NARUC

Winter Committee Meetings

Committee On Electricity

Energy Storage:

Three Views

Moderator:

Hon. Asim Haque, Ohio

- *Kenneth Collison, ICF International*
- *Hon. Cheryl LaFleur, FERC*
- *Ned Bartlett, Massachusetts Energy & Environ. Affairs*

Energy Storage - Outlook

NARUC Winter Meeting

Washington, DC

2/13/2017

Kenneth Collison
Vice President, ICF

Outline

- Current operational storage capacity
- Battery storage technology by sector
- Storage applications and advantages
- Costs and benefits
- Conclusion

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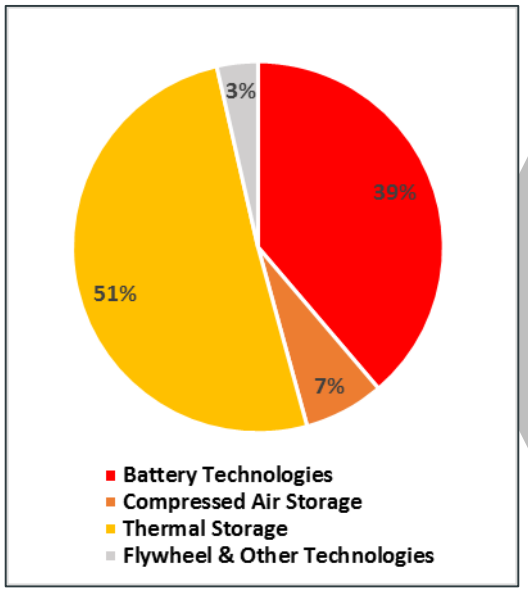
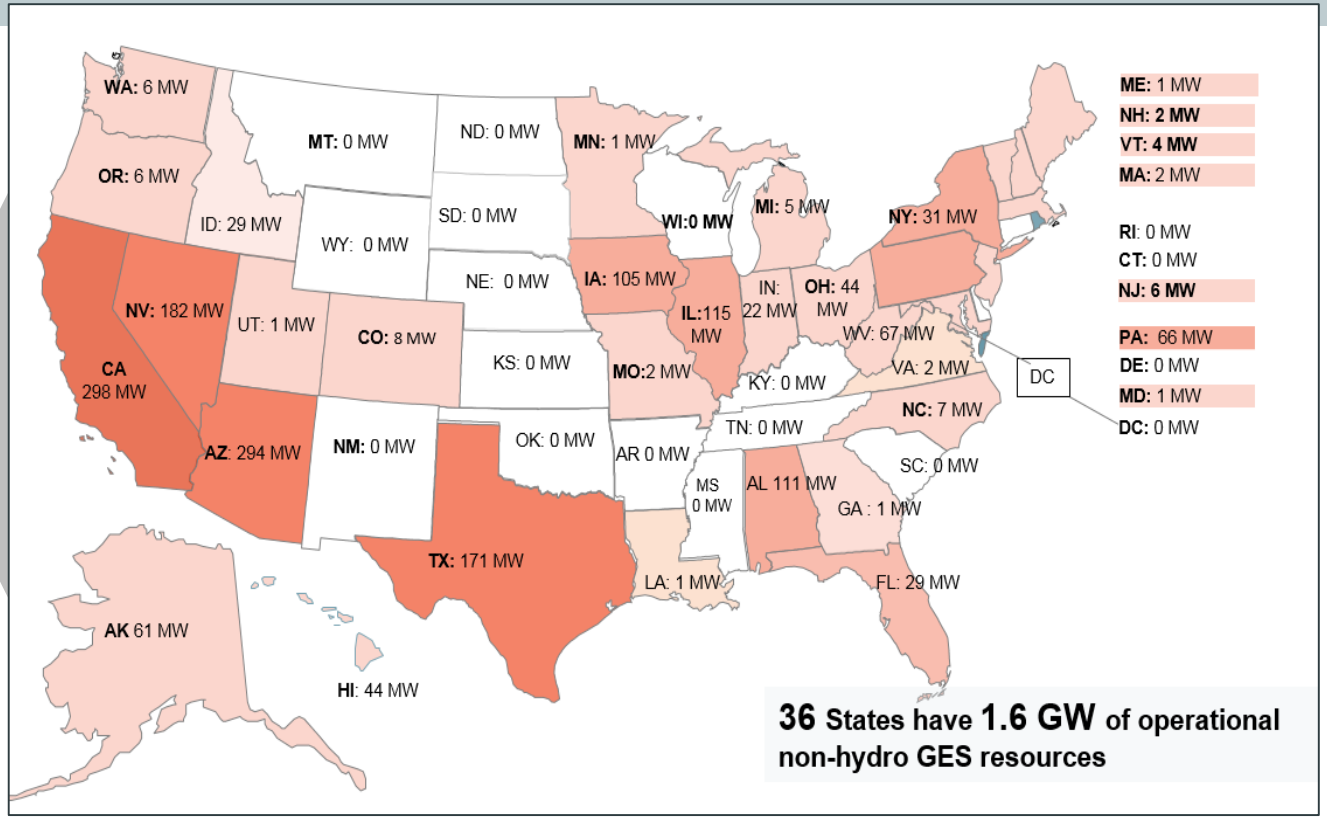
Operational Energy Storage Technologies (Non-hydro)

1.6 GW of operational non-hydro energy storage resources in 36 states





Source: US DOE Global Energy Storage Database

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Moving Forward – Battery energy technology is one of the fastest growing segments

77.5 MW of battery storage came online in California January 2017

Technology Type	Existing (MW)	Planned 2017-20 (MW)	Total (MW)
Lithium-based Battery	475	371	846
Lead Acid Battery	87	21	108
Sodium-based battery	26		26
Nickel-based battery	27	10	37
Zinc-based Battery	3	15	18
Vanadium-based Battery	2	22	25
Total	**620**	**441**	**1061**

Source: US DOE Global Energy Storage Database

20MW, 4 hours-SCE
TESLA, constructed in 88 days

37.5MW, 4 hours – SDG&E
AES (largest 30 MW installation)

20MW, 4 hours – SCE
Greensmith in under 4 months

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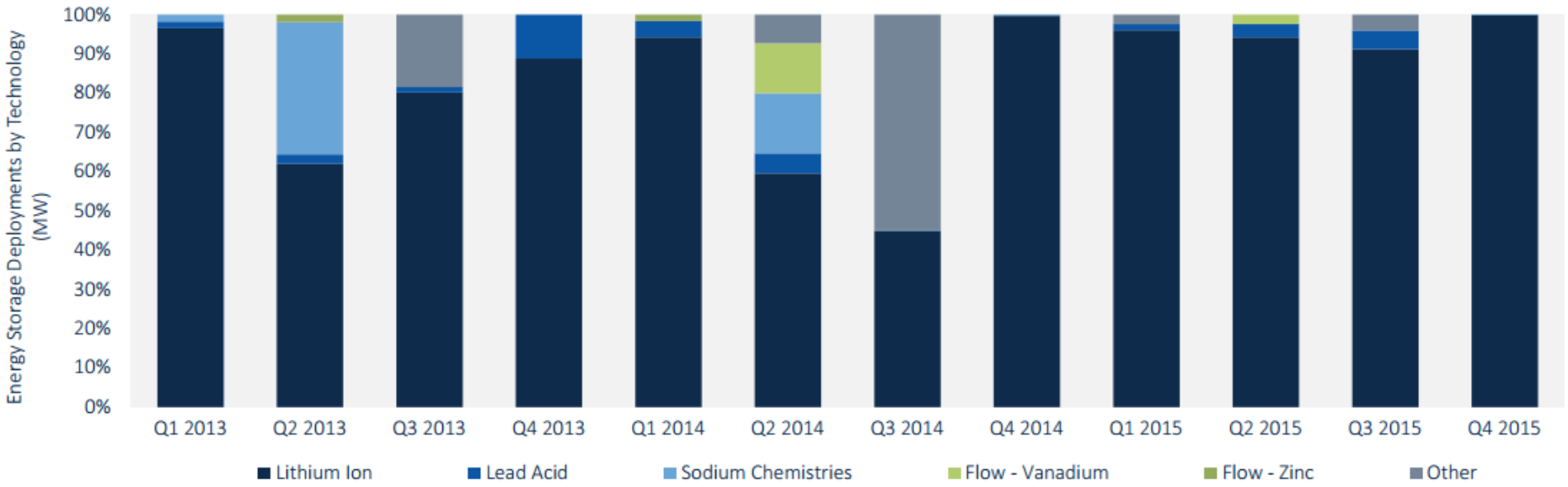
Energy Storage: Capacity Added by Sector per Year

- **Technology Trends:**
  - Lithium-ion = **96 %** of 2015 deployment vs. **72 %** of 2014
    - 50% cost decline since 2010
    - High power for short-duration applications and up to 4 hours of energy for resource adequacy contribution
  - Advanced lead-acid
  - Flow batteries



Source: GTM

*Pumped hydropower storage not included

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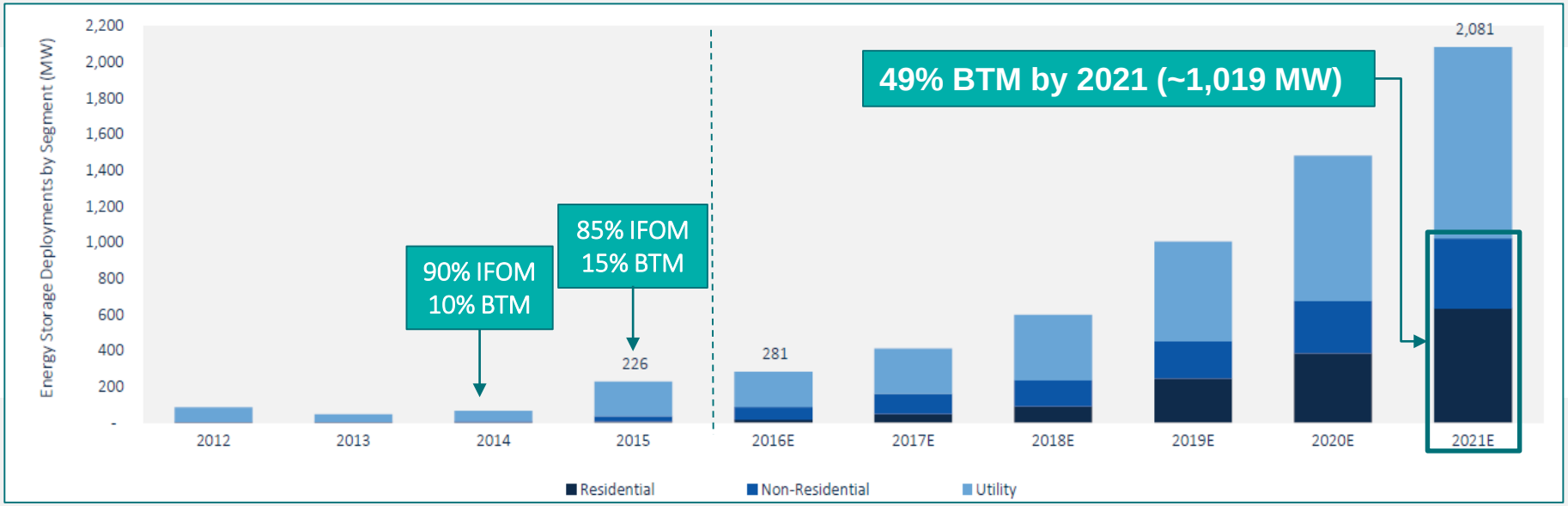
Energy Storage: Capacity Added by Sector per Year

Capacity Added:

- **2015** = 226 MW
  - **IFOM**: 192 MW
  - **BTM**: 34 MW
- **2021** = 2,081 MW
  - **IFOM**: 1,061 MW
  - **BTM:** 1,019 MW

*"Using energy storage to maximize self consumption of generation from a **distributed PV system** under a **non-NEM** rate is economically attractive **if** that same energy storage system is **allowed to deliver a suite of ISO/RTO and utility services** to earn revenue -RMI*



Source: GTM
**non-hydro*

This graph reflects only new installations in each year

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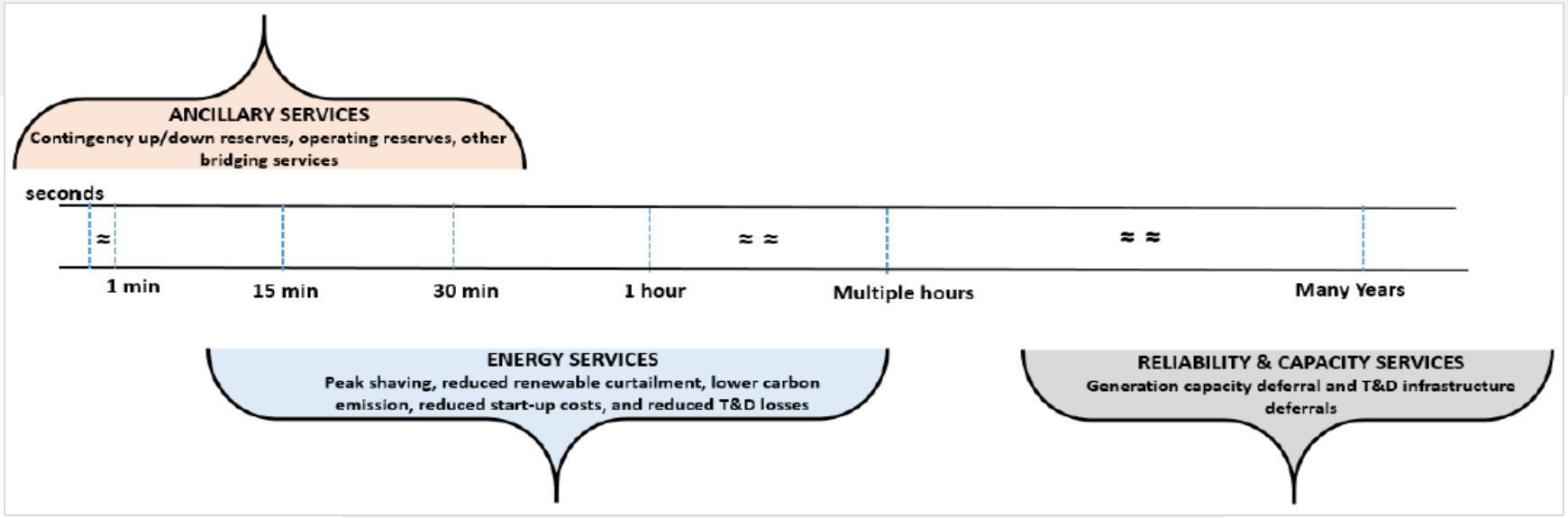
What Jump-Started Energy Storage in US

The grid operates in all time scales, and Energy Storage can derive value from many applications



Applications in 2 regions gave it a jump-start:

- **Frequency regulation in the PJM market – 15 minutes of stored energy**
- **Resource adequacy value in California – 4 hours of stored energy**

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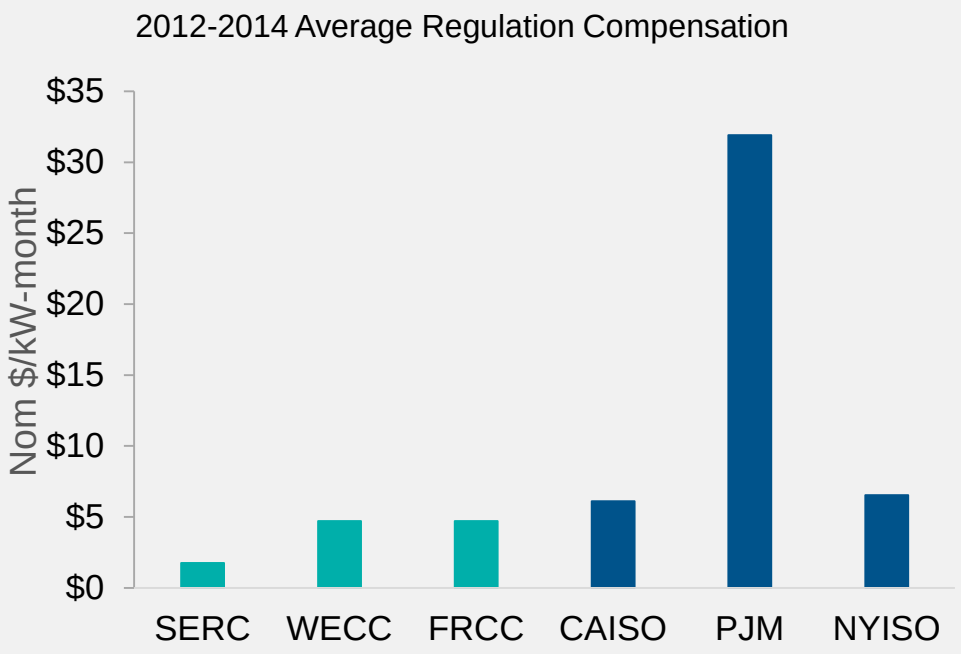
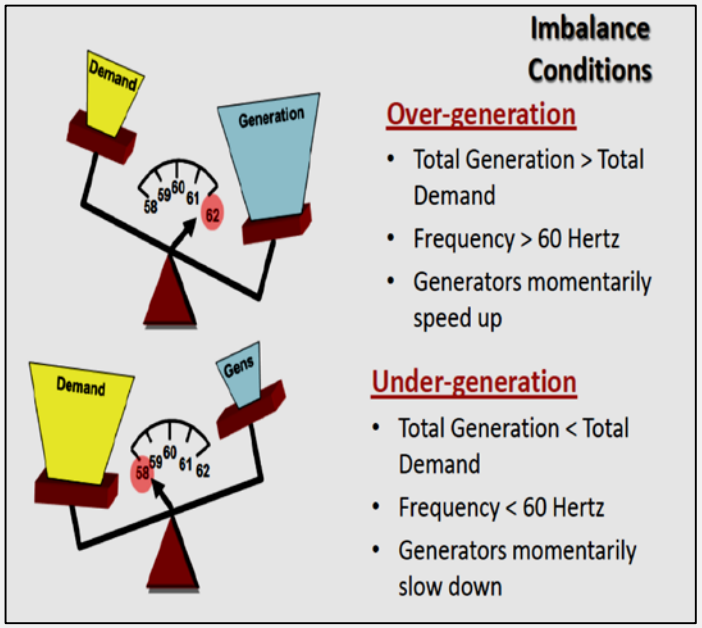
Frequency Regulation Market

PJM market has seen record deployments of Energy Storage.

- 250 MW of Energy Storage in a market size of 700 MW*





Source: PJM

* A new proposal will increase the market size to 800 MW

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Resource Adequacy Value

Dependable or FIRM capacity available from a resource during the time of need

- **100 MW of CC ~ 100% capacity**
- **100 MW of Solar PV ~ 38% capacity (PJM)**
- **100 MW of Wind plant ~ 13% capacity (PJM)**

In most markets, 4 hour energy storage resource is required for full resource adequacy contribution.

Market	Storage Eligible?	Minimum Availability / Operating Capacity
CAISO	Yes	At least 4 consecutive hours for over three consecutive days
PJM	Yes	Capacity assessed on performance assessment hours
ISO-NE	Yes	The capability is assessed based on the audit duration (2 hours)
NYISO	Yes	The resource must be able to provide energy for at least 4 consecutive hours
MISO	Yes	As a load modifying resource that can supply 4 hours of energy consecutively

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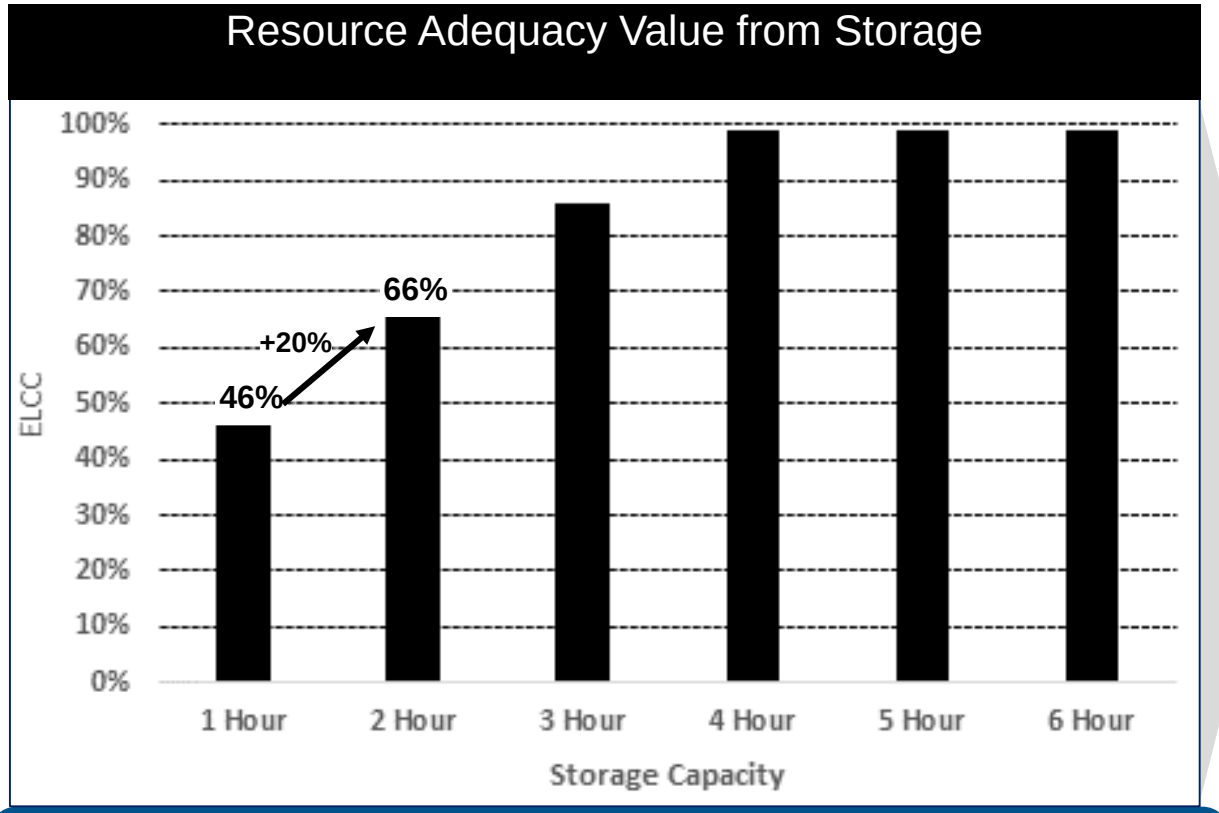
Duration of Stored Energy Matters…..



Incremental Capacity Value

1st Hour Block – 46%
2nd Hour Block – 20%

Saturation effect kicks in for Storage > 4Hr

- ✓ The first 1-hour block provides the highest (incremental) capacity value
- ✓ Greater than 4-hour of Energy Storage provides ≈ 100% capacity value

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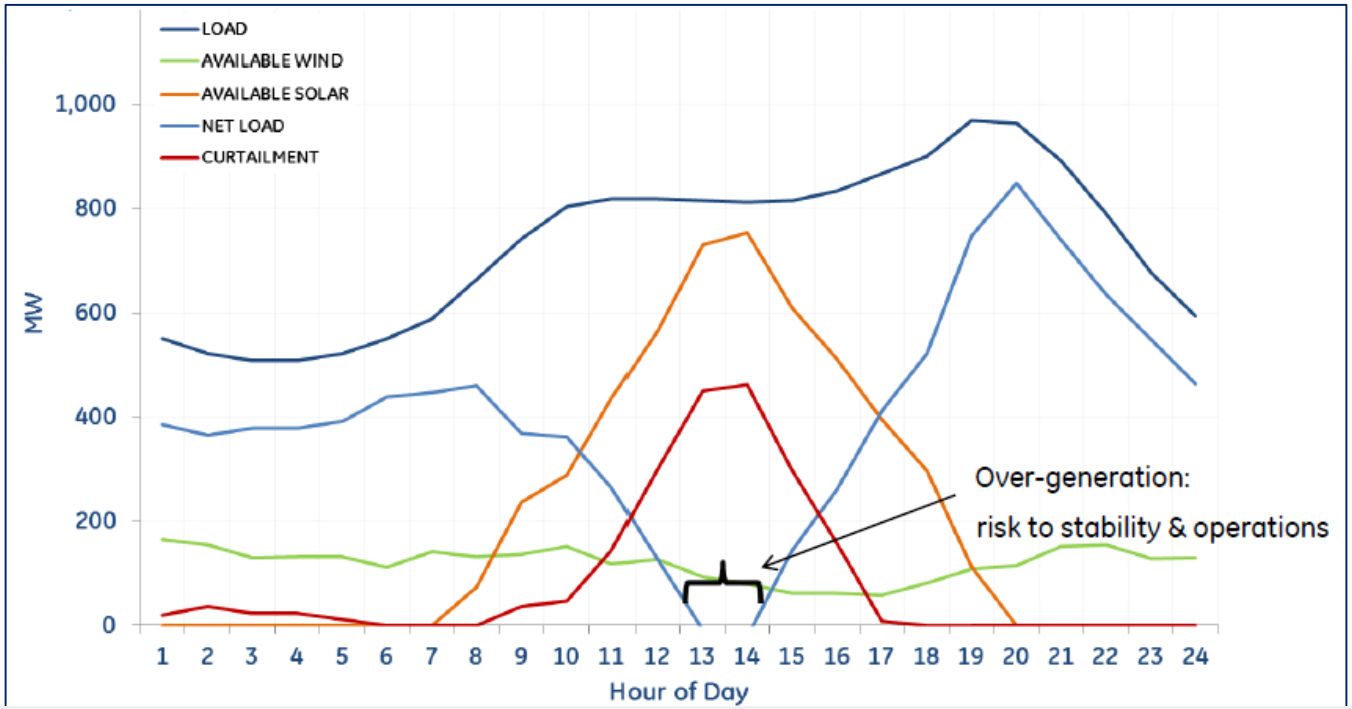
Other Ancillary Services

The Famous Duck Curve – It is not only a flexibility issue but can manifest as a grid stability problem. Hawaii is tackling it today!!



Hawaii RPS Study – A simulated scenario with 40% of electrical load served by solar and wind energy.
Solar PV energy – 30%
Wind energy – 10%

In 2015, 23.4% of Hawaii's electricity was generated from renewables. Hawaii's RPS goal is to achieve 100% renewable penetration by 2045

Figure Source: Hawaii RPS Study

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Storage Mitigates Over-generation Issue

Energy Storage and the Duck Curve

Energy Storage reduces over-generation by operating through its normal charge cycle

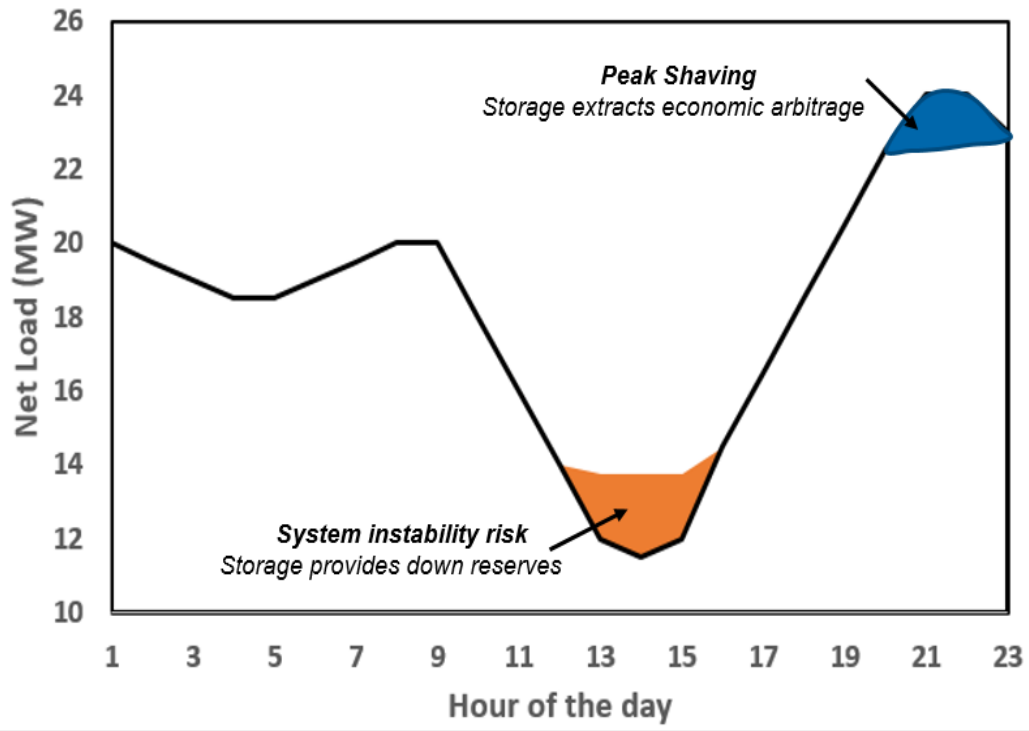

Figure Source: Hawaii RPS Study

California PUC approved pilot programs last November to encourage large electric customers to shift their use in the middle of the day

PG&E proposed a "super off-peak" credit of 4 cents/kWh from 8:30 a.m. to 3:30 p.m in March, April, and weekends/holidays in May and June

SDG&E proposed hourly dynamic pricing to agriculture and water pumping stations. The credits are expected to fall between 10 a.m. and 2 p.m. from November through April.

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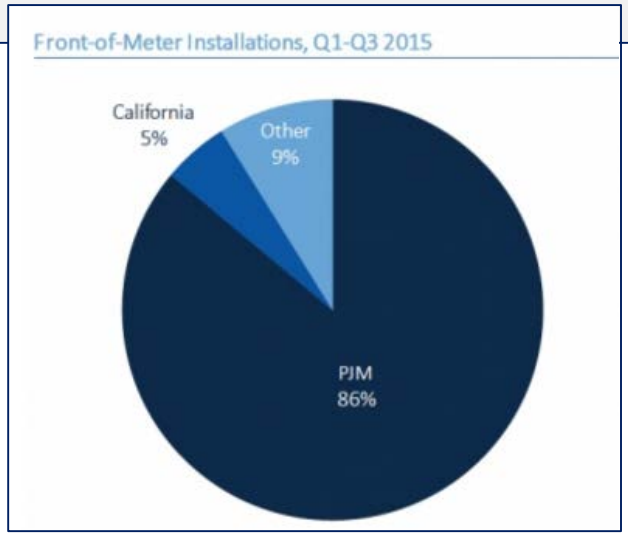
Energy Storage: Applications

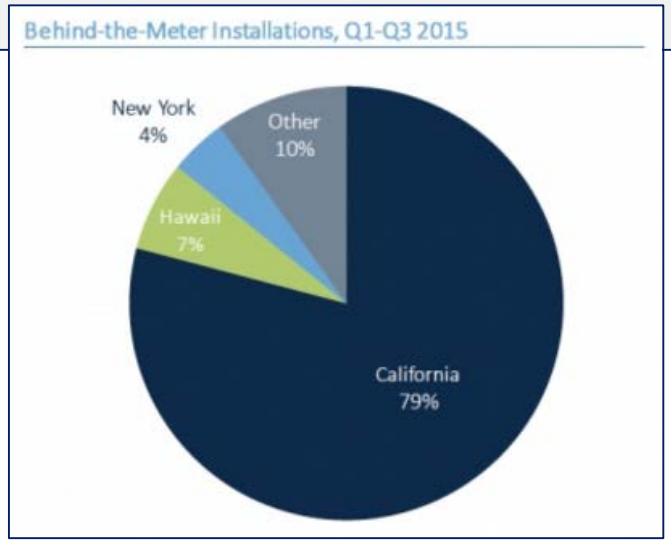
In Front of Meter

- **Frequency regulation**
  - CA + PJM (ex. NJ) = 92% market since 2013
- **Renewables integration**
  - HI: Kauia Island Utility Cooperative (KIUC) signed PPA for 20 MW solar + storage at 11 cents/kWh in Jan 2017
  - KIUC signed a PPA of 13 cents/kWh for a 13 MW solar + storage project in Sep 2015
- **Investment deferral (NWA)**
  - NY: BQDM 11MW of the 52MW consist on non-traditional utility-side solutions (storage, CVO, fuel cells and solar PV)

Behind the Meter

- **Renewables integration**
  - NY: ~ $ 2,100/KW battery storage incentive for summer peak demand reduction
  - VT: Green Mountain Power offers a 3.3 kW Tesla Powerwall to residential customers with 3 options: purchase, purchase w/power sharing which credits customers $31.76/month or leasing for $1.25/day w/sharing
- **End User (Behind-the-Meter) = Peak Shaving**
  - CA, HI, NY: Stem, Green Charge Network, Demand Energy and others deploying BTM storage for commercial customers for peak shaving





Source: GTM

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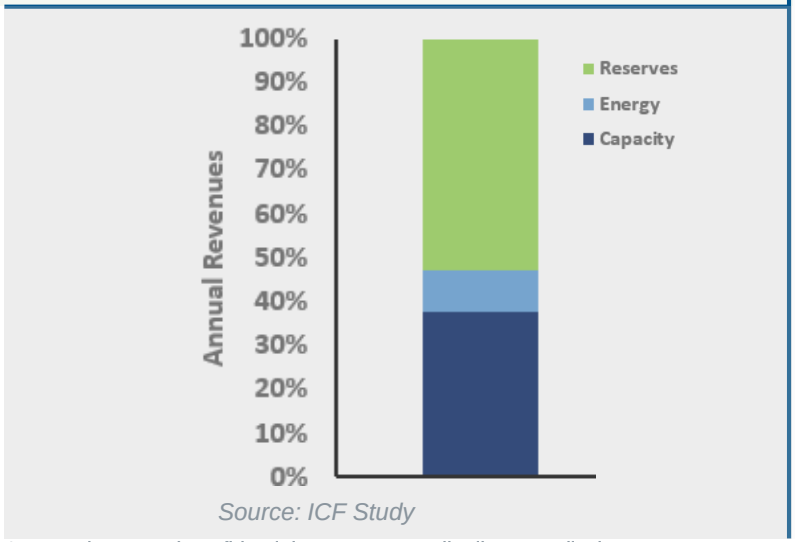
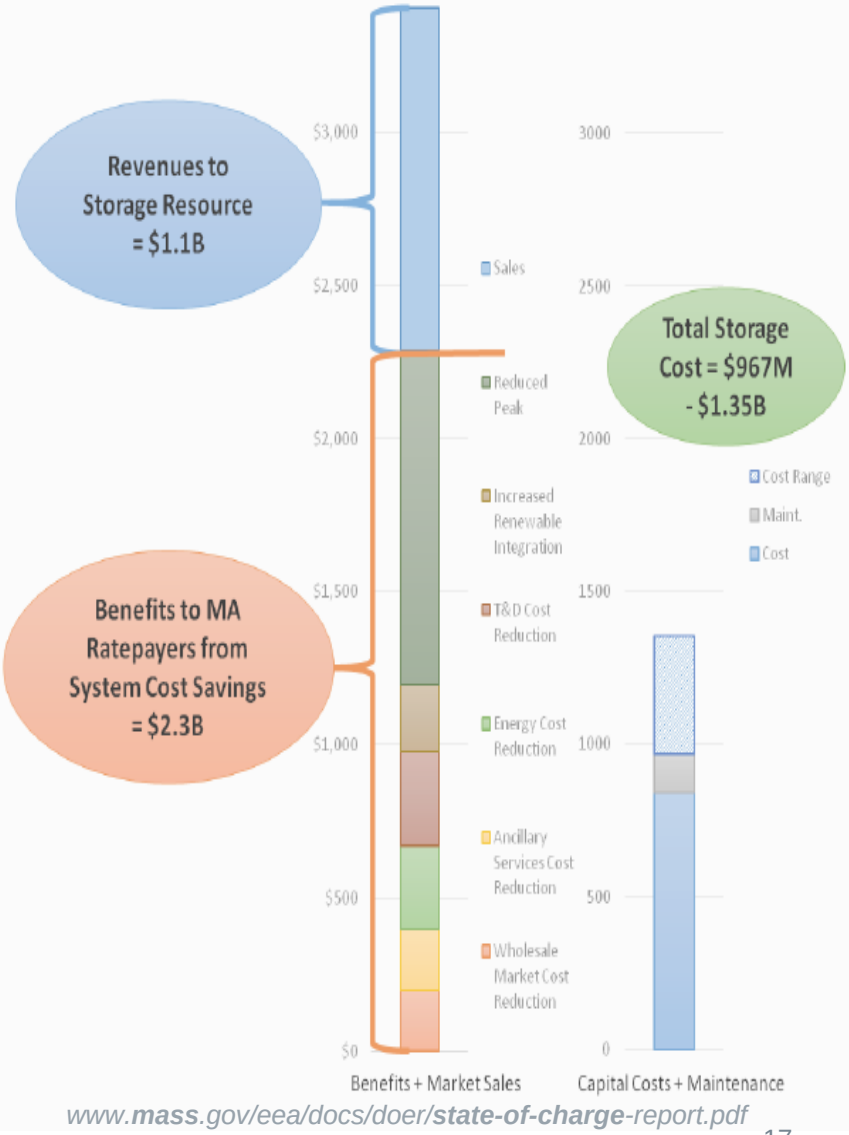
We are at the intersection of declining costs and development of supportive policies

EPRI, **Energy Storage Cost Summary for Utility Planning:2016**



Source: ICF Study



*www.**mass**.gov/eea/docs/doer/**state-of-charge**-report.pdf*

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Key Takeaways

- **Advanced energy storage technologies are a fast growing segment of the power markets and will become even more attractive with declining costs**
- **Given its unique characteristics, advanced energy storage technology has the potential to provide significant benefits**
- **Market evolution would be required to fully exploit these storage technologies**
- **Storage could be key in meeting renewable and clean energy goals**

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Thank You!

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Appendix

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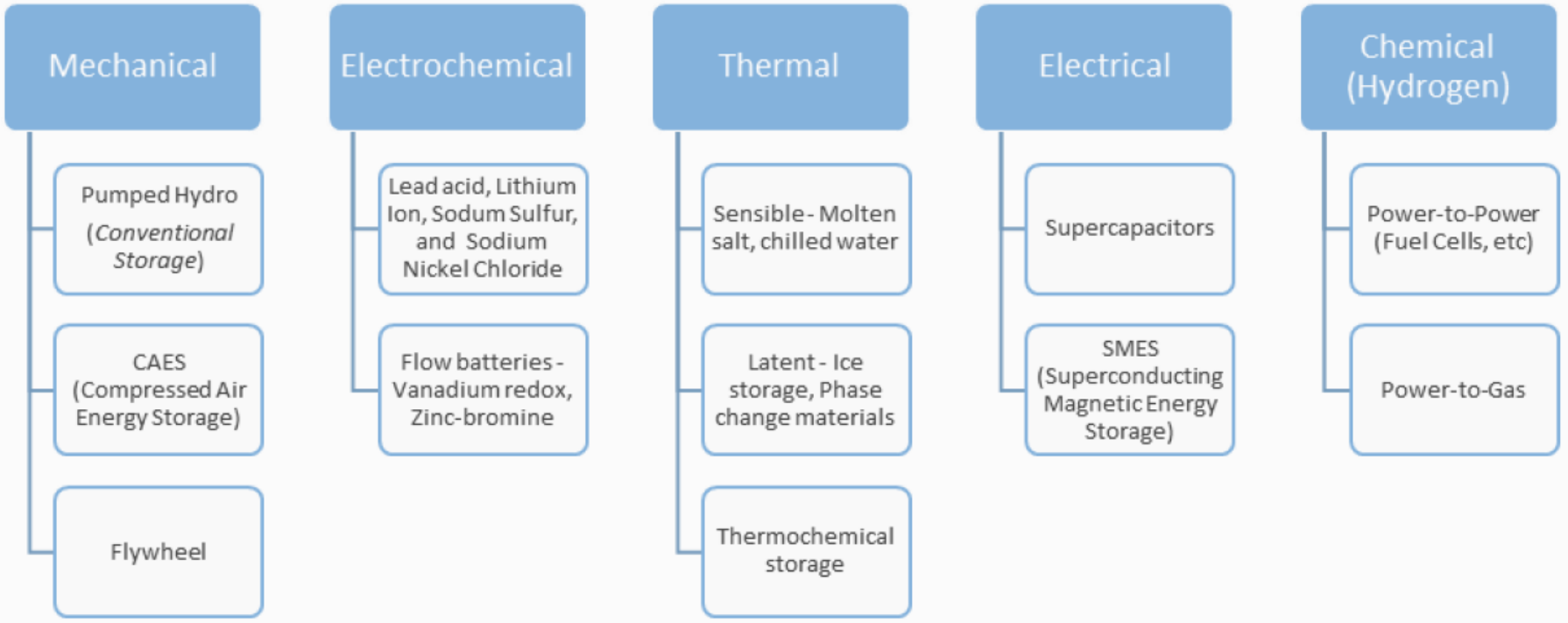
Classification of Energy Storage Technologies



Source: State Of Charge, Massachusetts Energy Storage Initiative Study

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Reducing Barriers to Electric Storage Resources Providing Wholesale Services

February 13, 2017

Acting Chairman Cheryl A. LaFleur

Federal Energy Regulatory Commission

Recent FERC Actions

- Electric Storage Participation in the Organized Wholesale Electric Markets (Docket Nos. AD16-20-000, RM16-23-000)
- Storage as Transmission Asset Technical Conference and Policy Statement (AD16-25-000, PL17-2-000)
- Reform of Generator Interconnection Procedures and Agreements (Docket Nos. RM16-12-000, RM15-21-000, RM17-8-000)
- Order Partially Granting Indianapolis Power and Light's Complaint against MISO Tariff (EL17-8-000)

NOPR on Electric Storage Participation in the Organized Wholesale Electric Markets

The Commission issued a NOPR in November 2016 proposing to require each RTO and ISO to:

(1) establish a participation model consisting of market rules that accommodates the participation of storage resources in wholesale electric markets and

(2) allow distributed energy resource aggregators, including electric storage resources, to participate directly in the organized wholesale electric markets.

I issued a statement on this order because I am especially interested in comment on needed operational coordination among the RTO/ISOs, the distribution control centers, and the distributed energy resource aggregators.

Policy Statement on Utilization of Electric Storage as a Transmission Asset

On January 19, 2017 the Commission issued a policy statement on electric storage resources that seek to concurrently recover their costs through cost-based and market-based rates, which provided guidance related to:

- double recovery of costs,
- potential for adverse competitive impacts, and
- the need for independence of regional grid operators from market participants.

I dissented on this order because of its broad rationale in dismissing concerns about the potential impacts of multiple payment streams on pricing in wholesale electric markets, which I think raises larger issues.

NOPR on Generator Interconnection Procedures and Agreements

The Commission's December 2016 Generator Interconnection NOPR included a few proposed reforms that could particularly benefit electric storage resources:

- Revising the definition of Generating Facility in the LGIA and LGIP to explicitly include electric storage resources
- Allowing interconnection customers to request interconnection service below the rated generating facility capacity (e.g., a combined wind/storage facility)
- Requiring transmission providers to establish a process for provisional interconnection service before all network upgrades are completed
- Requiring transmission providers to establish an expedited process for the utilization of surplus interconnection service
- Requiring transmission providers review and report to the Commission on whether their modeling and study practices adequately account for the operational characteristics of electric storage resources.

Indianapolis Power and Light's Complaint

- In a recent complaint, Indianapolis Power & Light argued that MISO's Tariff is unjust and unreasonable because it fails to properly account for currently available grid-scale battery storage devices. They argued, among other things, that the MISO Tariff's "Stored Energy Resource" resource type does not allow electric storage resources to provide all products that they are technically capable of providing.
- On this issue, the Commission granted IPL's complaint, finding that MISO's tariff was unjust and unreasonable because it unnecessarily restricts competition by preventing electric storage resources from providing all the services that they are technically capable of providing, which could lead to unjust and unreasonable rates. The Commission directed MISO to submit a compliance filing within 60 days.
- Note that this order is still within the rehearing window, so I can't discuss it.

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