Electric Energy Storage: Primer

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PJM as Regional Transmission Organization (RTO)

OPERATIONS

Matches supply with demand like...

MARKETS

Energy Market Pricing like...

PLANNING

Planning for the future like...

- 65 million people served
- 21% of US GDP
- 165 GW peak load
- Founded 1927

The Nature of Electric Energy Storage

Seeking Alpha | Portfolio | News | Articles | StockTalk | Alerts

The Lithium Ion Battery Conundrum: W
Win The Holy Grail Of Energy Storage
Electric Cars?

Jun. 17, 2014 1:59 PM ET | 22 comments | About: Electrovaya Inc. (EFLVF), Includes: CSIQ,

FINANCIAL TIMES

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January 14, 2011 3:48 pm

Electricity storage: holy grail
renewables industry

By Fiona Harvey, Environment Correspondent

HUFF POST GREEN ...ittle Secret;

Bill Radvak Become a fan
President and CEO, American Vanadium Corp

Energy Storage: The Holy Grail of Our Energy Revolution?

Posted: 05/03/2013 5:20 pm EDT | Updated: 07/03/2013 5:12 am EDT

WIRED Search for the Holy Grail of Energy Storage

BUSINESS | DESIGN | ENTERTAINMENT | GEAR

ARCH FOR THE HOLY GRAIL OF
ERGY STORAGE CONTINUES

theguardian

BloombergBusiness | News

Power to the people: bring on the superbattery
John Naughton

Efficient storage of electricity, especially from renewable sou...s, is the holy grail of the energy industry. And Elon Musk could have a gamechang... his sleeve

Giant Batter...
Wind Storage
Commodities

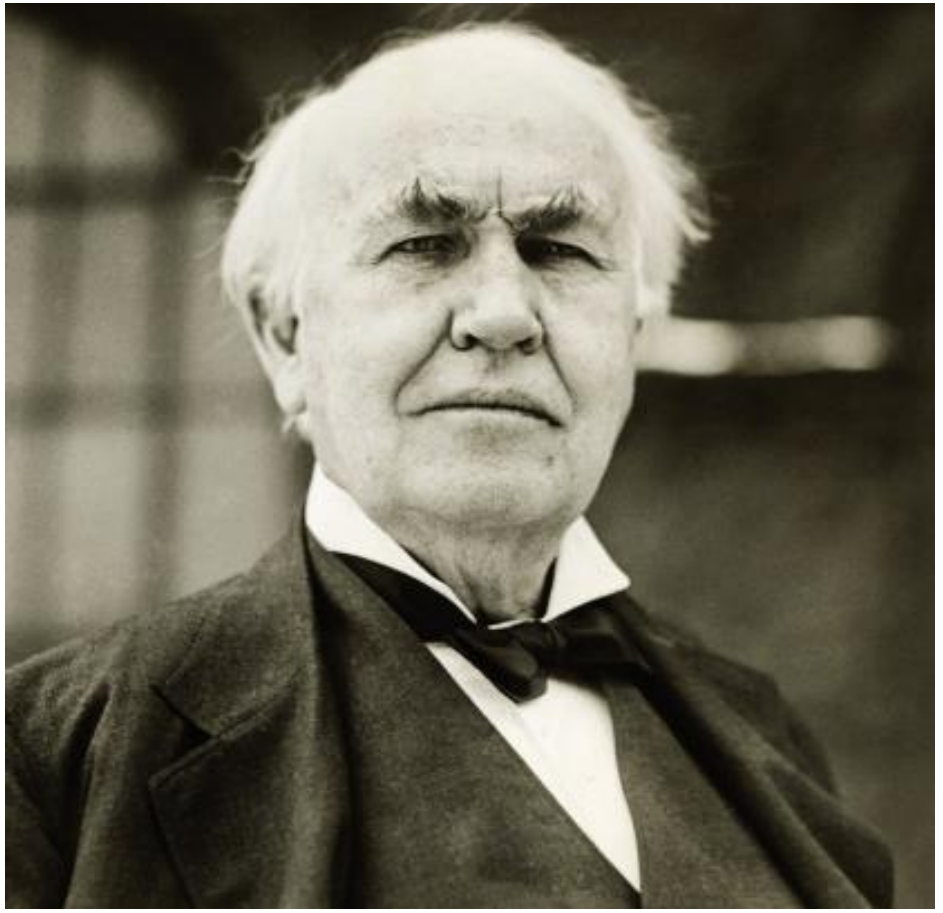
...uel Cells Bulletin
...13, Issue 9, September 2013, Pages 12–15

...ergy storage: The Holy Grail for renewable energy grid integration

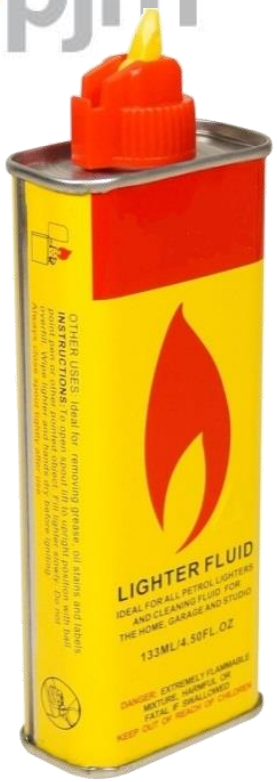
The Legend of Energy Storage: as Old as Electricity

"The storage battery is, in my opinion, a catchpenny, a sensation, a mechanism for swindling the public by stock companies. The storage battery is one of those peculiar things which appeals to the imagination, and no more perfect thing could be desired by stock swindlers than that very selfsame thing. ... Just as soon as a man gets working on the secondary battery it brings out his latent capacity for lying."

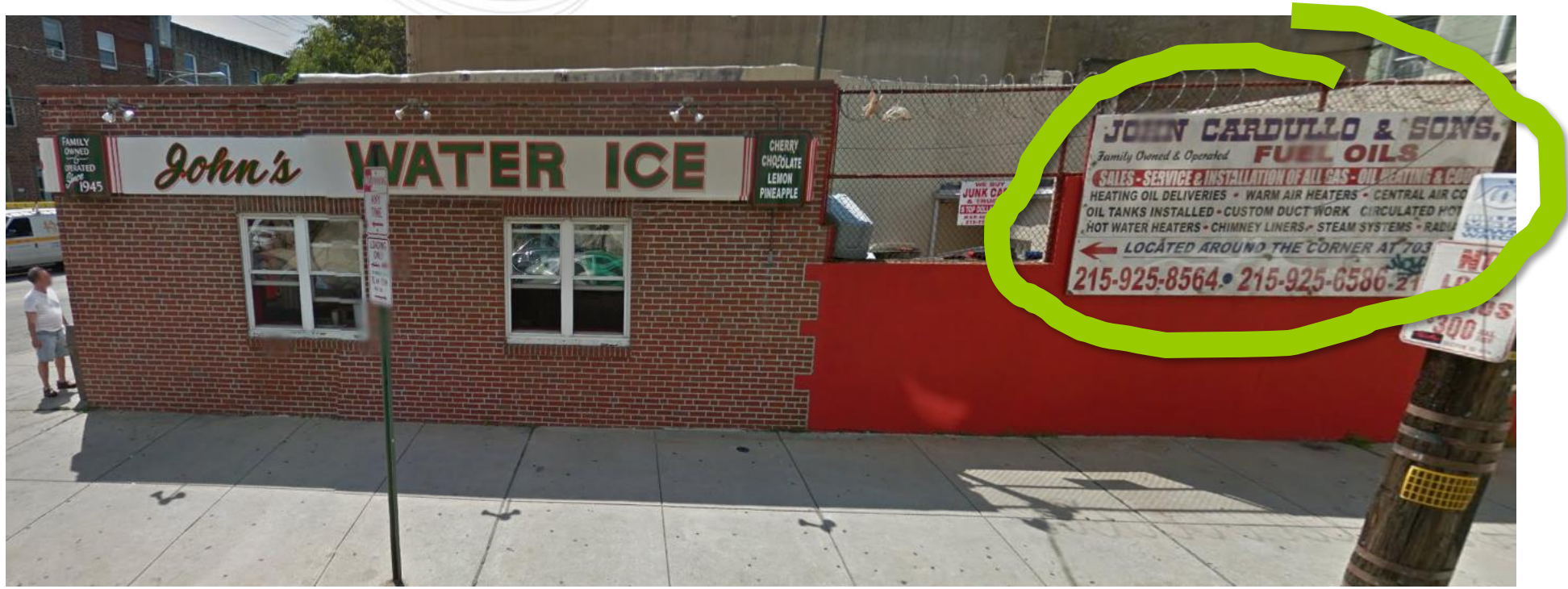
--Thomas Edison, 1883



How to Schedule Fuel Oil Delivery



~$0.02
per kWh



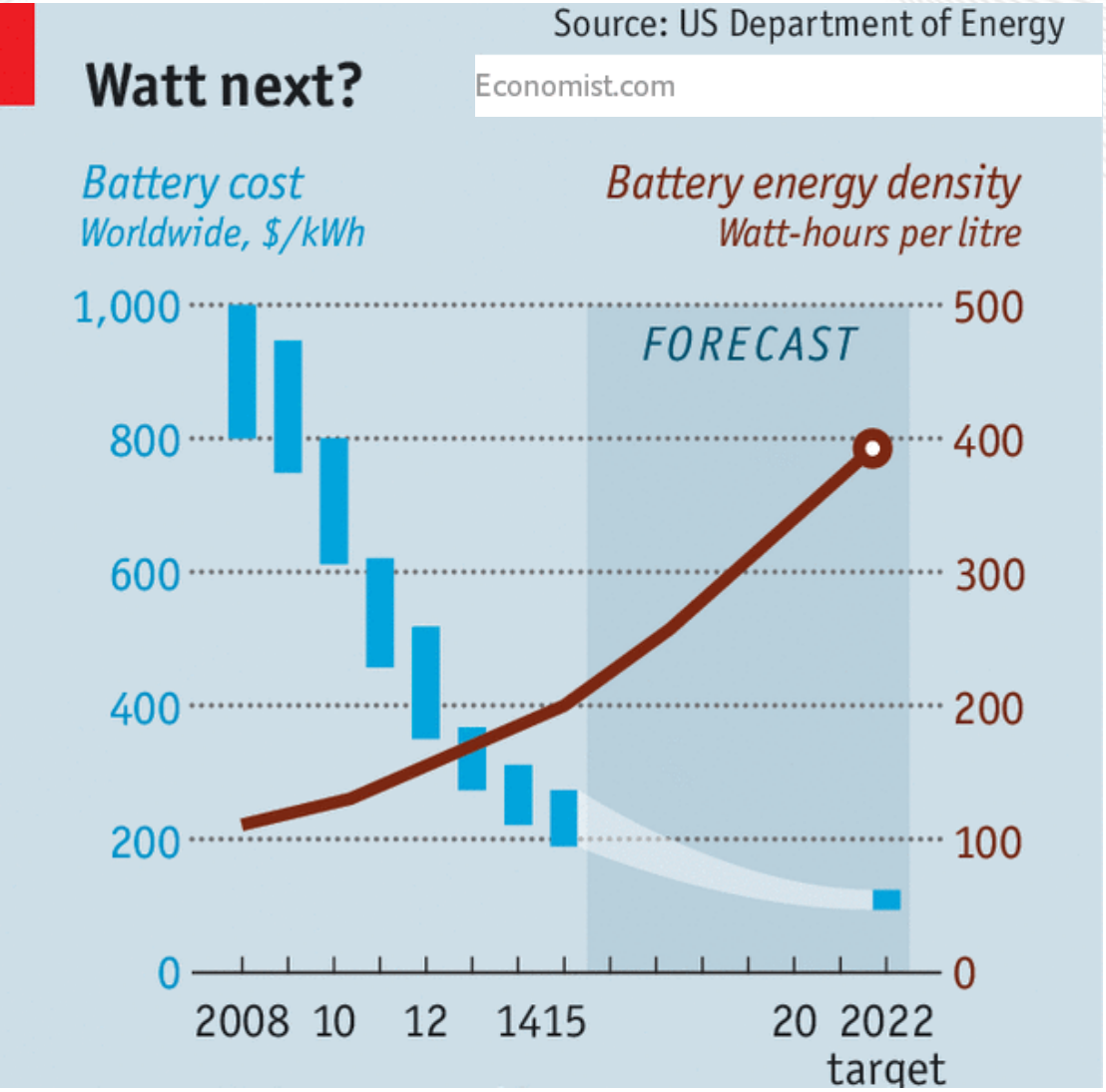
How to Schedule Electricity Delivery

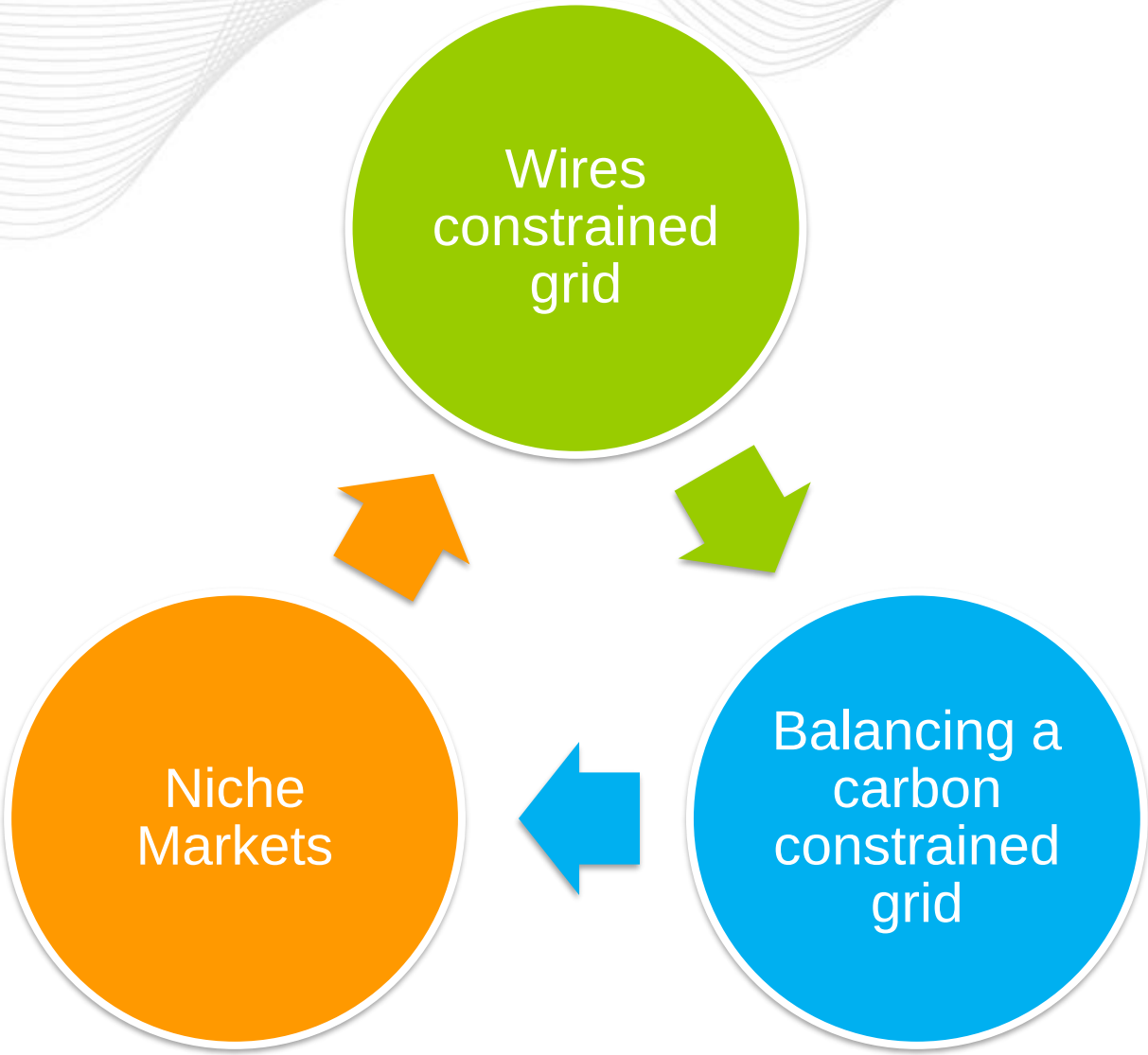
~$200 per kWh

Lack of storage defines the electric grid

- Fact 1: Transport of electricity is incredibly fast:
  - ~ 2 seconds to take power from a generator in Oklahoma to a customer in Maine.
- Fact 2: Storage of electricity is fantastically expensive:
  - ~ 3 – 4 orders of magnitude higher than e.g., oil storage.
  - Most electricity storage is ~1–4 hours, none over 24 hours.
- Thus: electric grid = “conveyor belt” directly from producer to consumer.
- Special “Balancing Authority” utilities required to dispatch generators (and loads) to balance supply and demand on a minute-by-minute basis
  - E.g., PJM, Southern Company, Western Area Power Administration

Battery Costs Continue to Decline, Growth Opportunities for Storage

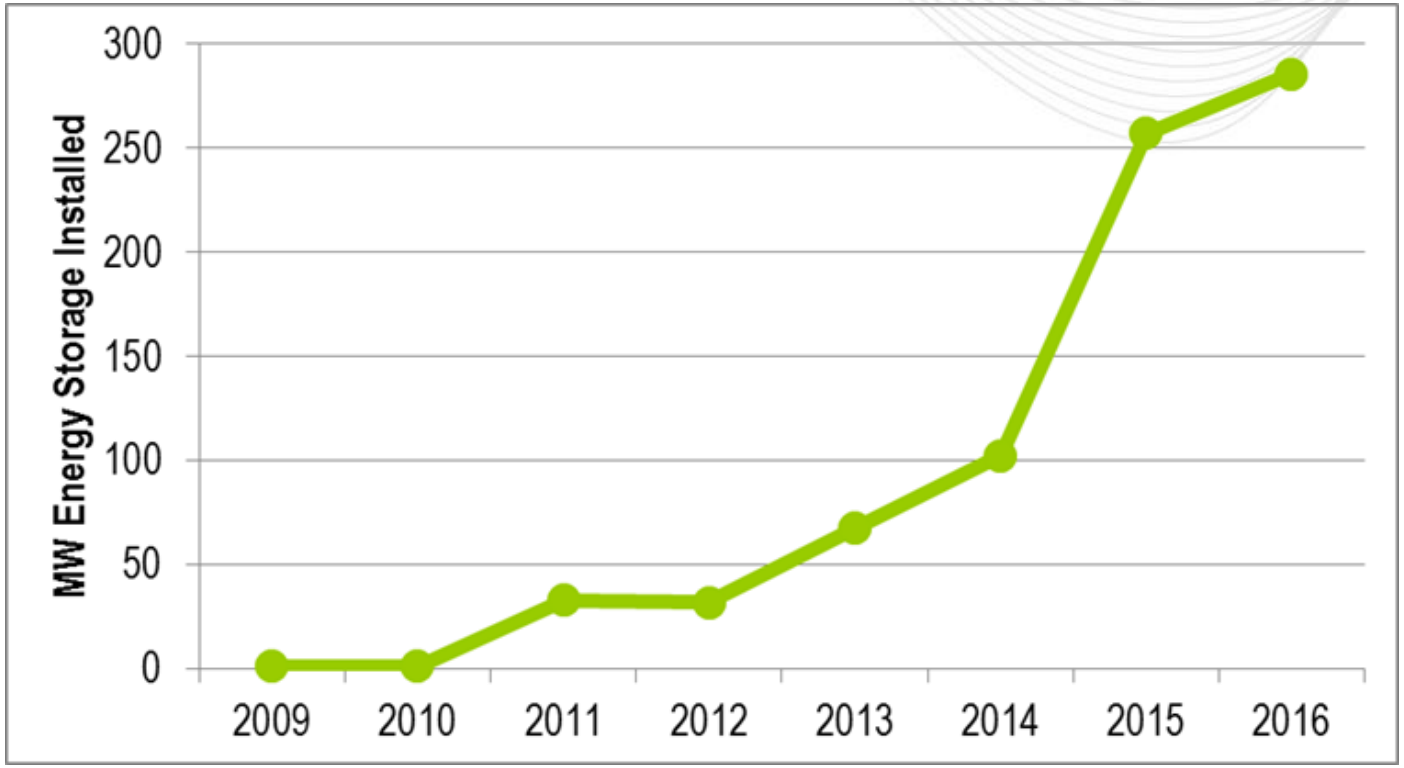




Storage Use Cases

Storage Use Case	Type	Jurisdiction	Incentivized?
Emergency Backup	Wires	Local	Customer
Reduce Retail “Demand Charges”, etc.	Wires	Local	Retail bill reduction: mostly large customers, but also states without Net Metering
“Non-Wires Alternatives”	Wires	~Local	Limited pilots
Regulating Reserves	Niche	FERC	Only in ISO/RTOs
Frequency Response	Niche	FERC	Limited cases
Energy Arbitrage	Balancing	FERC or Local	Most feasible in ISO/RTOs
Resource Adequacy	Balancing	FERC or Local	Integrated Resource Planning or ISO/RTO markets

Use Case: Regulating Reserves in PJM



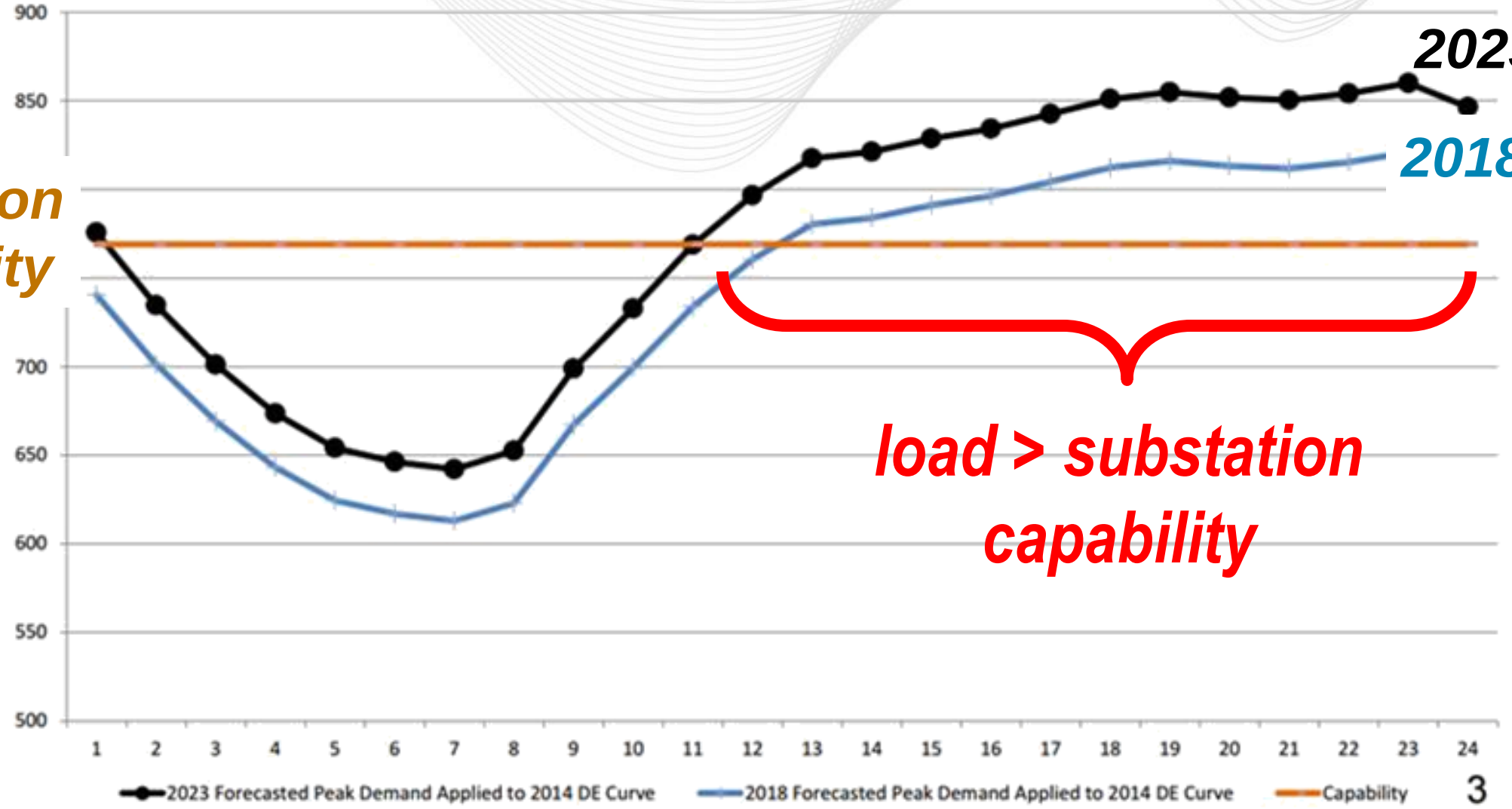
- PJM storage growth starting with “fast” Regulating Reserves* in 2008.
- At today’s deployment, more “fast” frequency regulation is not needed**.

**AKA Frequency Regulation*

***http://www.pjm.com/~/media/committees-groups/task-forces/rmistf/postings/regulation-market-whitepaper.ashx*

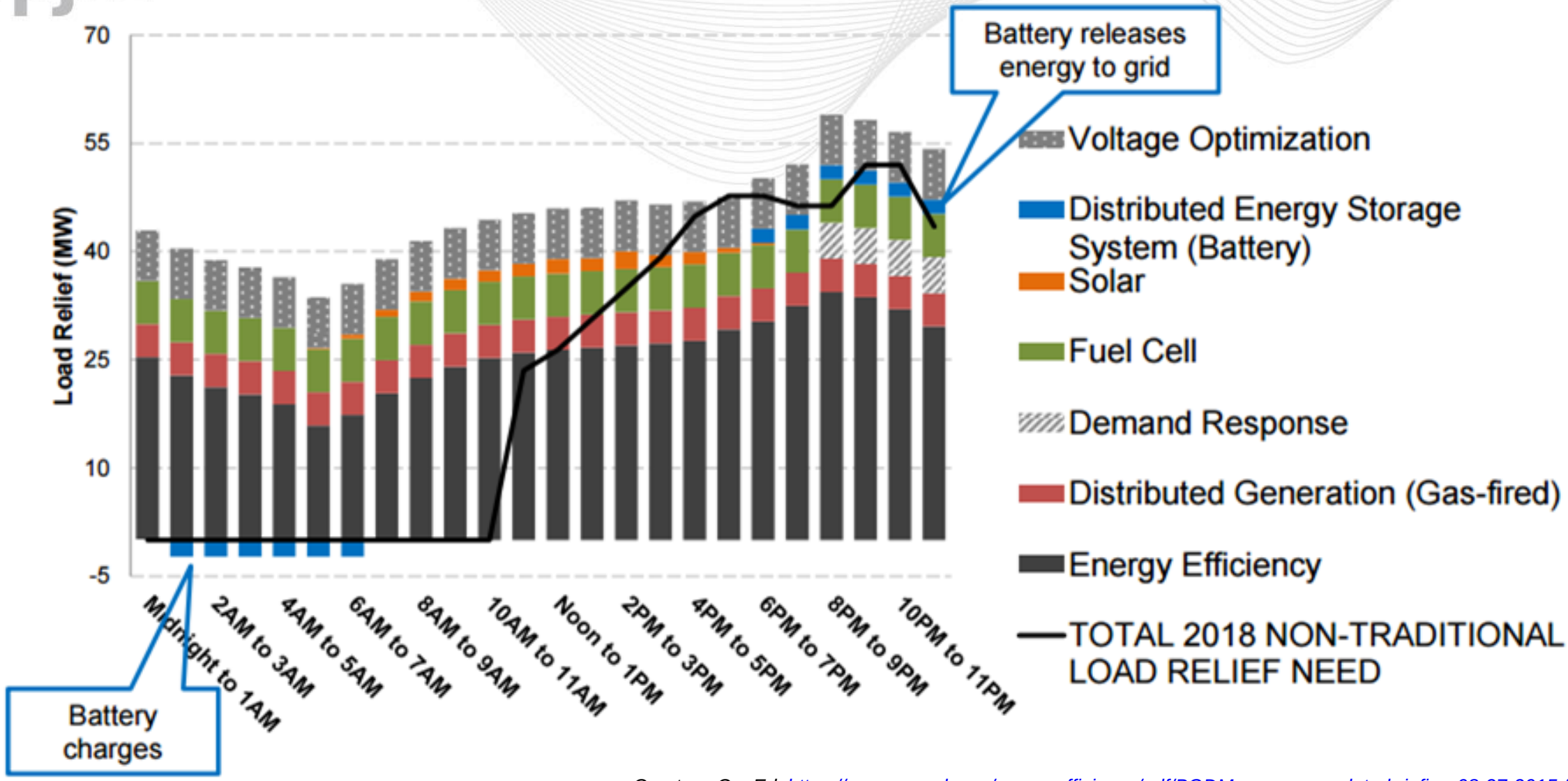
***http://www.pjm.com/~/media/committees-groups/task-forces/rmistf/postings/rts-curve-points-updated.ashx*

Use Case: Non-Wires Alternative



Courtesy ConEd: https://www.coned.com/energyefficiency/pdf/BQDM-program-update-briefing-08-27-2015-final.pdf

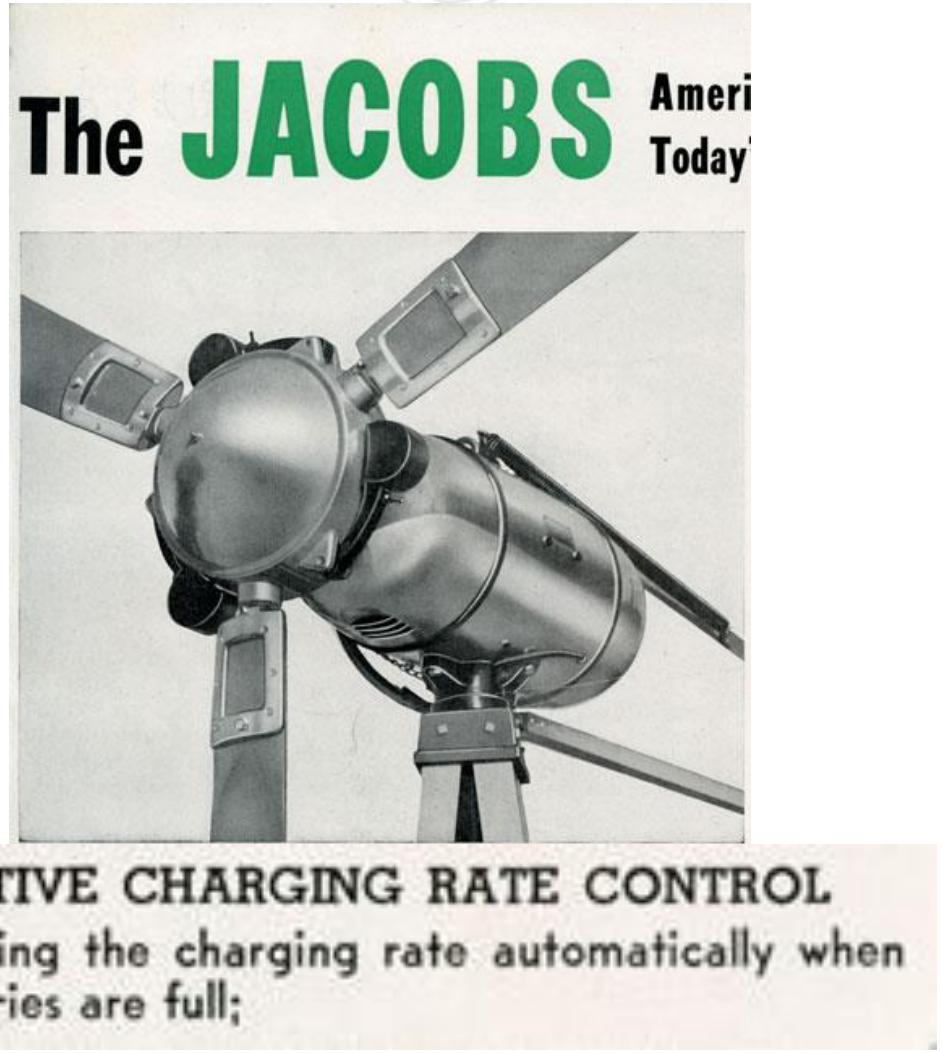
Use Case: Non-Wires Alternative



Courtesy ConEd: https://www.coned.com/energyefficiency/pdf/BQDM-program-update-briefing-08-27-2015-final.pdf

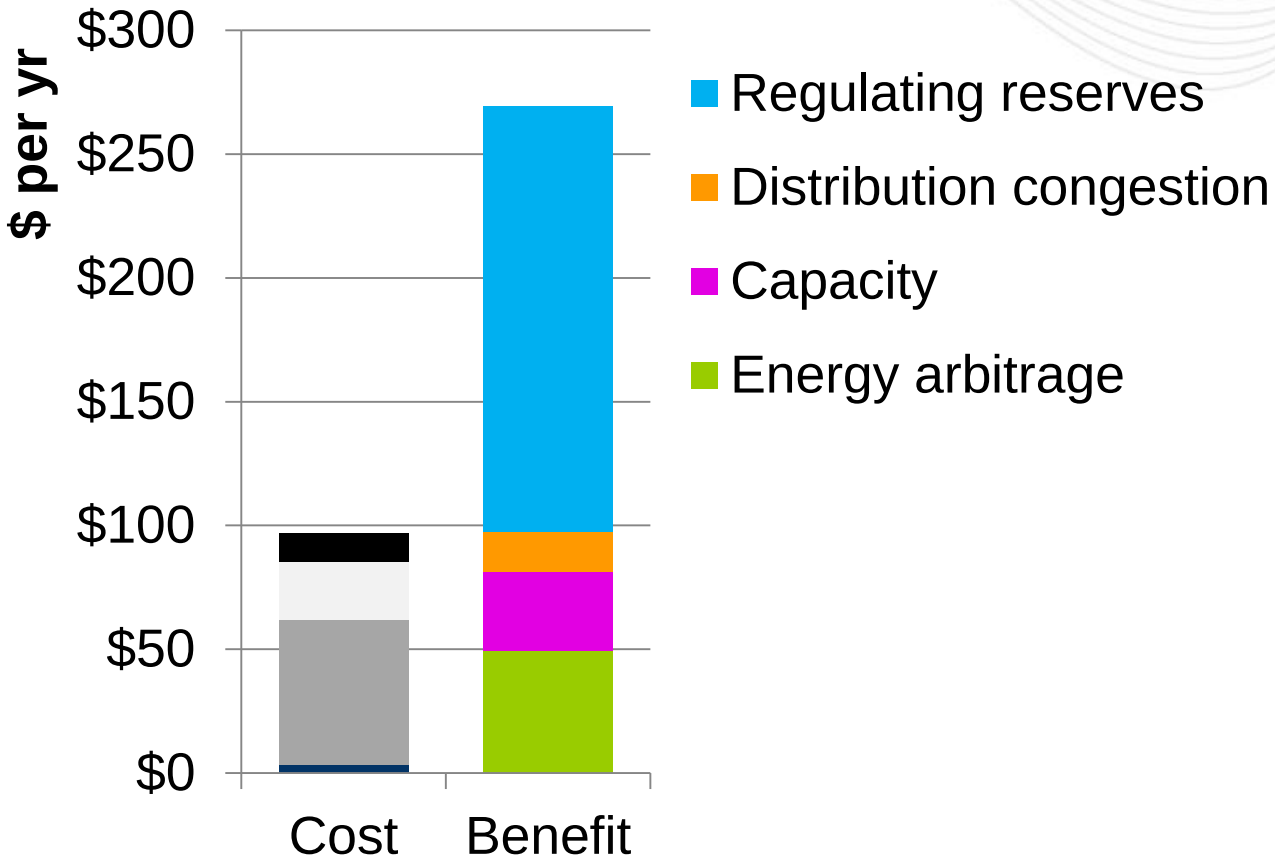
Use Case: Enabling Resilience from DER

- ~3 GW of customer-sited solar in PJM
- Of this: ~0 GW of resilience benefit
- Battery can enable islanded backup solar system



Multiuse: Distribution "Non-Wires Alt" plus Reserves + Energy + Capacity

Brattle/NRECA 2016 PJM Study



Challenges from Spanning 2 jurisdictions:

- Avoid double counting schedules, metering, and settlements
- Schedule coordination
- Priority in firm contracts, e.g. firm distribution congestion management vs. firm RTO generation
- Conflict e.g.: back-to-back calls with limited energy, or simultaneous local overgeneration + regional peak load
- Different interests for dynamic inverter requirements

Regulatory Questions

- How to fairly and optimally stack benefits for “multiuse” batteries?
- Is Energy Storage a generator?
  - If so, what are the implications for “wires” use cases in deregulated states?
- How do you fairly “model” energy storage in utility or ISO/RTO resource optimization systems?
- Does Energy Storage store energy, and if so, what are the jurisdictional implications?
  - E.g., most electricity withdrawals are considered end-use retail—however, wholesale energy storage withdrawals are counted as wholesale “time shifting” transactions.
  - How do you account for energy storage devices that perform both wholesale and retail functions?

The Punchline

- Storage: no holy grails just yet.
- Not a catchpenny either: growing niches of value and significant promise for the future.