



Recent Trends in Energy Storage Markets & Policies

Edward Burgess
Rutgers Energy Institute – 13th Annual Energy Symposium
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Strategen provides insight to global corporations, utilities and public sector leaders, helping them to develop impactful and financially sustainable clean energy strategies

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DOE GLOBAL ENERGY STORAGE DATABASE

Office of Electricity Delivery & Energy Reliability



HOME

PROJECTS ▾

POLICIES ▾

SEARCH



1660 Projects, 193594 MW

Technology Type ▾

Rated Power ▾

Ownership Model ▾

Country ▾

Duration ▾

Status ▾

State/Province ▾

Service/Use Case ▾

Grid Interconnection ▾

FILTER DATABASE

EXPORT DATA XLS

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Map View

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Storage analytics and cost/benefit

New York City's Aging Power Plants: Risks, Replacement Options, and the Role of Energy Storage



Prepared For: NY
September 20, 2016

Evolving the RPS: A Clean Peak Standard for a Smarter Renewable Future



California's Residential Utility Consumer Office



December 1, 2016

ENERGY TRANSITION LAB
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UNIVERSITY OF MINNESOTA
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MODERNIZING MINNESOTA'S GRID: An Economic Analysis of Energy Storage Opportunities

Minnesota Energy Storage
Strategy Workshop Final Report
July 11, 2017

Disclaimer: Views in this report do not necessarily reflect those of all participants.

Topics

Why?

What is energy storage?

Current state of energy storage (U.S. and globally)

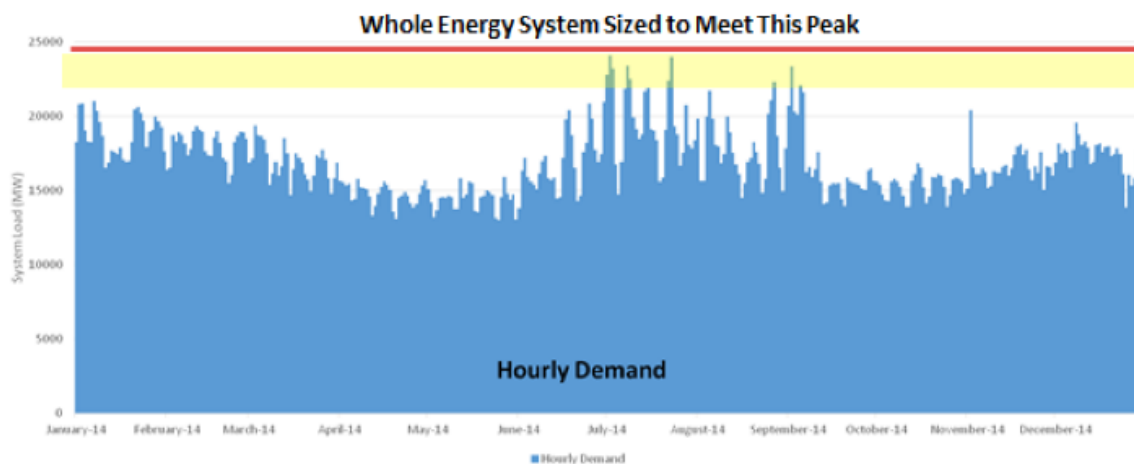
Value and services

Key trends and drivers

Moving forward

Meeting Peak Demand

Electric Grid is Sized for Highest Hour of Demand



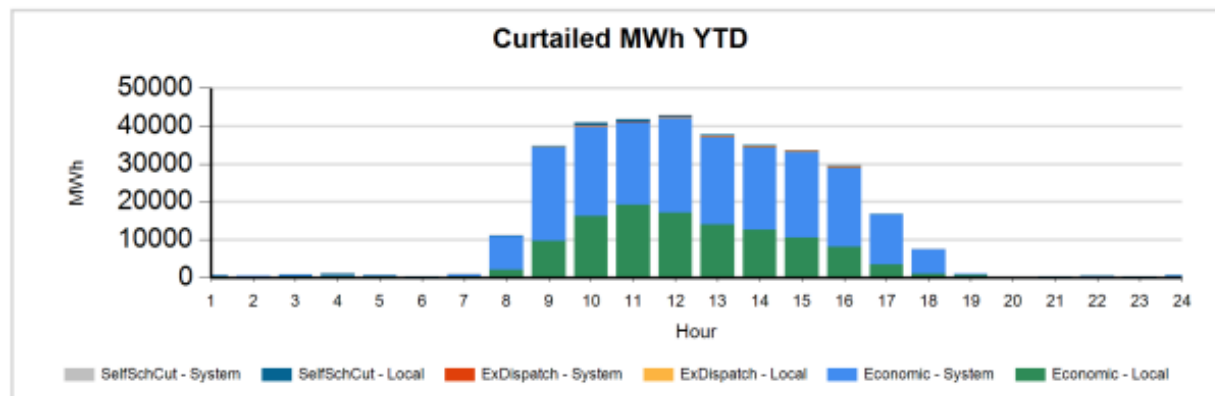
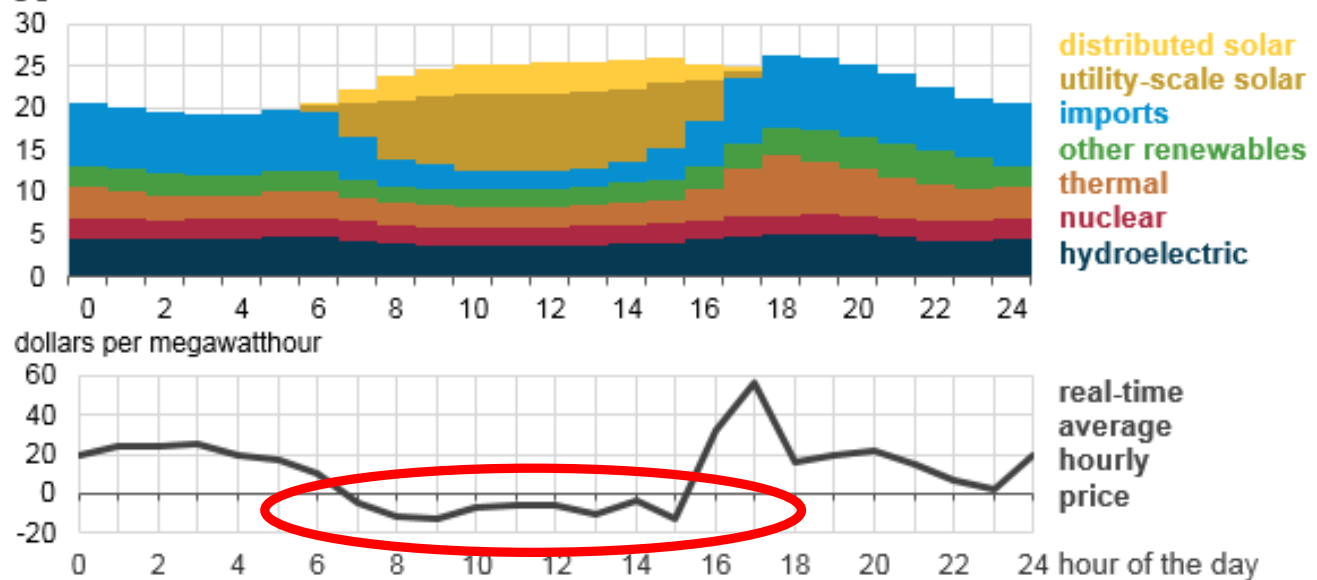
Top 1% of Hours accounts for 8% of Massachusetts Spend on Electricity
Top 10% of Hours accounts for 40% of Electricity Spend

- Analysis by AEE finds that for every \$1 spent on reducing peak demand, at least \$2.62 can be saved by ratepayers in Illinois and \$3.26 by ratepayers in Massachusetts.
- According to EIA:
 - Average peaker plant runs about 2-7% of the year
 - Over 70 GW of new peaker plants will be built in the U.S. before 2026

Renewable Energy Integration

California Independent System Operator net generation, March 11, 2017
gigawatt-hours

eia



Advantages Over Traditional Grid Technologies

- Real-world example from Portland General Electric:



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Energy storage is a very broad asset class

Electro-Chemical



(Flow battery / Lithium Ion)

Mechanical



(Flywheel)

Bulk Mechanical



(CAES)

Thermal



(Ice / Molten Salt)

Bulk Gravitational



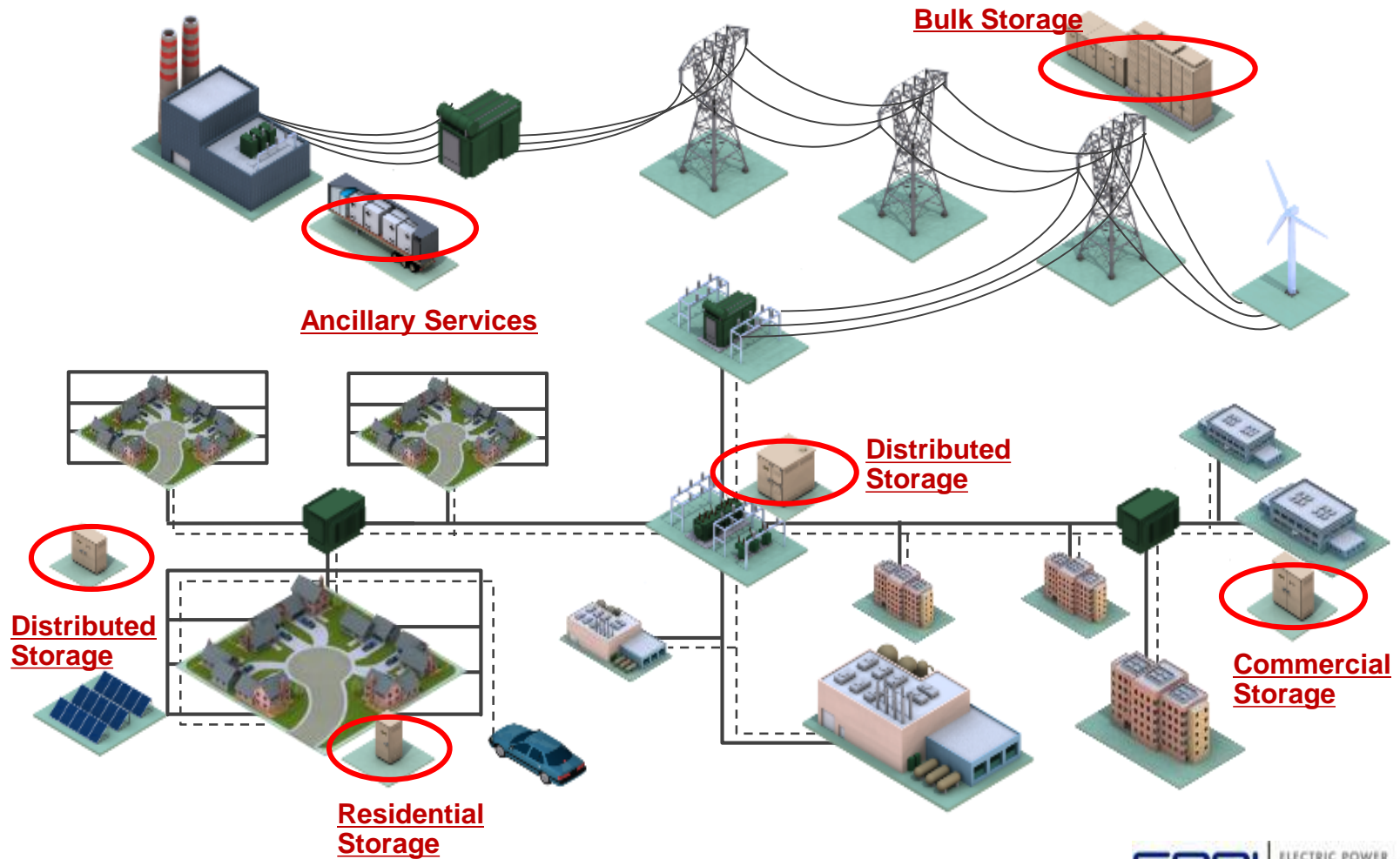
(Pumped Hydro)

Transportation and Chemical

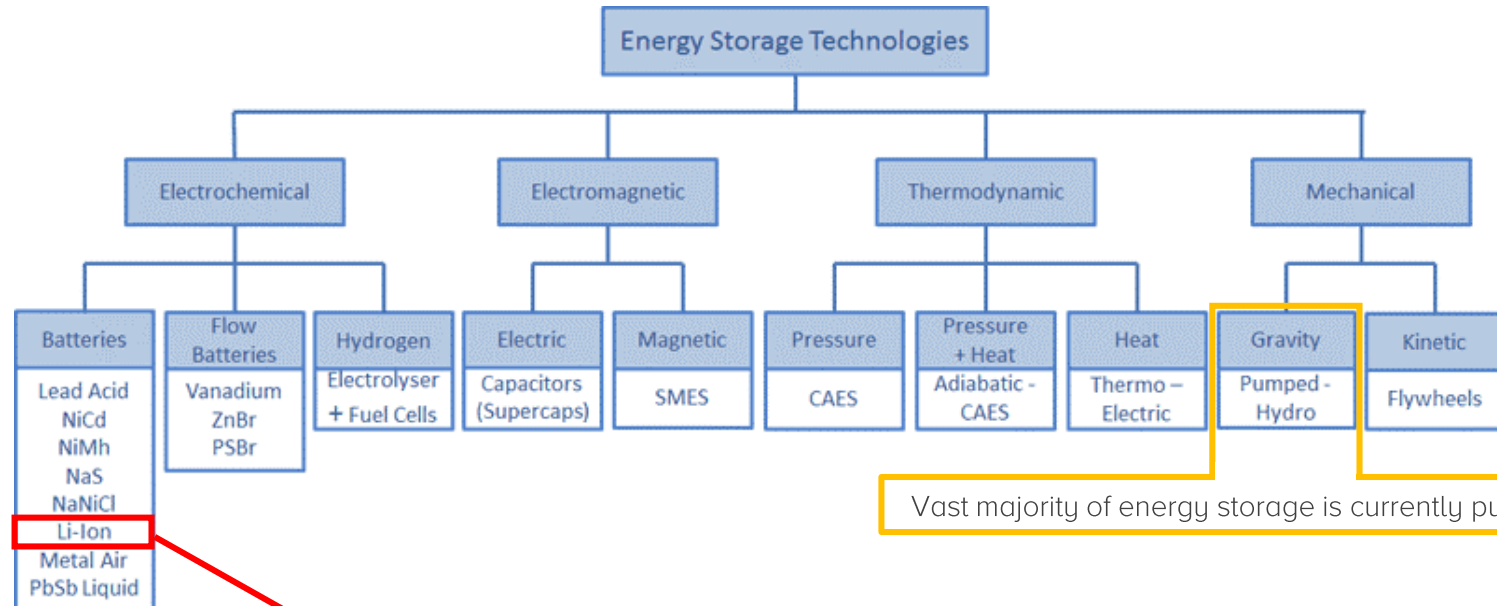


(Electric and Hydrogen Vehicles)

Broad electric power system applicability



Many energy storage technologies



Vast majority of energy storage is currently pumped hydro

* Pre-heating or cooling electric hot water systems or chillers respectively can also be considered energy storage in the context of the power system.

Lithium Battery Technologies

| Chemical Name | Material | Abbreviation | Applications |
|---------------------------------------|---|--------------|-------------------------------------|
| Lithium cobalt oxide | LiCoO ₂ | LCO | Cell phones, laptops, cameras |
| Lithium manganese oxide | LiMn ₂ O ₄ | LMO | Power tools, EVs, medical, hobbyist |
| Lithium iron phosphate | LiFePO ₄ | LFP | Power tools, EVs, medical, hobbyist |
| Lithium nickel manganese cobalt oxide | LiNiMnCoO ₂ | NMC | Power tools, EVs, medical, hobbyist |
| Lithium nickel cobalt aluminum oxide | LiNiCoAlO ₂ | NCA | EVs, grid storage |
| Lithium titanate | Li ₄ Ti ₅ O ₁₂ | LTO | EVs, grid storage |

Source: batteryuniversity.com

Topics

Why?

What is energy storage?

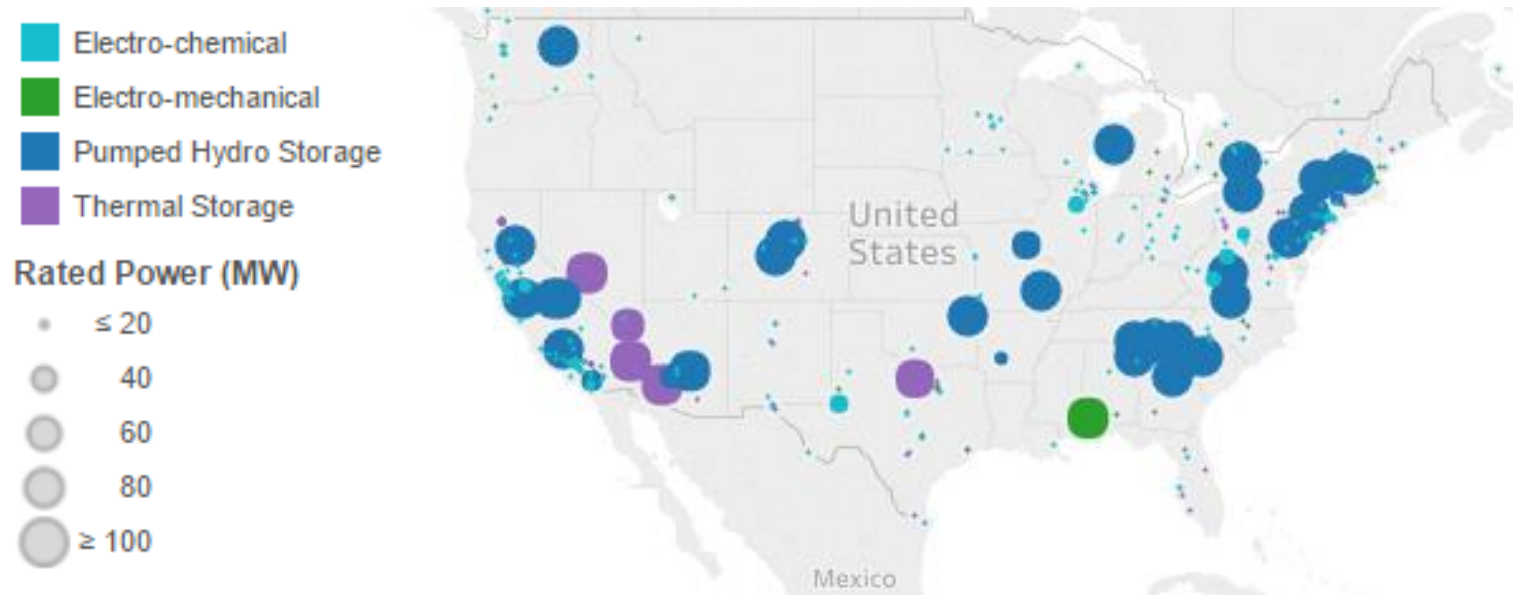
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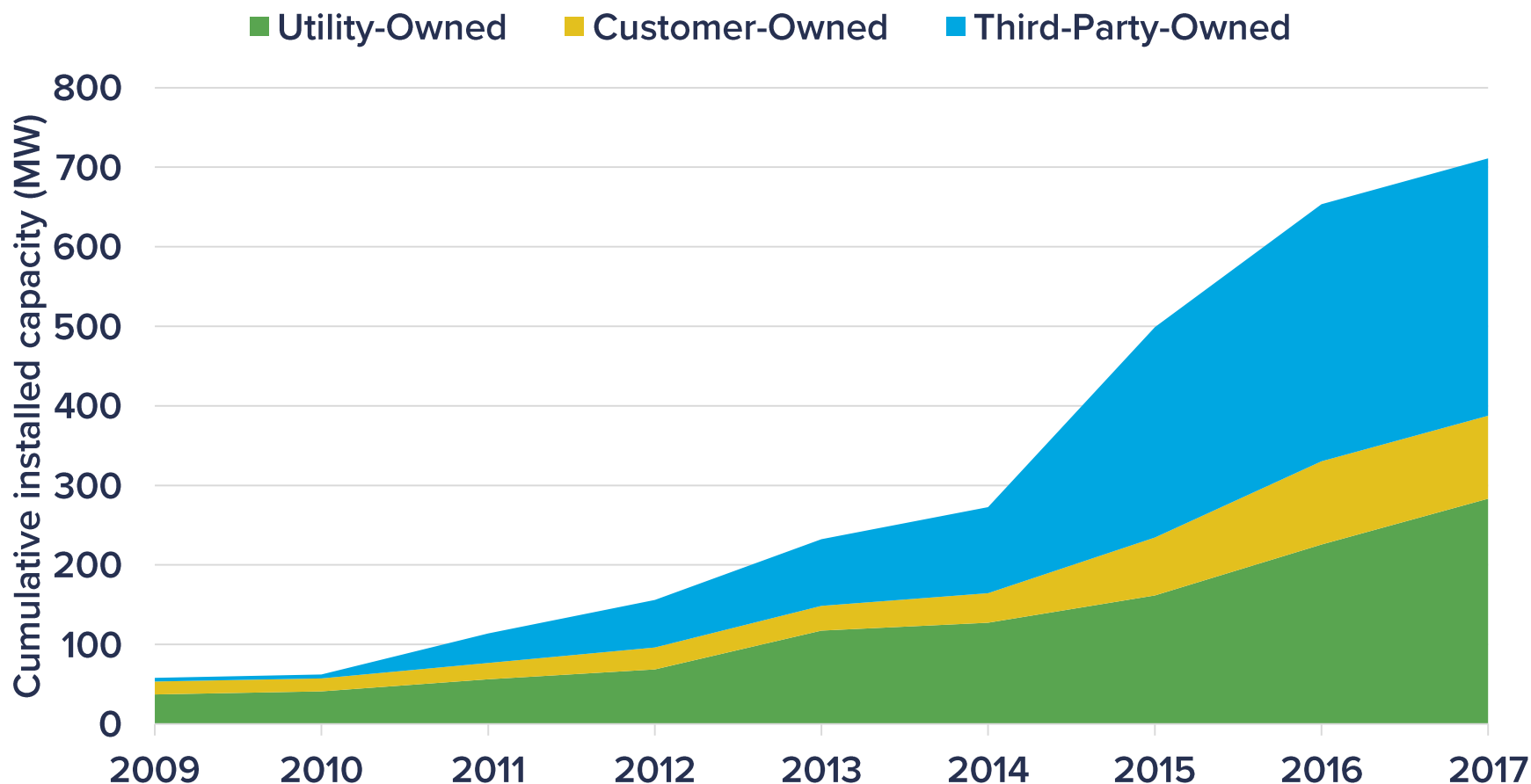
Operational energy storage capacity – U.S.



25,200 MW Storage

1,114,000 MW Total US Generation Capacity

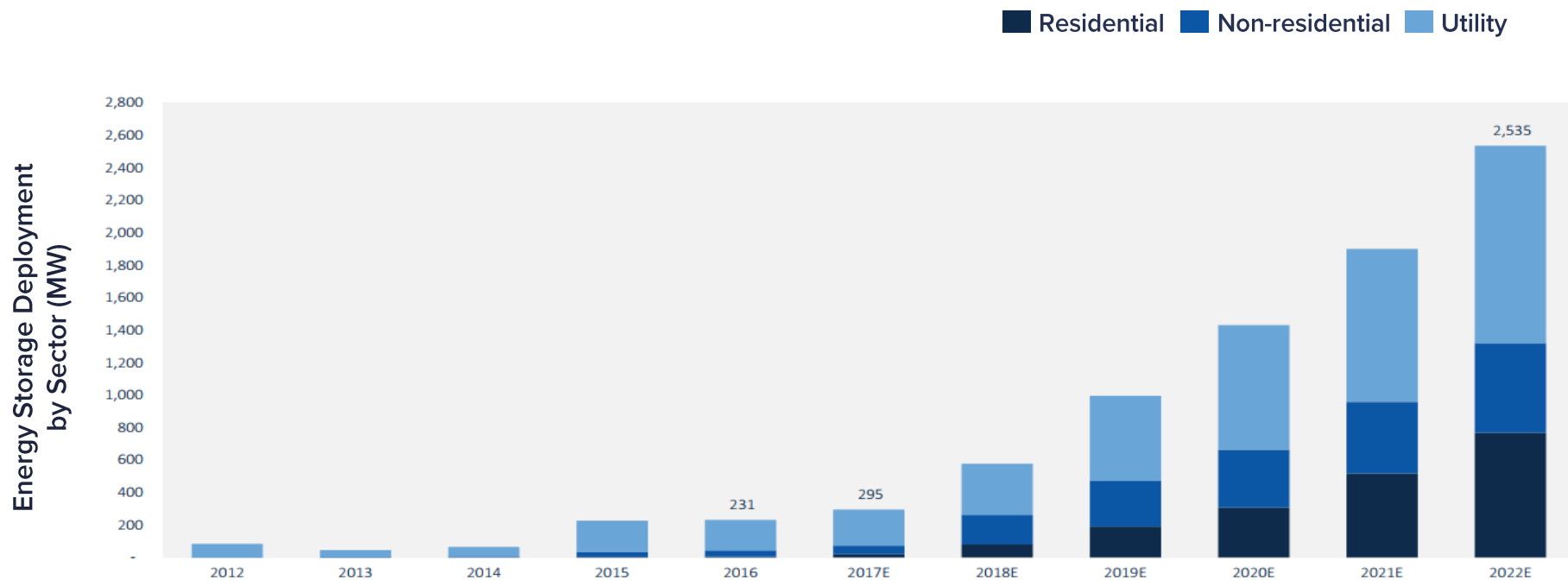
US battery storage is in an early growth phase



- Nearly 90,800 WORKERS were employed in the energy storage industry (47,634 in battery storage industry)

Source: DOE Global Energy Storage Database, accessed 1/11/2018

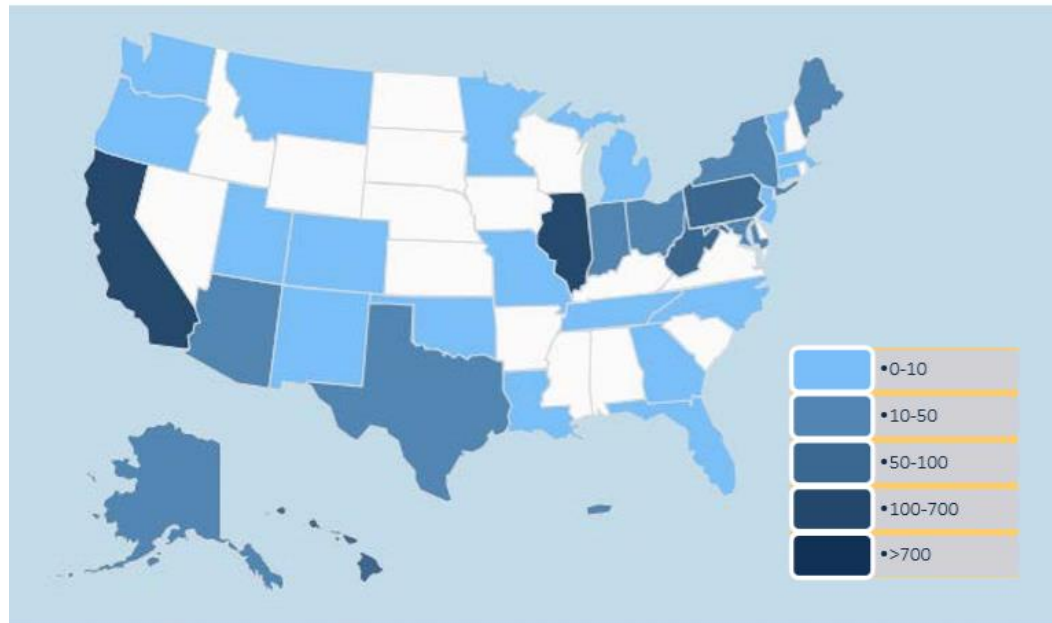
US energy storage is anticipated to grow quickly



Source: GTM Research/ESA US Energy Storage Monitor Q4 2017

State Level Deployment

Front of the Meter Deployments - MW



Source: GTM Research Energy Storage Data Hub

Behind the Meter Deployments - MW

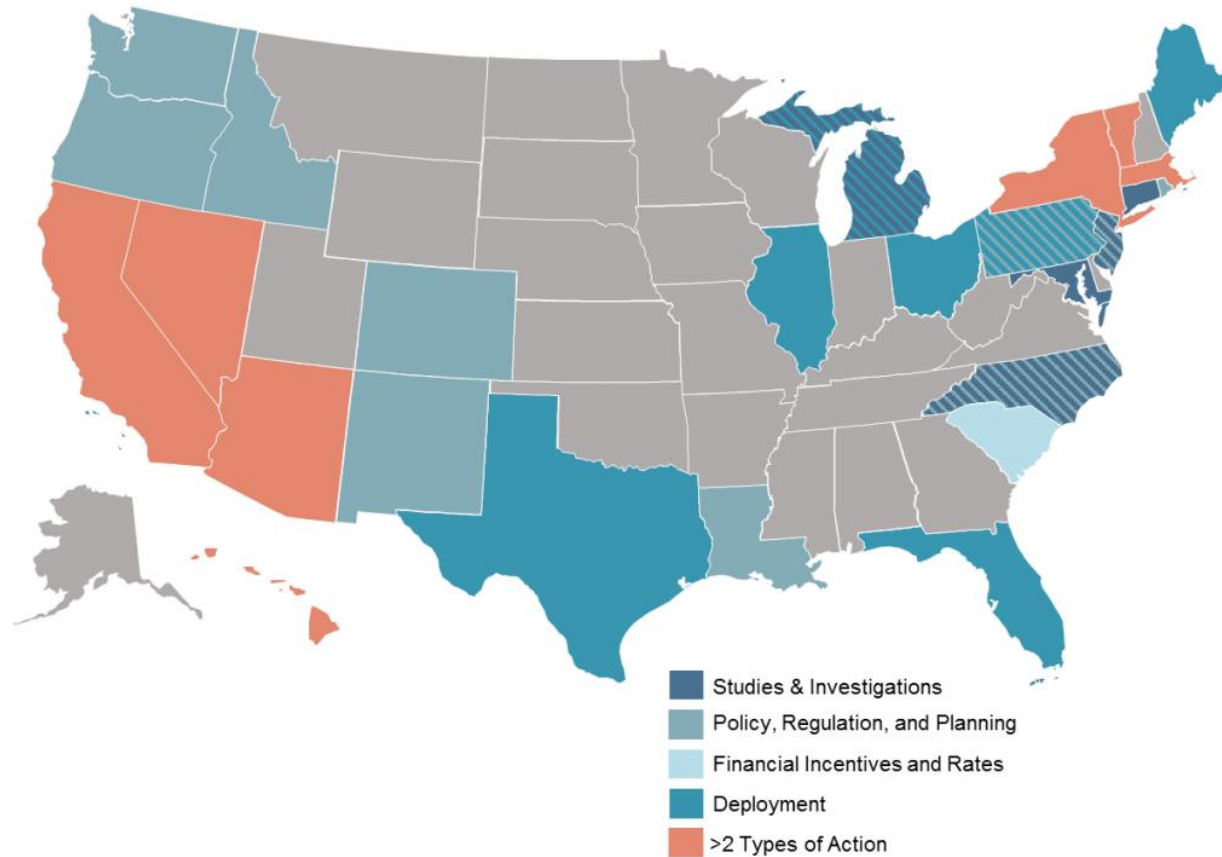
| State | Non-Residential | Residential | Total |
|----------------|-----------------|--------------|--------------|
| Arizona | 0.00 | 0.97 | 0.97 |
| California | 66.53 | 3.10 | 69.63 |
| Hawaii | 1.49 | 1.96 | 3.45 |
| Massachusetts | 0.00 | 0.18 | 0.18 |
| New Jersey | 1.89 | 0.04 | 1.92 |
| New York | 2.29 | 0.34 | 2.63 |
| PJM (Excl. NJ) | 2.25 | 0.05 | 2.29 |
| Texas | 0.00 | 0.14 | 0.14 |
| All Others | 4.21 | 4.16 | 8.38 |
| Total | 78.66 | 10.92 | 89.58 |

Source: GTM Research

Source: GTM Research Energy Storage Data Hub and [ESA \(2017\)](#)

Many states and utilities are learning by doing

Figure 5. Q3 2017 Action on Energy Storage, By Type of Action



Source: 50 States of Grid Modernization Q3 2017

Recent Developments in New Jersey

- Comprehensive energy legislation recently passed (S2314/A3723) :
 - Increases RPS to 50% by 2030
 - Offshore wind goal of 3,500 MW
 - Energy storage target of 2,000 MW by 2030
 - Creates community solar program
 - Requires 2%/yr utility energy efficiency gains
- Requires NJ Board of Public Utilities (BPU) to study costs and benefits of energy storage.



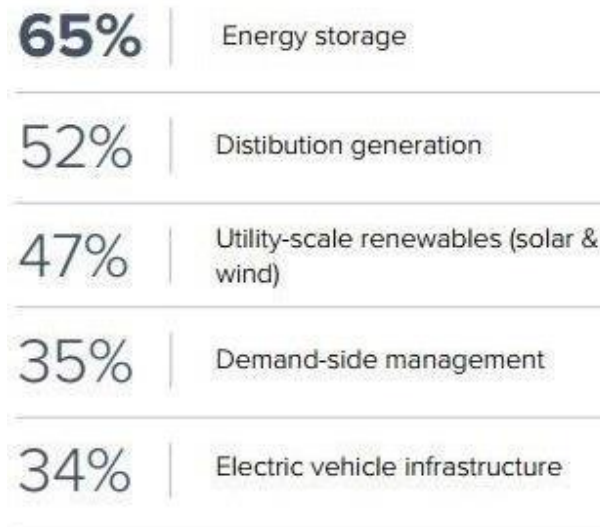
FERC Order 841 to unlock more value streams for storage

- Directs RTOs/ISOs to update tariffs within 9 months to ensure storage resources can participate in all markets, i.e., energy capacity, and ancillary services:
 1. Bidding parameters and operating limits for storage
 2. Ability to manage state of charge
 3. Reforms to transmission charges to encourage regulation or ramping services



Utility investment priorities

Survey: In which technologies do you think your utility should invest more?



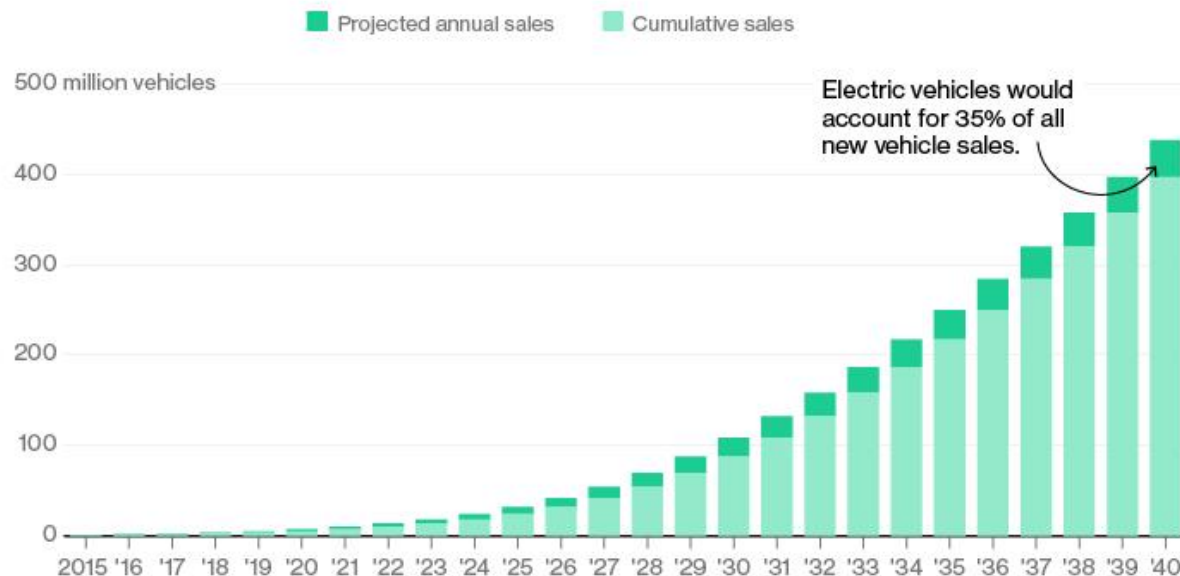
As many as 77% of utility executives are already investing or plan to invest in storage solutions in the next 10 years.

The importance of demand

- Modest sales of EV/hybrids can have significant impact on global cell production
- Currently, significant underutilization in global cell production

The Rise of Electric Cars

By 2022 electric vehicles will cost the same as their internal-combustion counterparts. That's the point of liftoff for sales.



Sources: Data compiled by Bloomberg New Energy Finance, Marklines

Bloomberg 

Source: CEMAC report to DOE

China investing in energy storage

- China is expecting Li-ion to play significant role in clean energy future
- China's 13th 5-year plan guarantees payouts if manufacturers meet targets
- Directing and encouraging internal manufacturing to increase production and capture market

CHINA IS LEADING THE CHARGE

Lithium-ion megafactories in China to grow capacity 6X by 2020



Global lithium-ion battery production capacity will increase by **521%** between 2016 and 2020.

Capacity in
2016

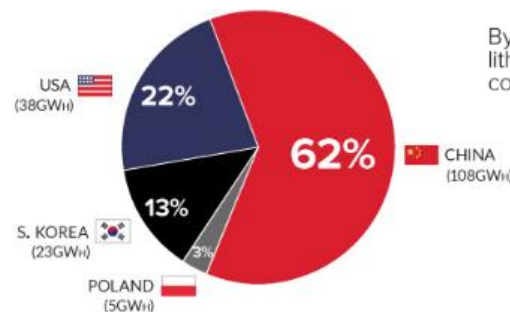


28
GWh

Capacity in
2020



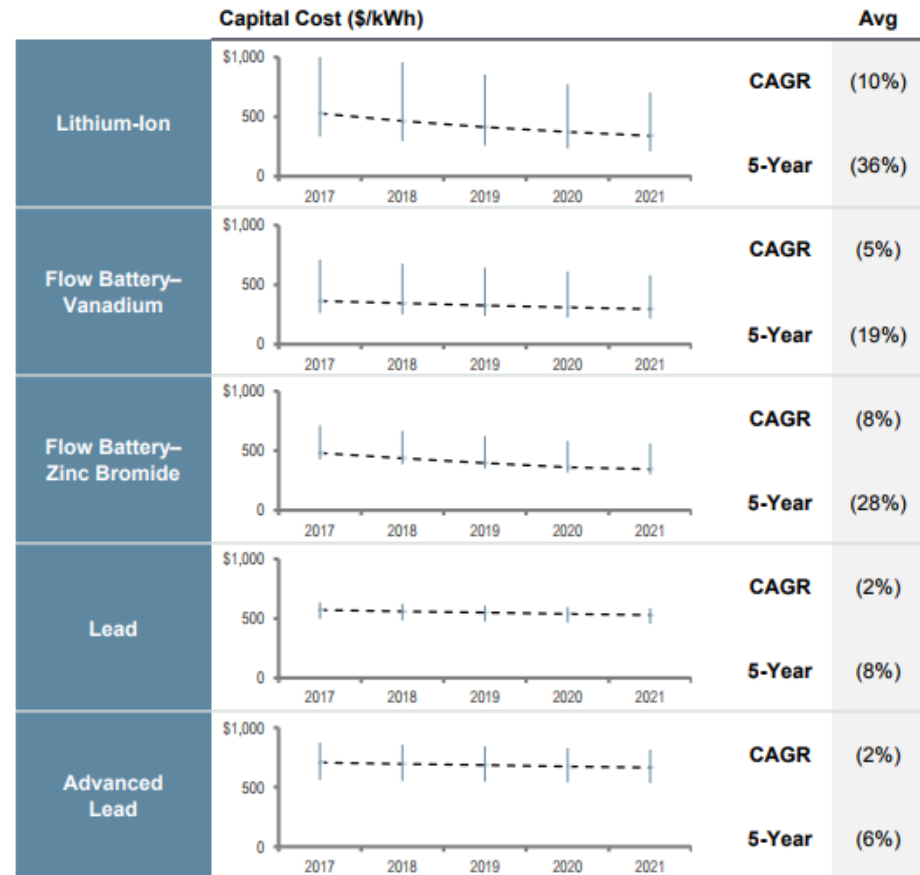
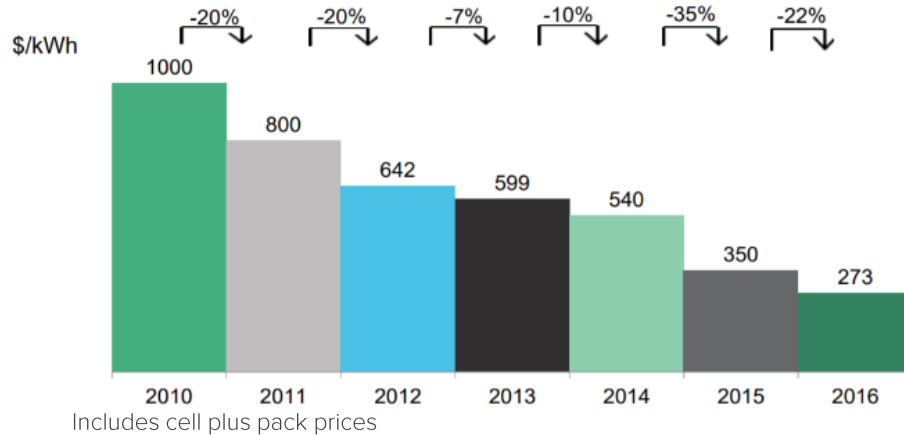
174
GWh



By 2020, mass production of lithium-ion batteries will still be concentrated in just **four** countries.

Battery costs are declining

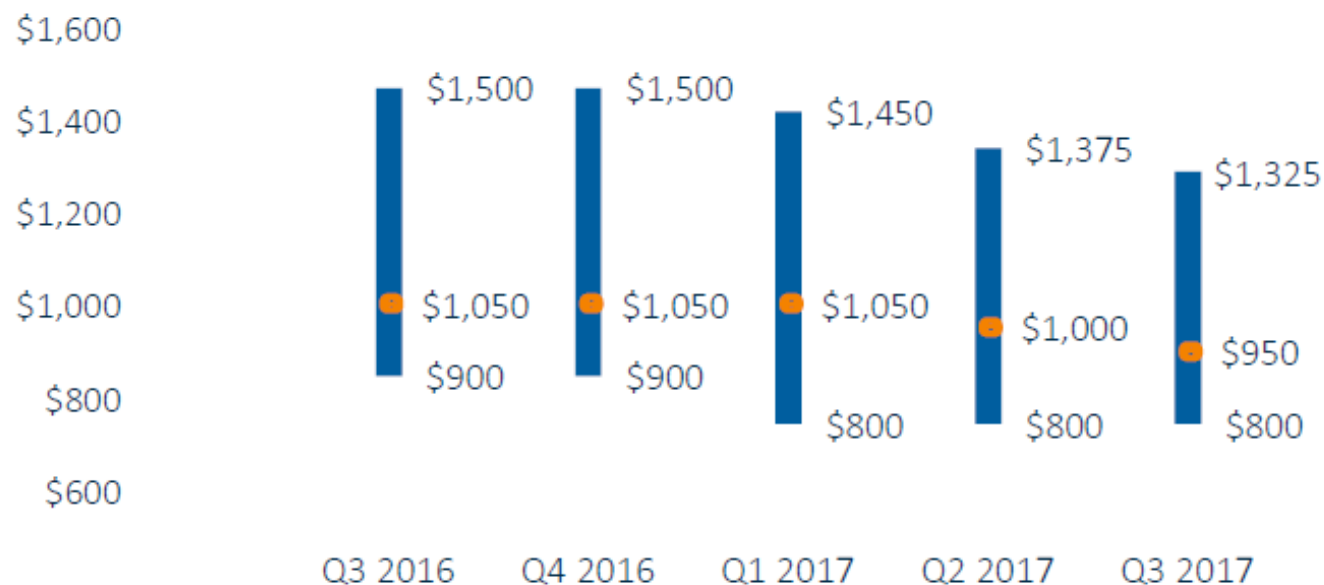
Lithium-ion price survey



As are installed costs for battery systems

- Price declines are largely due to increasing volumes

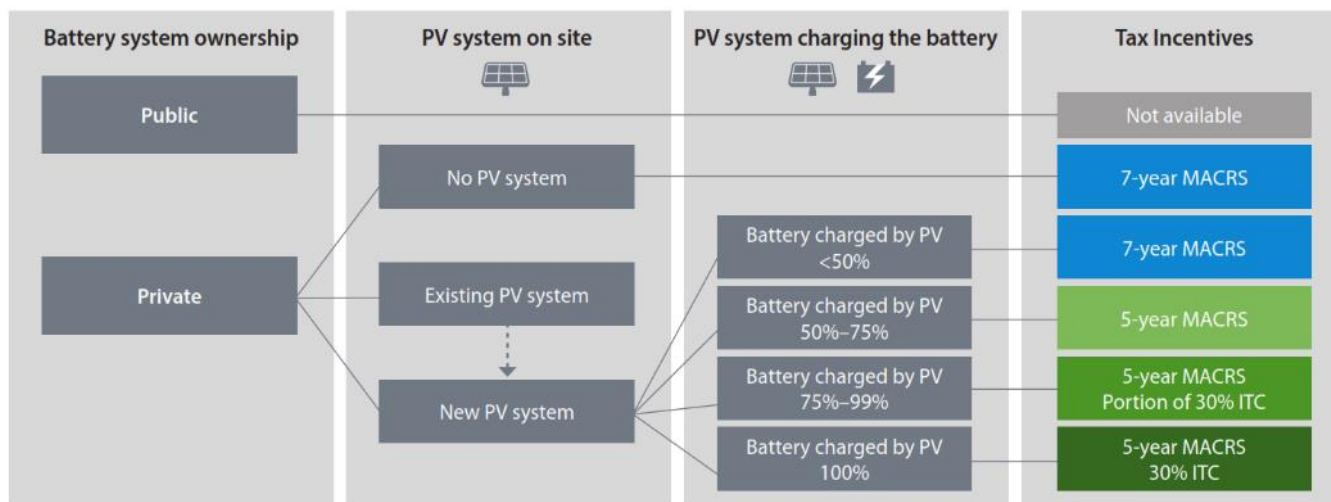
Historical System Price Trends: Non-Residential (\$/kWh)



Source: GTM Research

Pairing storage with renewables can unlock tax benefits

- Storage is eligible for federal ITC if charged from solar
 - Level of benefit dependent on ability to charge from solar-paired system
 - Battery must be $\geq 75\%$ charged from solar to receive ITC
 - Retrofits eligible for ITC, if 100% RE charged
- Tax reform includes changes to depreciation/MACRS, and ITC – stay tuned for new IRS rules



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Moving forward

Energy storage is flexible

- Energy storage can be deployed quickly, relocate and scaled up or down as required.

Example: Aliso Canyon in CA went from RFP to online in **7 months**

Total:
94.5 MW / 342 MWh

May 27, 2016

- SCE issues Aliso ACES RFO and DBT RFP

Jul. 18, 2016

- SDG&E files application for 150 MWhs of storage

Aug. 15, 2016

- SCE files application for 108 MWhs of storage

Aug. 18, 2016

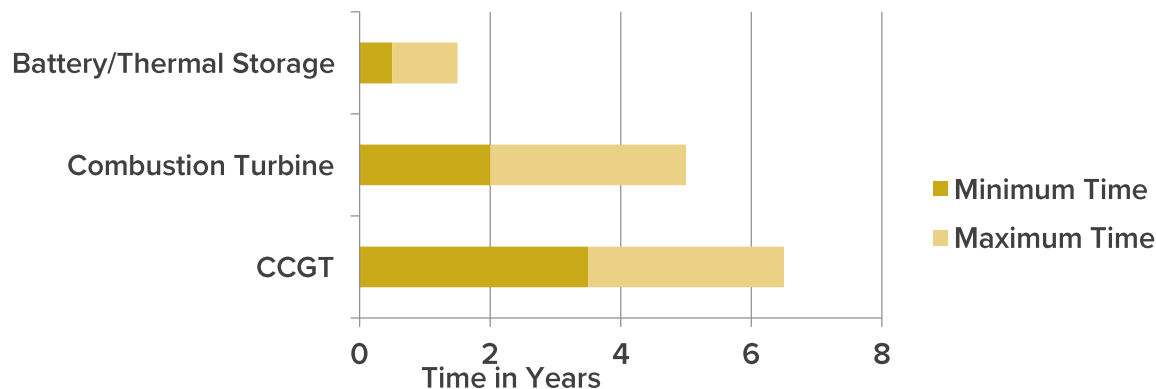
- CPUC approves SDG&E applications

Sept. 15, 2016

- CPUC approves SCE Round 1 applications

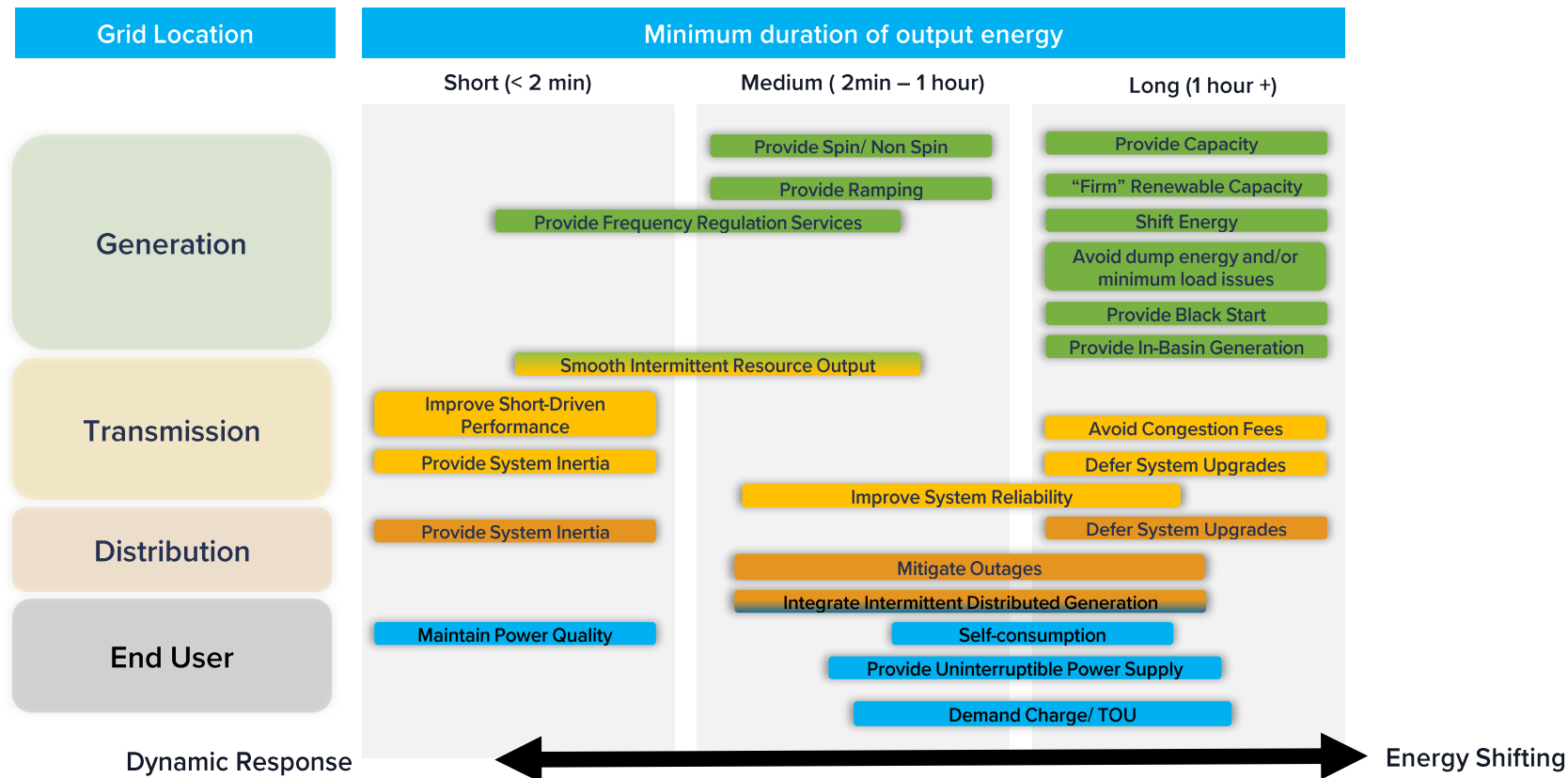
Dec. 31, 2016 – Feb. 2017

- Projects brought online



Operational use cases for storage systems

(There are many – cuts across multiple silos)



Approach to evaluating storage opportunities



1. Identify primary need

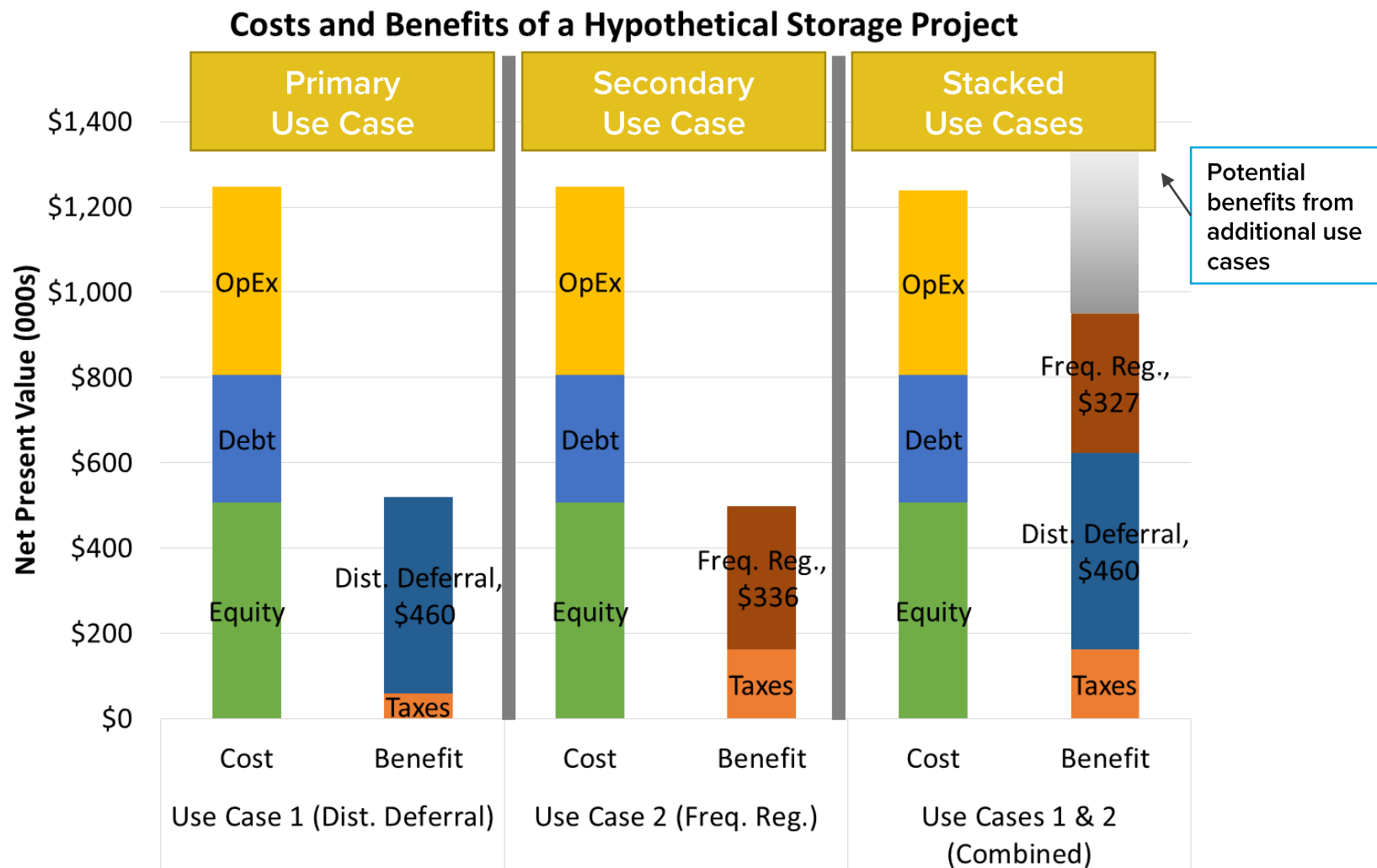


2. Explore combinations of stackable benefits; discard incompatible value streams



3. Optimize value streams and understand tradeoffs

Value stacking: Dist. deferral + frequency regulation



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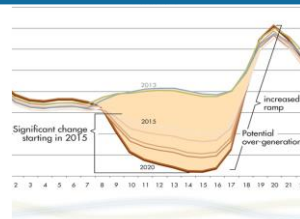
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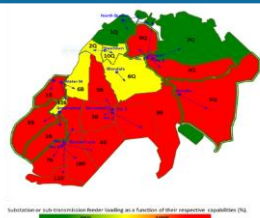
Major drivers of demand for storage in the U.S.

Renewable Energy Penetration



High penetrations of renewable energy in some markets has led to the need for additional integration solutions including energy storage.

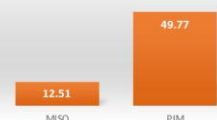
Local Capacity Needs



Storage is serving as a capacity resource in high-population areas where new generation or transmission are expensive to build.

Wholesale Market Opportunities

Average Frequency Regulation Price, 2014 (\$/MWh)



Storage has participated in organized wholesale markets, often by providing fast frequency regulation services.

Retail Bill Management

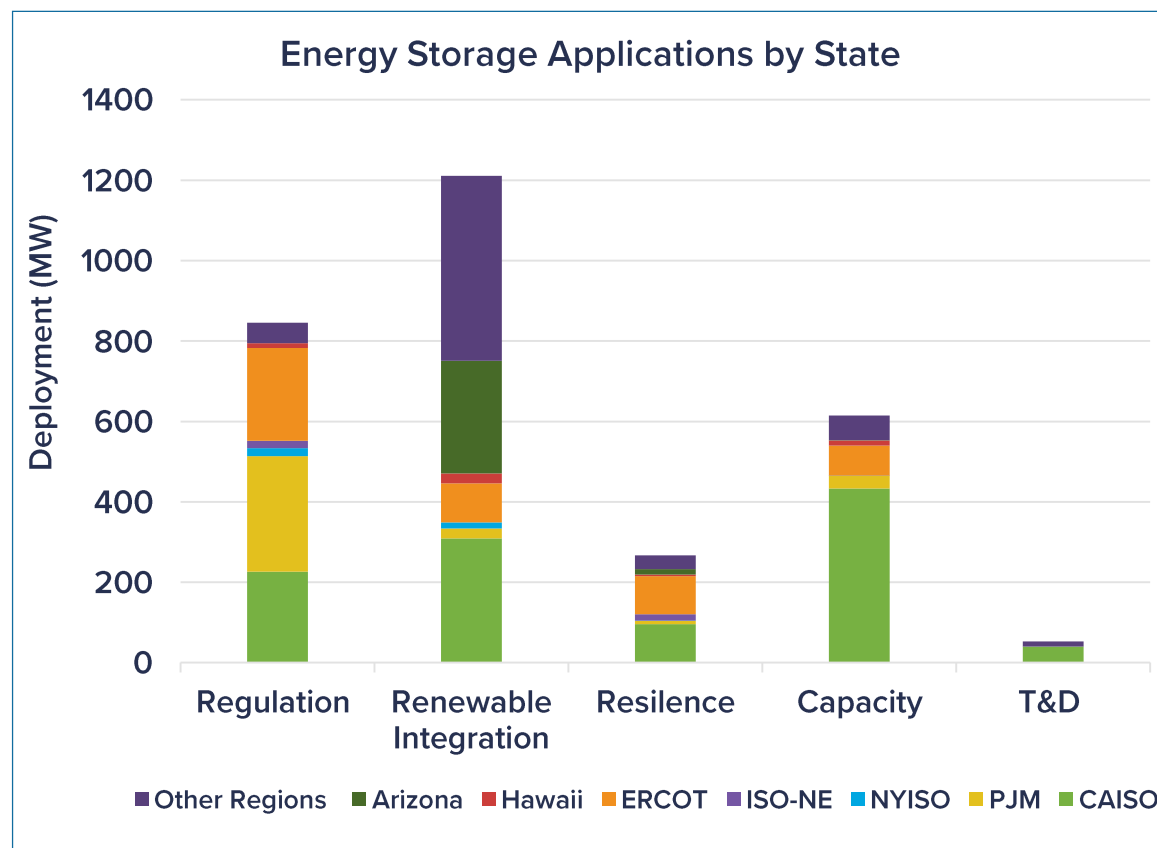


Storage is being offered to retail customers as a solution for demand charge management.

Sources: [Solar Industry Magazine](#); [Utility Dive](#)

US installed capacity by application

| Application | Description |
|-----------------------|--|
| Regulation | Market products for wholesale market participation |
| Renewable Integration | Storage sited with renewable projects |
| Resilience | Microgrids and Black Start applications |
| Capacity | Local Capacity and Resource Adequacy |
| T&D | Transmission and Distribution Upgrade Deferral |



Note: Pumped Hydro technology excluded. Some storage capacity may be double-counted if the system performs multiple applications
Source: DOE Energy Storage Database Accessed Jan 11, 2018

Frequency Regulation

- Frequency regulation (FR) storage projects are short duration applications therefore lower cost for batteries
- Important but shallow market as renewable generation increases
- FR was largest front-of-meter storage application in USA until 2016
 - 265 MW of fast-response storage in PJM
 - Typically 30 minute to an hour capacity
 - Volatile market pricing
 - Participation declined precipitously after market rule changes



Local Capacity Needs



Southern California Edison 2014 Procurement

| Seller | Resource Type | Contracts | MW |
|------------------------------|----------------------------|-----------|-------|
| Advanced Microgrid Solutions | BTM Battery Energy Storage | 4 | 50 |
| AES | FTM Battery Energy Storage | 1 | 100 |
| Ice Energy | BTM Thermal Energy Storage | 16 | 25.6 |
| NRG | FTM Battery Energy Storage | 1 | 0.5 |
| Stem | BTM Battery Energy Storage | 5 | 85 |
| Total | | 26 | 261.1 |



Procurement resulted in 5 times the capacity required by CPUC

Dispatchable Solar: PV + storage peaker



Source: <http://www.lyoninfrastructure.com/cooktown.html>

Australia: Cooktown Solar and Storage

- 33MW solar plus 1.4MW/5.4MWh Lithium based battery storage
- Fringe grid in Australia and will test the boundaries of operation of utility scale solar battery storage in these conditions.
- The Project is now in operation.
- Funding dependent on dispatchable/storage aspect to assist with supplying solar during evening peak
- Altogether, Lyon Group planning 1.7GW of PV and 1GW of battery storage by 2020

Arizona: Tucson Electric Power 100 MW solar plus storage plant

- 30 MW of four-hour duration batteries
- 20 year PPA
- ~3 cents/kWh solar – ~4.5 cents/kWh with battery
- Will be largest solar-plus-utility-scale-battery system in the US



Source: <http://insights.globalspec.com/article/4139/solar-storage-peaker-plant-for-kaua-i>

C&I and Co-op Demand Charge Mitigation

- Great River Energy Co-op in Minnesota issued RFP for 10 MW PV and 10 MW/20 MWh Storage system in 2018
- Primary use case for storage is to dispatch over 2-4 hours peak period for demand reduction
- Storage to be charged 100% by co-located PV

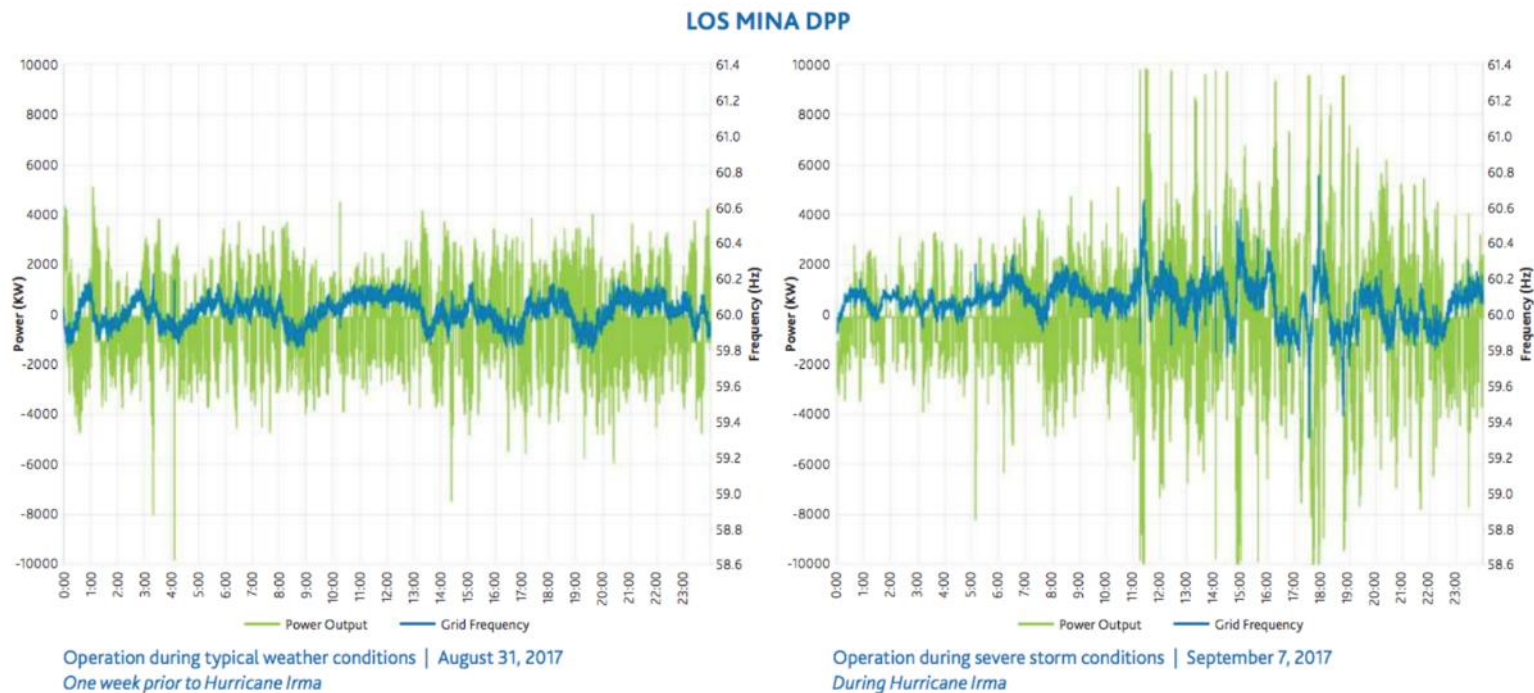


Irvine Company Hybrid Electric Buildings

- Batteries and advanced software
- 10 MW / 60 MWh
- 20 buildings
- 20% peak demand reduction

Grid Resilience

- 20 MW of storage in Santa Domingo, Dominican Republic provides efficient frequency regulation to the grid
- Provided key services during September's Hurricanes Irma and Maria, when about 50% of the island's power plants were forced offline



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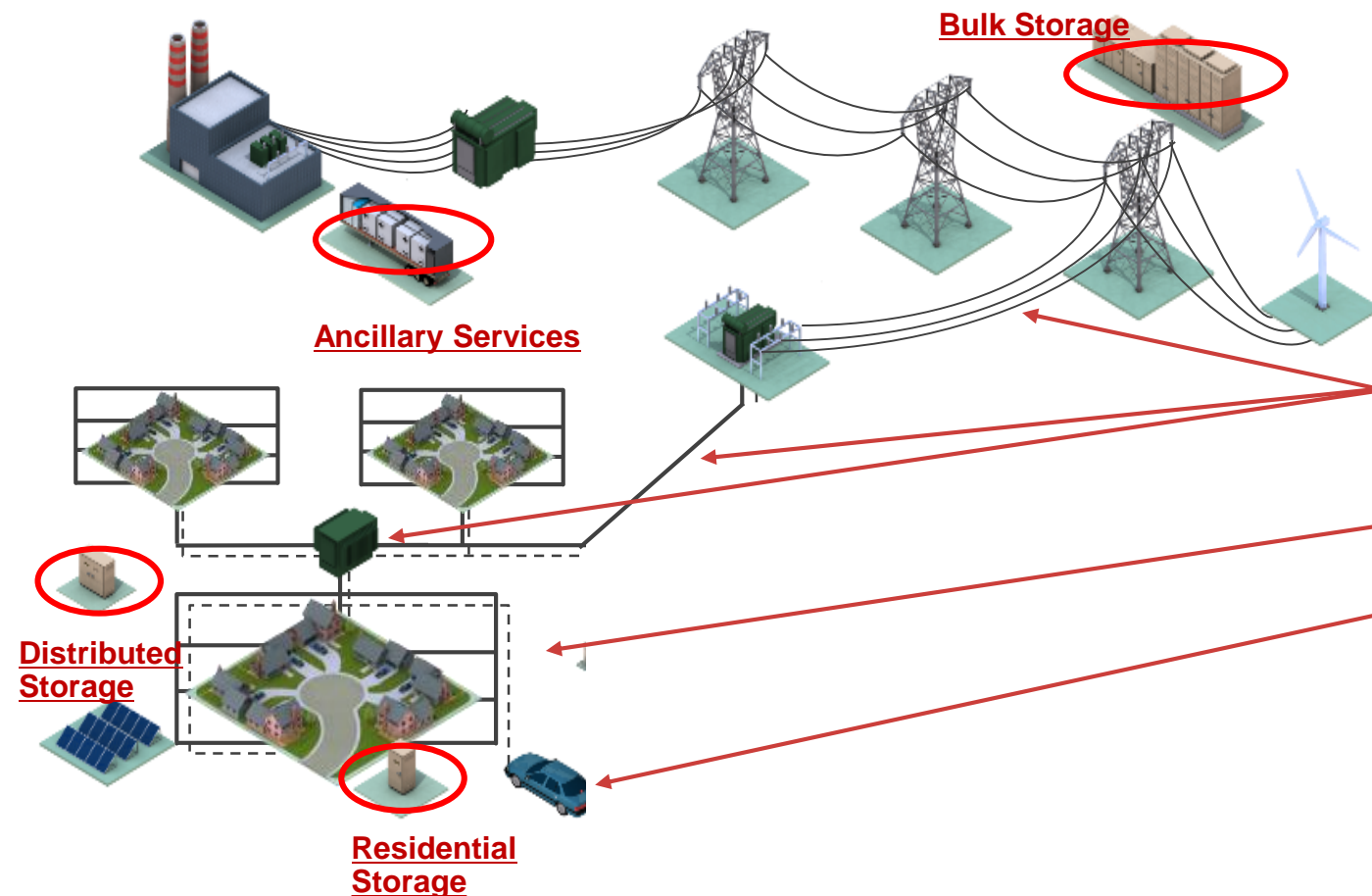
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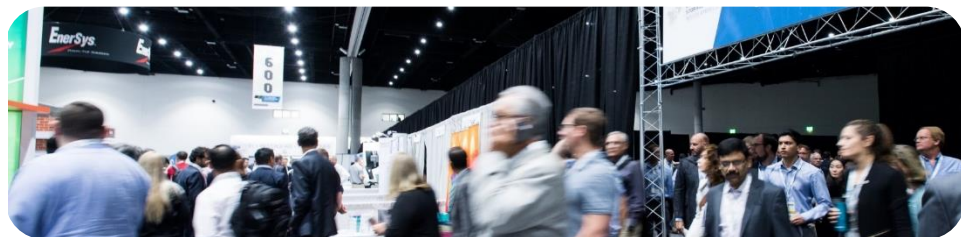
Making it a reality

Advances won't happen by themselves

- ✓ Market Rules
- ✓ Market Study, Valuation & Targets
- ✓ Procurements and Resource Plans
- ✓ Renewable Energy Strategy
- ✓ Non-wires Alternatives
- ✓ Resilience
- ✓ Rate Design
- ✓ EV Infrastructure



Source: EPRI



Thank you!

Edward Burgess
Director
Strategen Consulting, LLC

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