

Energy Storage: Moving Forward from Frequency Regulation

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for the



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Invenergy



Wind

77 projects
10,071 MW



Natural Gas

10 projects
5,519 MW



Solar

12 projects
231 MW



Advanced Energy Storage

6 projects
94 MW

Broad Expertise

We develop, own and operate large-scale renewable and other clean energy generation and storage facilities in North America, Latin America, Japan and Europe.

* As of June 1, 2017; includes projects that are operating, in construction or contracted.
Renewables include wind, solar and storage.

Developed Projects

GRAND RIDGE ENERGY STORAGE

- 31.5 MW li-ion advanced energy storage project

| COD | PROJECT | SIZE |
|---------------|---|-----------------------|
| 2012 | Grand Ridge IV (Lithium Titanate) | 1.5 MW / 1.0 MWh |
| 2014 | Goldthwaite (Sodium Nickel Chloride) | 0.6 MW / 1.2 MWh |
| 2015 | Grand Ridge Energy Storage (Lithium Iron Phosphate) | 31.5 MW / 12.2 MWh |
| 2015 | Beech Ridge Energy Storage (Lithium Iron Phosphate) | 31.5 MW / 12.2 MWh |
| 2016 | Grand Ridge IV Expansion (Lithium Iron Phosphate) | 3.0 MW / 1.4 MWh |
| 2018 | Orangeville Energy Storage (Lithium NMC) | 20 MW/ 10 MWh |
| 2019/ 2020 | To be announced | 36 MW/ 105 MWh |



7 ENERGY
STORAGE
PROJECTS
IN THE US

94 MW
OF
NAMEPLATE
CAPACITY

#1 PRIVATELY
HELD
ADVANCED
ENERGY STORAGE
OWNER/OPERATOR

Frequency Regulation – Launchpad for Storage

FERC Order 755 – Pay for Performance

- Order 784 – Still recognizes capability

PJM

- 800 : 5 : 30

Lessons Learned

- Yup, it's fast
- Decreases Reserve Requirements – Net Savings
- State-of-Charge Management

Early Market Evolution

Balancing & Ancillary Services

- Solar Integration – PR & HI

“Capacity”

- CA Resource Adequacy
- “Capacity Performance”

Reliability & Multiple Services

- Glacier - PSE
- BQDMP - ConEd



Bellingham Herald - 2016

Scoping the Next Wave

What is “Flexible Capacity”?

- Serving the Peak
- Optimizing the Fleet
 - Ramping
- Incremental & Mobile Installations

Additional FERC Activity

- RM17-8: Interconnection
 - Grand Ridge Energy Center
 - Supply vs. T&D
- RM16-6 & 16-1: Frequency Response & Reactive Power

Technology Advancements

- Carts & horses, chickens & eggs



Market Product Structure

Meet NERC Standards

Market-Wide or Zonal Eligibility

Pay for Performance

- **Does duration become a factor?**
- **Performance-based Dispatch**

**State-of-Charge Management &
Intra-Hour Co-optimization**





**We are
Invenergy.**

**Working
towards a
clean energy
future.**