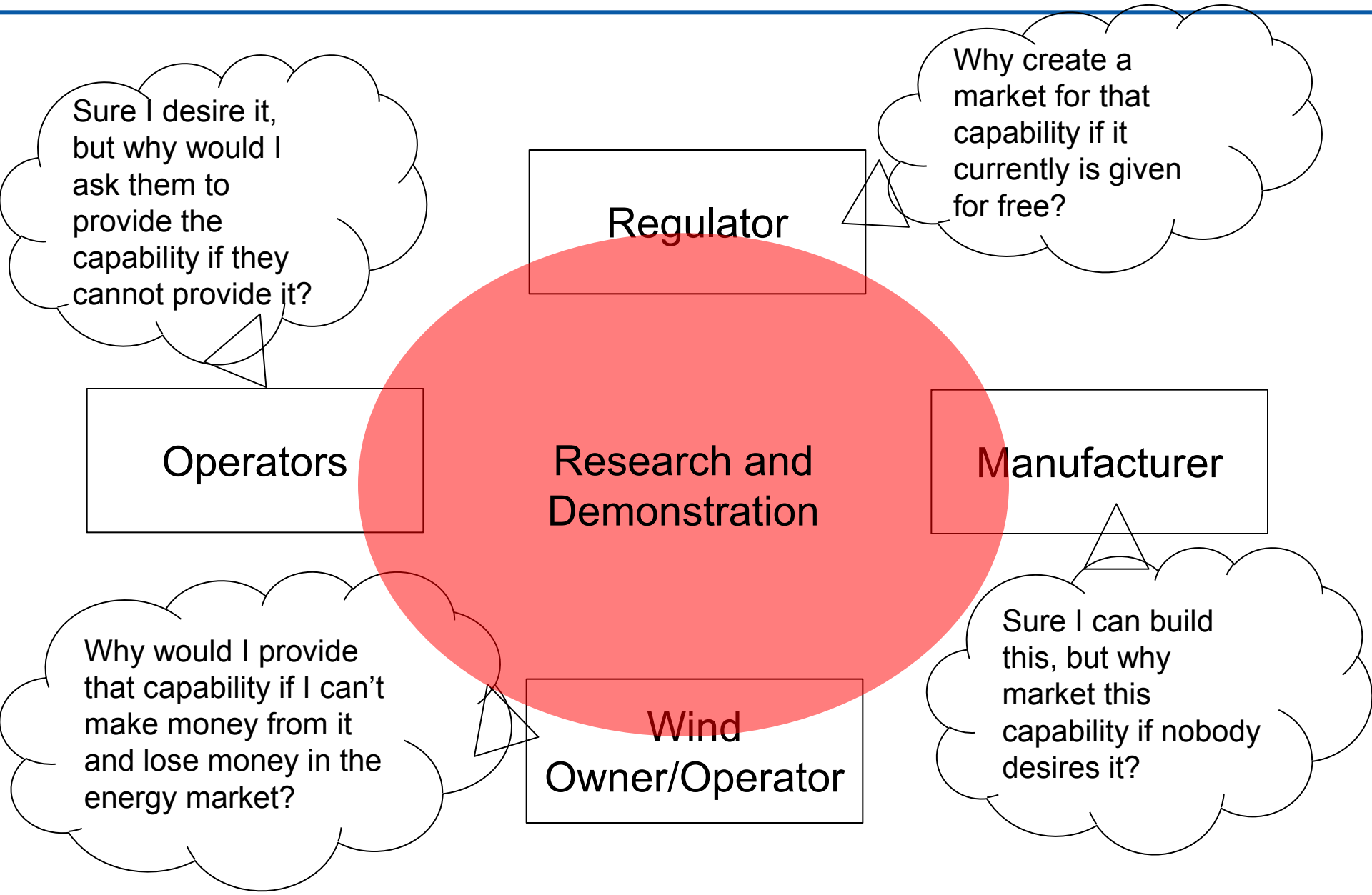
Active Power Control

- Inertial Response
- Primary Frequency Response (Governor Response)
- Secondary Response (AGC, ACE Regulation, Load Frequency Control)

Making the Case

- Current decline of the North American Eastern Interconnection frequency response of about 60-70 MW/0.1 Hz per year
  - Ingleson and Allan 2010, Ingleson and Ellis 2004, etc.
- 2011 FERC/LBNL study on Frequency Response Metrics to assess requirements for reliable integration of VG
  - recommends “expanded use of frequency control capabilities that could be provided by variable renewable generation technologies (primary frequency control, etc.)”
- Kirby et al “Providing minute to minute regulation from wind plants”
  - “The analysis has shown that there is a potential for wind plants to aid power system reliability and increase their own profits by providing regulation.”
- Wind power integration studies (e.g. EWITS, WWSIS, etc.) have recommended use of wind power providing secondary and tertiary reserve power during min load periods

Differences in Perspective



Active Power Control Project

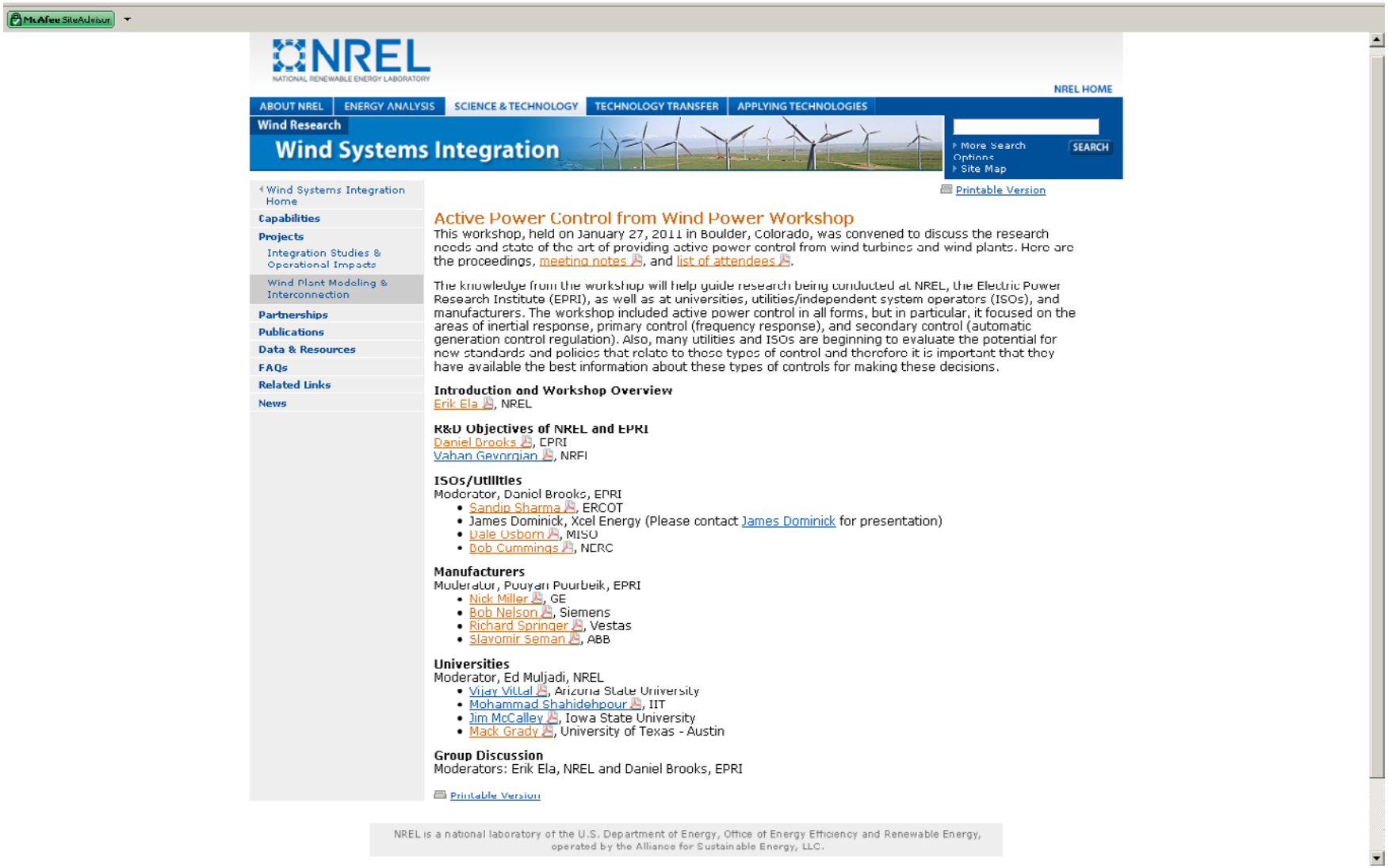
- NREL and EPRI joint project, to test at NWTC facilities
- Economic and power system analysis and simulations
- Computer simulations of control capabilities
- CART machine field test
- Utility scale wind turbine test and demonstration

- Parameter adjustments (dead bands, ramp rates, droop characteristic, etc.)
- Different wind speeds, upward and downward, high varying wind
- All three responses together

- Publish results and demonstrate to regulators, operators, wind owner/operators, and manufacturers

Active Power Control from Wind Power Workshop

www.nrel.gov/wind/systemsintegration/active_power_control_workshop.html



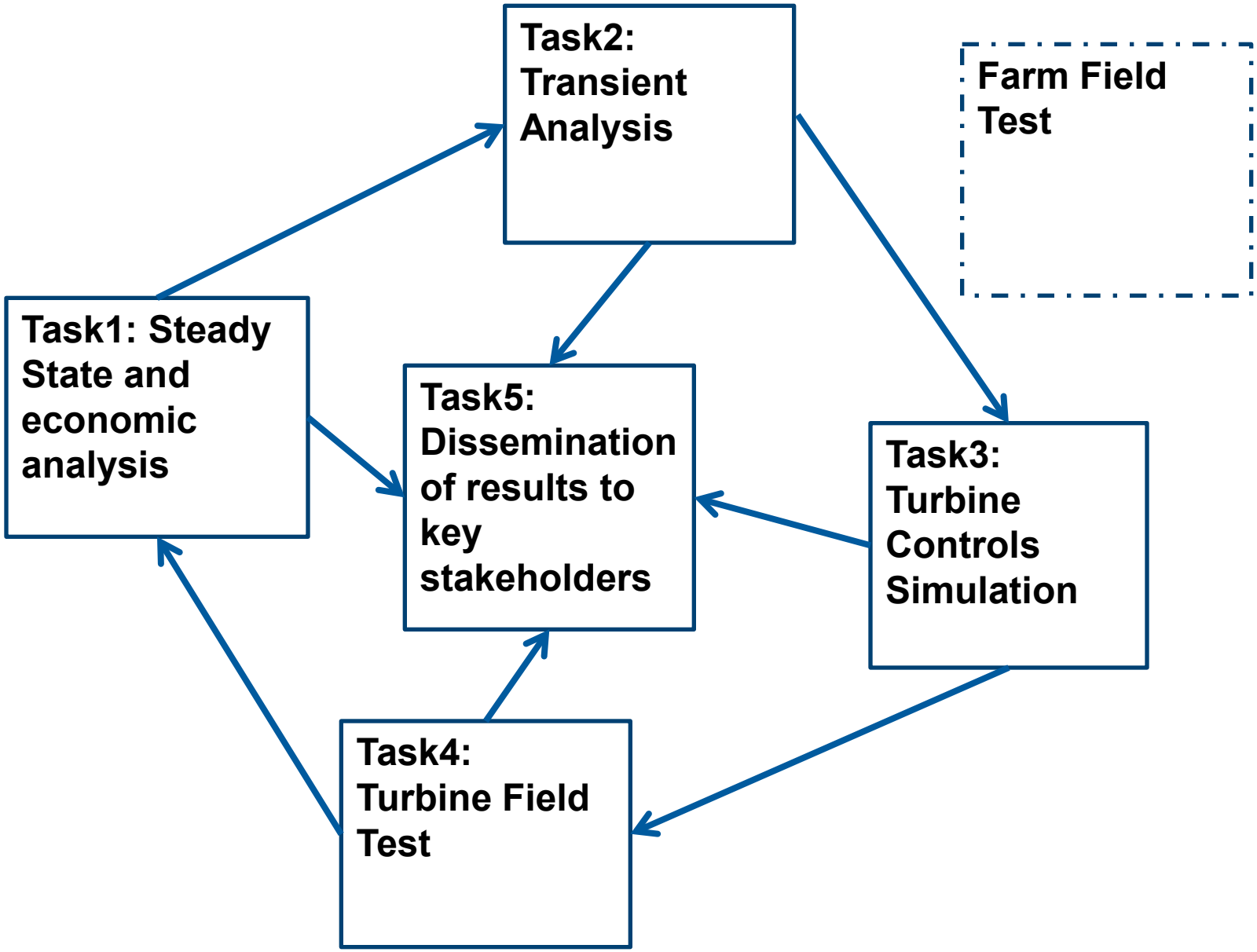
Key Takeaways

- Do we need a new vernacular? Does the existing terminology still work?
- Have we determined what the right goal is yet?
  - Frequency response vs. nadir response, nadir vs. settling frequency, CPS2 vs. BAAL? Will the need change based on what policies are driving requirements?
  - UFLS setting???
- Of the response categories, which will need wind to assist in first, which will cost wind the most to provide, and which will overall be the most important product

Key Takeaways

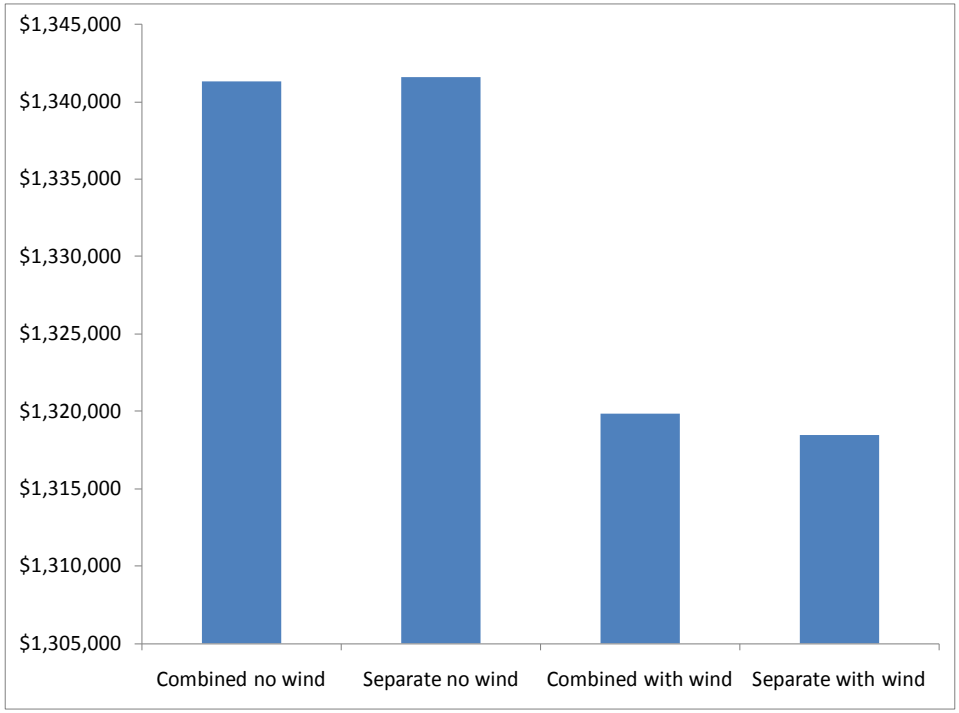
- Markets vs. policy???
- How will requirements change the steady state needs
  - Can primary, inertial response, influence unit commitment decisions?
- How can we turn all of our knobs to give the most desired response without necessarily copying the physical responses of conventional generation?
- Have we tried everything to see what can go wrong
  - “Turn over the rocks and look for snakes”
- Who else needs to see these test results? What test results does who need to see?

Project Tasks



Steady State and Economic Analysis

- Unit commitment and dispatch with wind providing services
  - AGC regulation
  - Primary frequency response
  - Inertia
- Higher resolution steady state modeling.
  - Can wind follow AGC?
- Finding the marginal cost (dual) of various control constraints



- **What is the priority?**
- **What is the business case?**

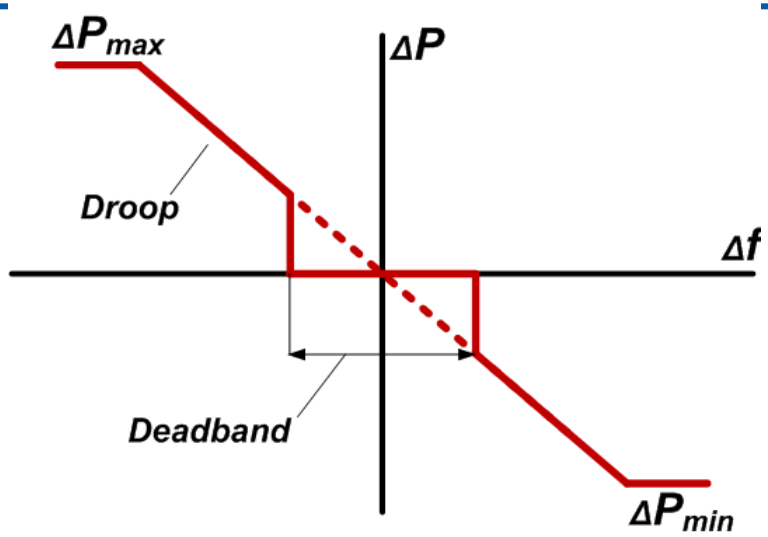
Transient Analysis

- Investigate wind power contribution into power system overall frequency response
  - Test different wind turbine types (3 and 4)
  - Test different inertial algorithms
  - Test different droop characteristics, deadbands, limits, etc.

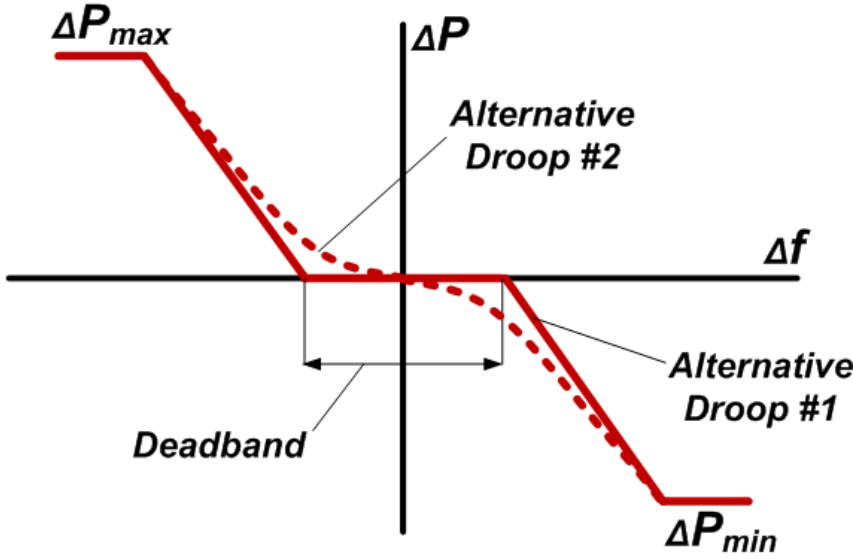
- Above tasks can be done for various power system configurations
  - Different generation mixes (hydro, steam, gas)
  - Different droop characteristics for conventional generation
  - Cases when conventional generators do not provide droop

- **What is the needed response?**
- **How does the wind response assist?**

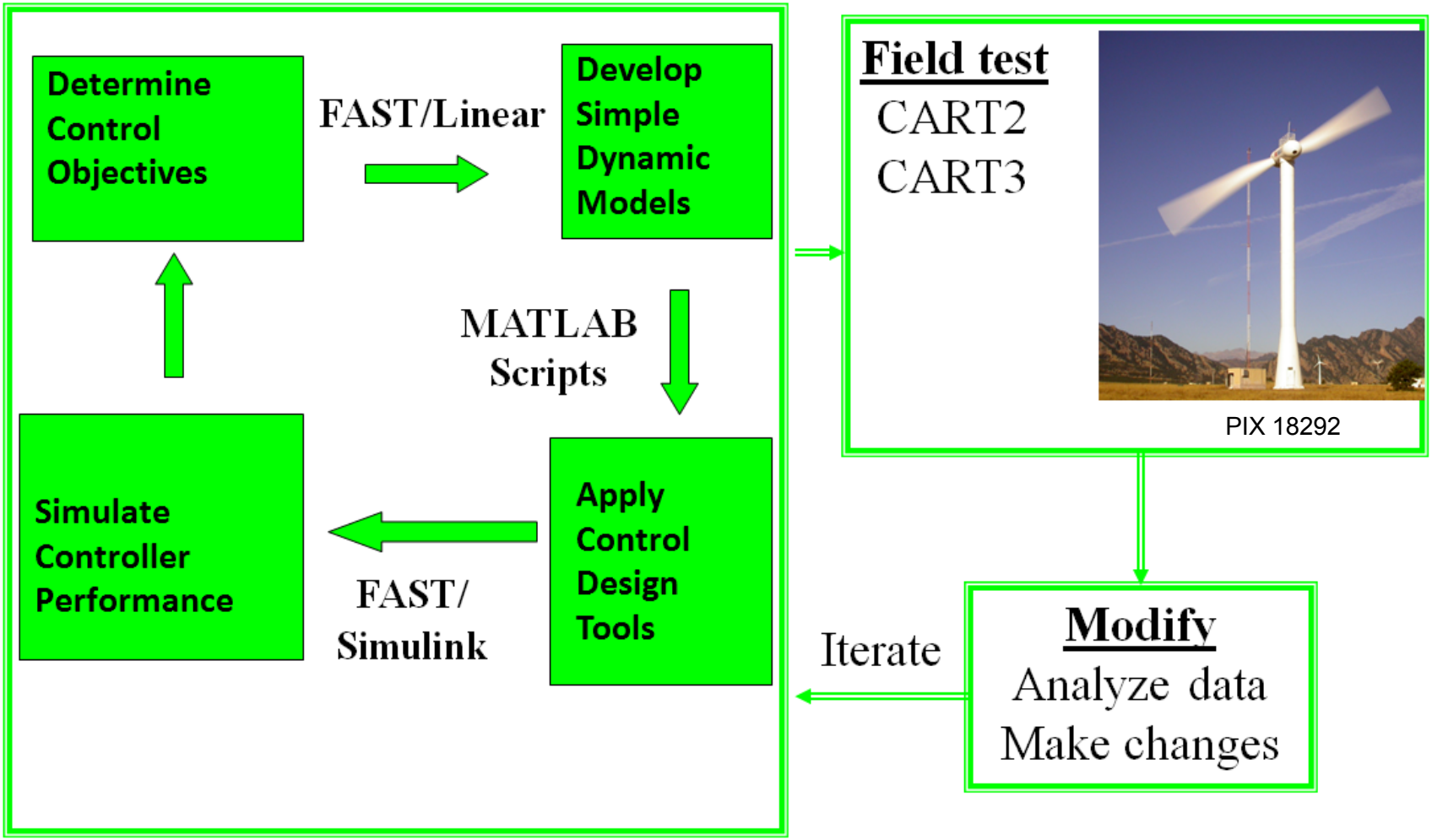
General Droop Characteristic



Modified Droop Characteristics



Advanced Controls Research at NWTC



courtesy of Alan Wright

- What does the response look like?
- How does it compare to current providers?
- How does it affect the machine life, etc.?

Schedule

- September-December 2010: Project initiation, cooperative research and development agreement.
- January 2011: Active Power Control from Wind Power Workshop in Boulder, CO.
- February-March 2011: Project technical kickoff, scope breakdown.
- Late 2011: Interim project report.
- October 2010 – April 2011: Next wind season field tests.
- Late 2012: Final project report, demonstrations.

Industry Guidance

Workshop participants and other interested partners will be kept aware of project as it moves forward.

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www.nrel.gov/wind/systemsintegration/projects_modeling_interconnection.html

Questions??