



The Power to Control.



Extending the Grid with Storage

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Overview

- Storage accepted as Transmission in US law.
- Storage installation provides grid support on weak radial transmission for Kahuku Windfarm.
- Curtailment relief through decreased commitment of fossil units on Maui.
- Incremental system capacity with Ancillary Services provided in Texas.

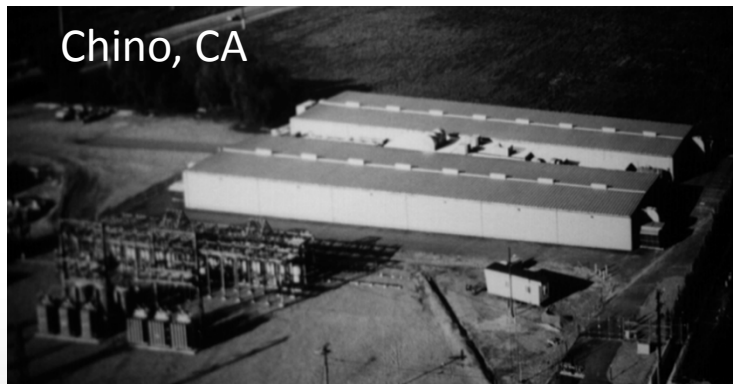
Making Room for Wind on the Grid



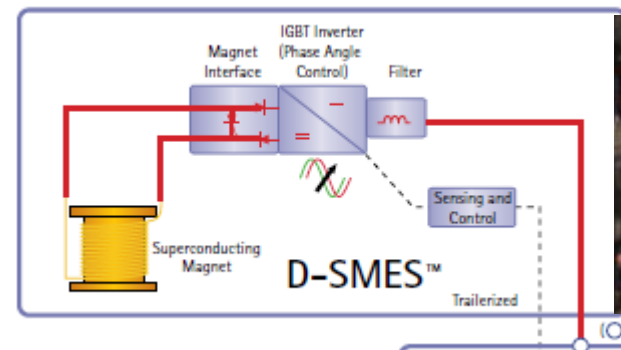
Precedents for using Storage to increase available Transmission:

- Federal policy to be compensated as Transmission (Energy Policy Act 2005, FERC rules and decisions)
- Installations around the country proved the concept

How can these be applied to wind?



Rhineland Loop, WI



Fairbanks, AK





■ Kahuku Interconnection Study

- New substation at northern end of island on existing radial 46 KV line with loads
- Momentary islanding risk when fault on line isolates wind and load showed as voltage spike
- Solution required to complete Interconnection plans





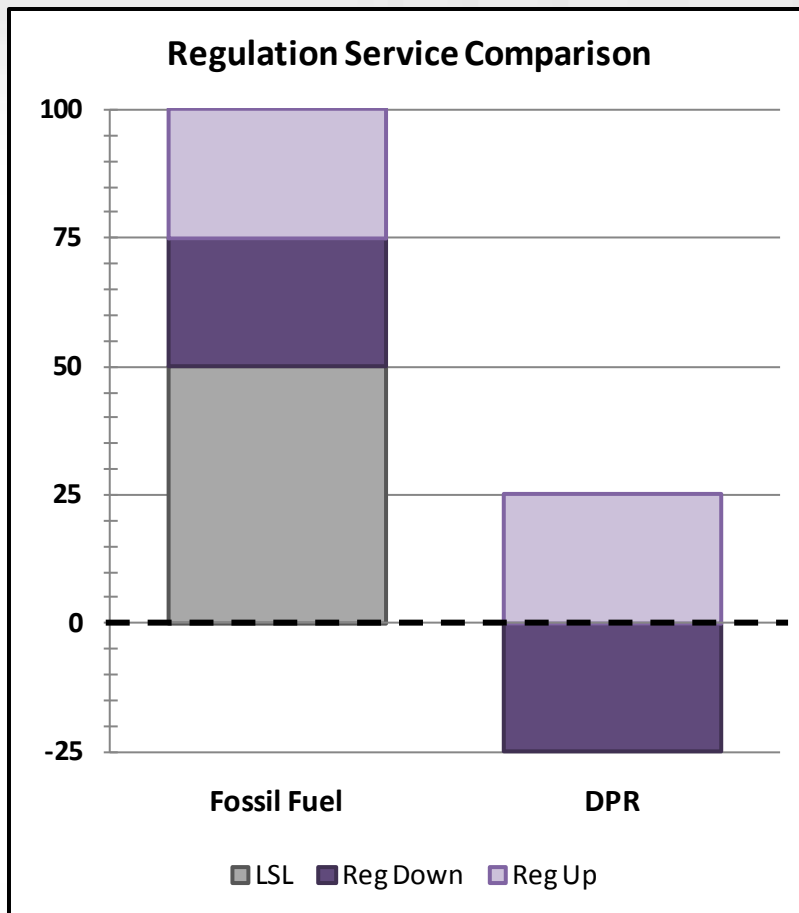
- Interconnection Study re-run using the Battery Energy Storage System planned for ramp rate mitigation
- 15 MW, 10 MWH was planned, and included in PPA pricing
- When functions defined to respond to fault on grid, same battery system provided protection against voltage spike



Low Loads and Generator Regulation



- Moving Ancillary Services to Storage decreases curtailments



- Fossil Fuel plant 100 MW provides 25 MW Reg Up and 25 MW Reg Down from 75 MW midpoint
 - Battery with midpoint of **0 MW** provides 25 MW Reg Up and 25 MW Reg Down
 - Replacing Fossil A/S with Storage A/S **provides ~35 GWh of servable load**
- *(DPR is our brand name for Storage system)*

Zero Midpoint Ancillary Services Commercial Order



10 MW/20 MWh Storage system for Kaheawa Wind II in Hawaii

- Will operate on 21 MW wind farm on island of Maui to supply:
 - Up to 10 MW Up Reserve and 8 MW Down Reserve
 - Sophisticated droop response for frequency deviations beyond deadband
 - Ramp Control to $\pm 1\text{MW/min}$
 - AGC response capabilities
- Energy Storage creates value for IPP and Utility
 - Reserves capability allows gen offline, reducing curtailment
 - Expected $\sim 70\%$ increase annual production of wind farm
 - Higher wind penetration and less generator A/S operation lead to lower variable costs



- Battery system to provide market with Ancillary Services better than fossil plants
- Improve system ability to meet peak demand by shifting over 100 MW of fossil units from Frequency Regulation.
- Greater effectiveness of Fast-responding Storage for Frequency Regulation

Battery at Notrees



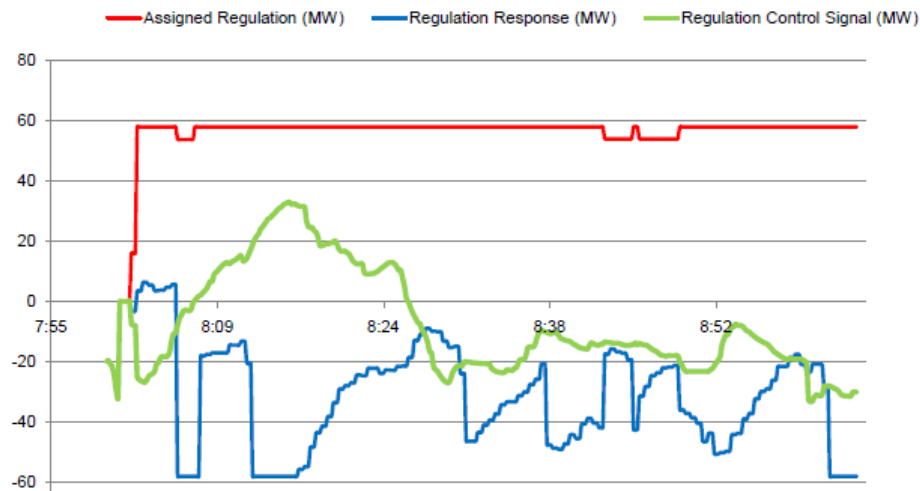
- Installation underway at an existing W. Texas windfarm.
- ARRA demonstrate 36 MW/24 MWH storage system.
- Market participation for Ancillary Services.
- National Labs, FERC, ISOs recognize Frequency Regulation benefits of fast-responding units 2x to 5x greater than fossil units.
- ERCOT review of grid benefits, reduced reserves when Storage is providing Ancillary Services to grid.



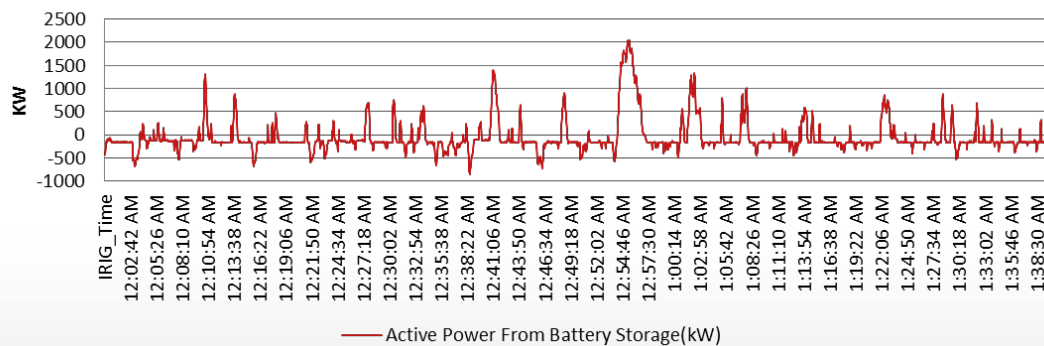
Room for Improvement



Example 3 – Fleet Signal



Two-second Response to Wind From Battery



Active Power From Battery Storage(kW)

The Challenge of Innovation



Logic will get you from A to B.
Imagination will take you everywhere.
- Albert Einstein



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