MI POWER GRID

Making the Most of Michigan's Energy Future

New Technologies and Business Models

Stakeholder Meeting 5: Storage

The meeting will begin promptly at 1:00 pm.

March 24, 2021

1PM – 5 PM

MPSC

Michigan Public Service Commission

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Making the Most of Michigan's Energy Future

New Technologies and Business Models: Welcome and Overview

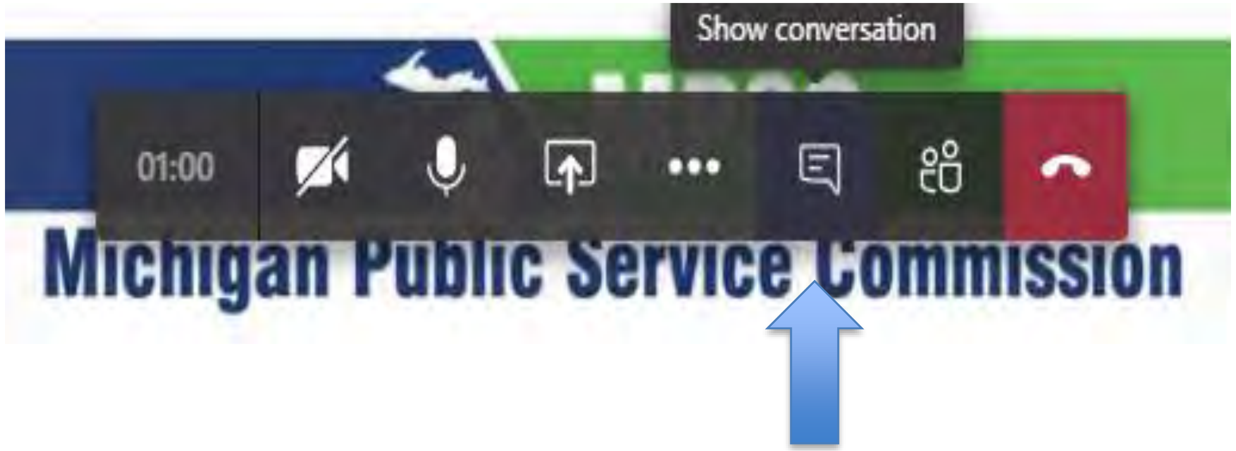
Joy Wang
WangJ3@Michigan.gov
Smart Grid Section
Michigan Public Service Commission

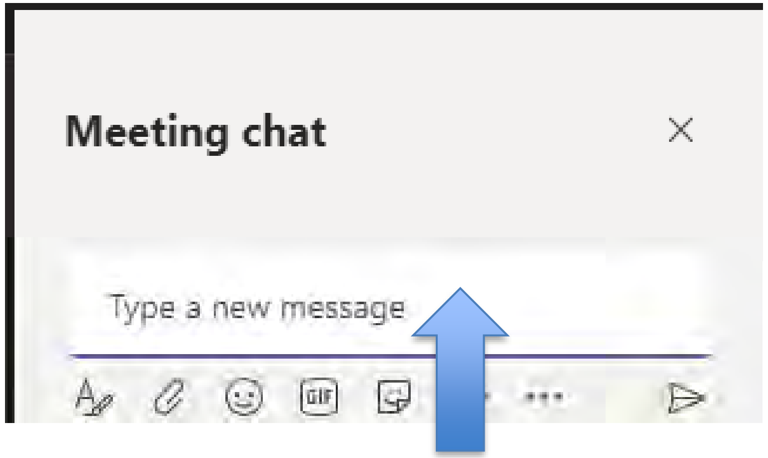
Agenda: Storage

1:00 pm	Welcome & Opening Statements	Joy Wang, MPSC Staff, and Katherine Peretick, Commissioner, MPSC
1:05 pm	The State of Energy Storage – Opportunities and Barriers	Julian Boggs, Energy Storage Association
1:40 pm	NREL Energy Storage Research & the Storage Futures Study	Nate Blair, National Renewable Energy Laboratory
2:15 pm	Break	
2:20 pm	*Panel: Utility Storage Solutions –* *Experiences, Barriers, & Opportunities* Kirk Eisert, Indiana Michigan Power Co. Noah Feingold, DTE Energy Teresa Hatcher, Consumers Energy	Moderator: Inês Ribeiro Canella, Mosaic Environmental Consulting
3:10 pm	GMP Energy Storage	Craig Ferreira, Green Mountain Power
3:30 pm	Break	
3:40 pm	The Future of Energy Storage: A Roadmap for Michigan	Tanya Paslawski, 5 Lakes Energy
3:50 pm	*Panel: Opportunities & Barriers for* *Energy Storage Deployment in Michigan* Rachel Goldwasser, Key Capture Energy Jason Houck, Form Energy, Inc. Jon Mulder, Volta Power Systems Kevin O'Connell, Michigan CAT & McAllister Machinery Reed Shick, Advanced Battery Concepts	Moderator: Laura Sherman, Michigan Energy Innovation Business Council
4:45 pm	New Innovations in Thermal Storage: Maximizing the Benefits of Non-Traditional Storage	Eric Rehberg, Armada Power
4:55 pm	Closing Statements	Joy Wang, MPSC Staff
5:00 pm	Adjourn	

Housekeeping

- This meeting is being recorded
- Recording and slides posted on workgroup website in about a week
- All audience members will be muted
- Please type questions into the chat box
  - To access chat box:





- Staff will ask chat box questions during Q&A

Housekeeping, cont.

- During the meeting, if clarification of your question is needed, we will ask you to unmute.
  - To unmute:
    - Phone: Press *6
    - Teams: Click mic button
  - Please mute yourself again after your clarification.
- Chat box may note when audience members enter/exit.
  - These notices are automatic:

- If you are not a session speaker, please turn off your video.
- If Teams via web browser is not working, try a different web browser.
  - All work except Safari
- Please share your thoughts on the meeting with us by filling out the survey.

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Making the Most of Michigan's Energy Future

Opening Remarks

Katherine Peretick
Commissioner
Michigan Public Service Commission

Stakeholder Meeting 5: Storage
March 24, 2021

MPSC
Michigan Public Service Commission

The State of Energy Storage – Opportunities and Barriers

Julian Boggs
State Policy Director
U.S. Energy Storage Association

The State of Energy Storage Opportunities and Barriers

Julian Boggs, State Policy Director

March 24, 2021

www.energystorage.org

Energy storage is flexibility

Supplying the precise amount of electricity exactly when and where you need it

Optimize the electric grid & enable system transformation

- Efficiency // save households & businesses money
- Resilience // make service more disruption-proof
- Adaptability // integrate diverse, changing resource mix

Roles of storage in a cleaner electricity system

- **Avoiding peakers & related infrastructure**
  - Storage already substituting gas capacity in CA, AZ, HI
- **Integrating higher levels of renewables**
  - Ramping & other fast-balancing; curtailment avoidance to increase GHG reductions
  - Can help integrate nuclear & renewables
- **Enabling more rooftop solar, EVs, and other distributed energy resources (DERs)**
- **Facilitate electrification of other sectors**
  - Storage key to fast-charging infrastructure, especially heavy duty vehicles, vessels
- **Making the grid more efficient**
  - Increases generating fleet efficiency; reduces line losses as DER; can be utilized for multiple services; enables right-sized & just-in-time capacity

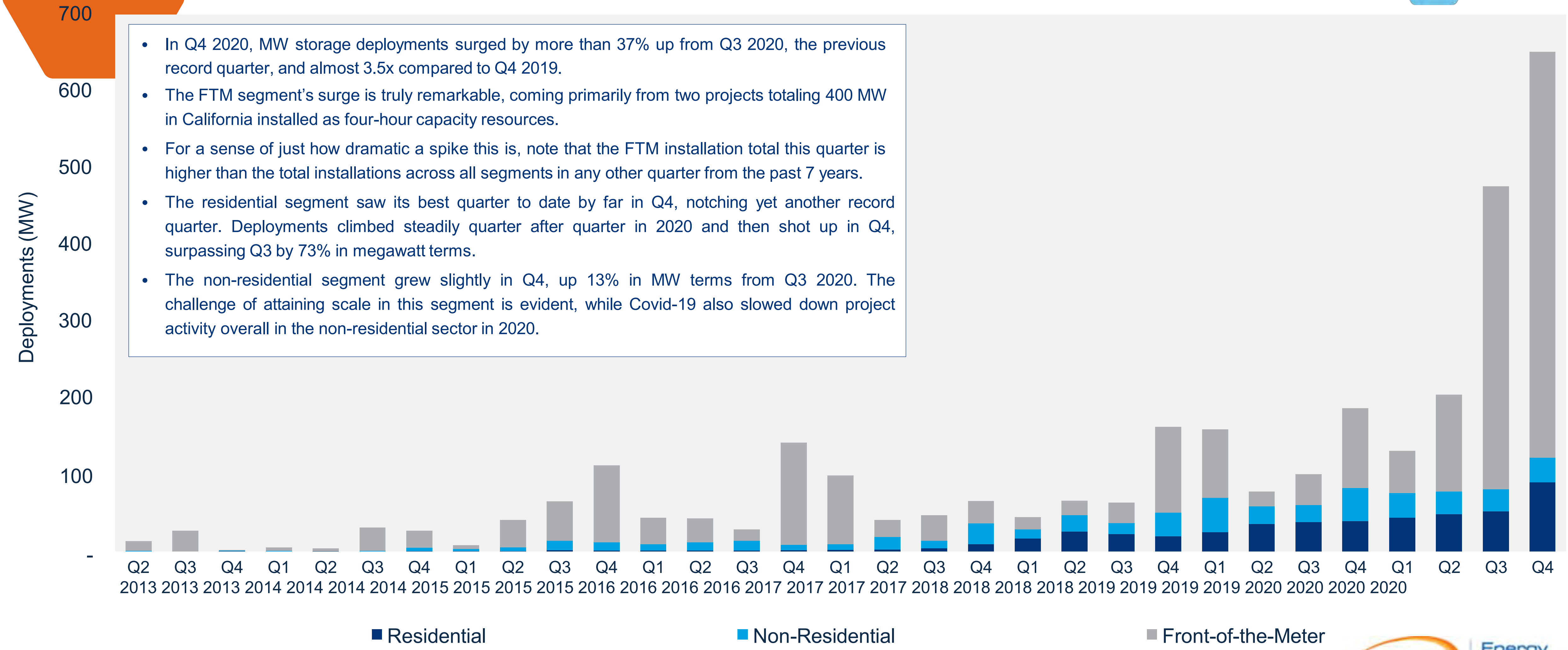

Mechanical Storage
Battery Storage
Thermal Storage
342
341

U.S. deployments set a new quarterly record: 651.2 MW in Q4

After an unprecedented FTM spike in Q3, the final quarter of 2020 spiked even further

woodmac.com

- In Q4 2020, MW storage deployments surged by more than 37% up from Q3 2020, the previous record quarter, and almost 3.5x compared to Q4 2019.
- The FTM segment's surge is truly remarkable, coming primarily from two projects totaling 400 MW in California installed as four-hour capacity resources.
- For a sense of just how dramatic a spike this is, note that the FTM installation total this quarter is higher than the total installations across all segments in any other quarter from the past 7 years.
- The residential segment saw its best quarter to date by far in Q4, notching yet another record quarter. Deployments climbed steadily quarter after quarter in 2020 and then shot up in Q4, surpassing Q3 by 73% in megawatt terms.
- The non-residential segment grew slightly in Q4, up 13% in MW terms from Q3 2020. The challenge of attaining scale in this segment is evident, while Covid-19 also slowed down project activity overall in the non-residential sector in 2020.



Source: Wood Mackenzie Power & Renewables

Top energy storage states, full year 2020

California's front-of-the-meter installations were the key storage success story of 2020

Top three markets by segment in 2020 (energy capacity)

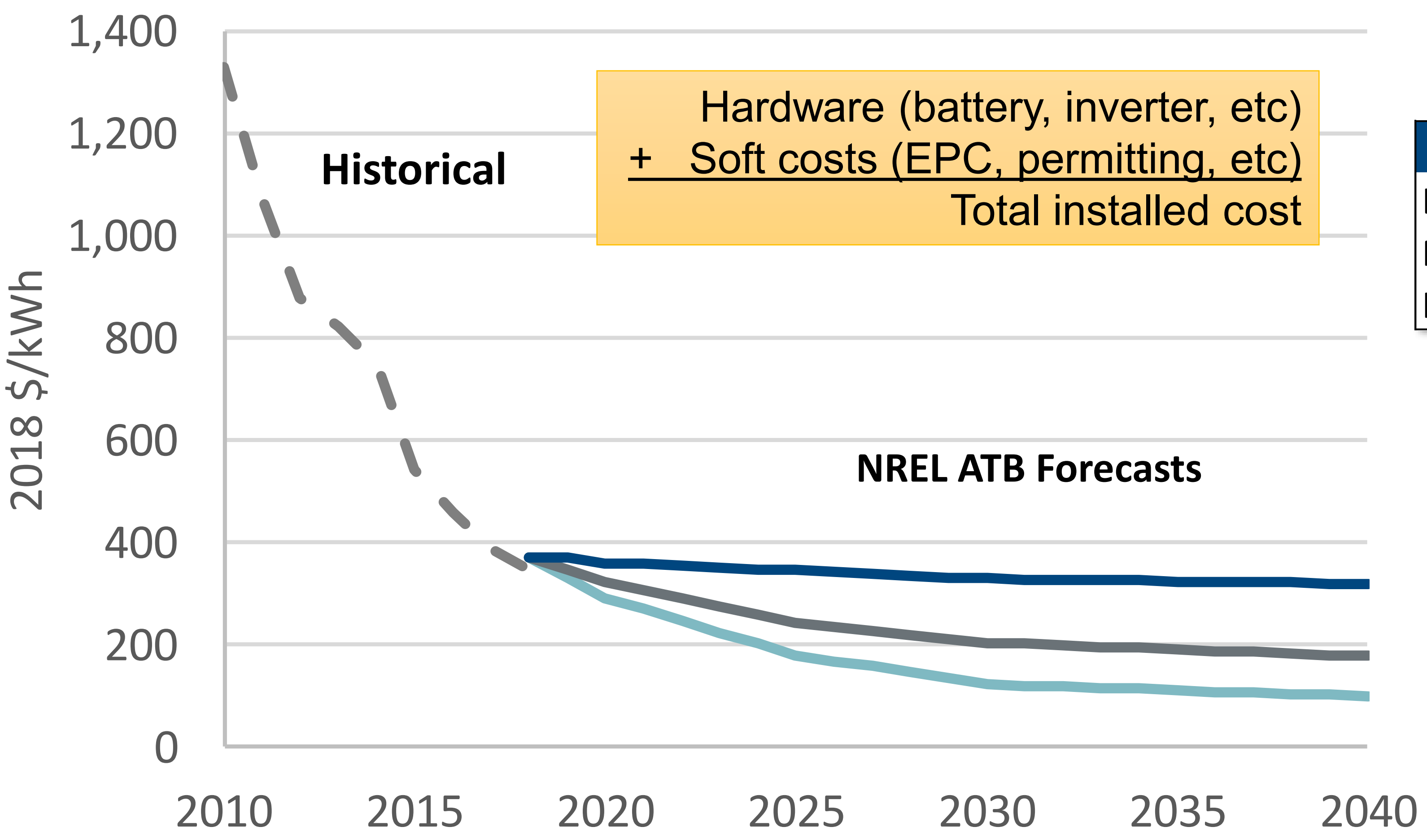
Rank	Residential	Deployments (MWh)	Non-residential	Deployments (MWh)	Front-of-the-meter	Deployments (MWh)
1	California	309	California	139	California	2,372
2	Hawaii	85	Massachusetts	94	Texas	116
3	"All Others"	64.9	Hawaii	43	New Jersey	42

Source: Wood Mackenzie Power & Renewables

The "All Others" bucket includes all U.S. states except the following: AZ, CA, CO, CT, FL, HI, MA, NV, PJM states (excl MI), NY, TX, VA. Notable markets within the residential All Others bucket include Michigan and the Carolinas.

Battery storage installed costs

Bulk-scale 4-hour lithium-ion grid battery installed cost ($/kWh)



Annual Cost Decline Rates from 2018

	2025	2030	2040
Low Cost	-10%	-9%	-6%
Mid Cost	-6%	-5%	-3%
High Cost	-1%	-1%	-1%

Source: Bloomberg New Energy Finance (2018) and NREL (2019b) with Brattle analysis.

Notes: Historical estimate assumes Bloomberg NEF battery pack cost estimate plus a constant non-pack cost estimate of approximately $170/kWh. NREL costs are for a 4-hour, utility-scale lithium ion battery.

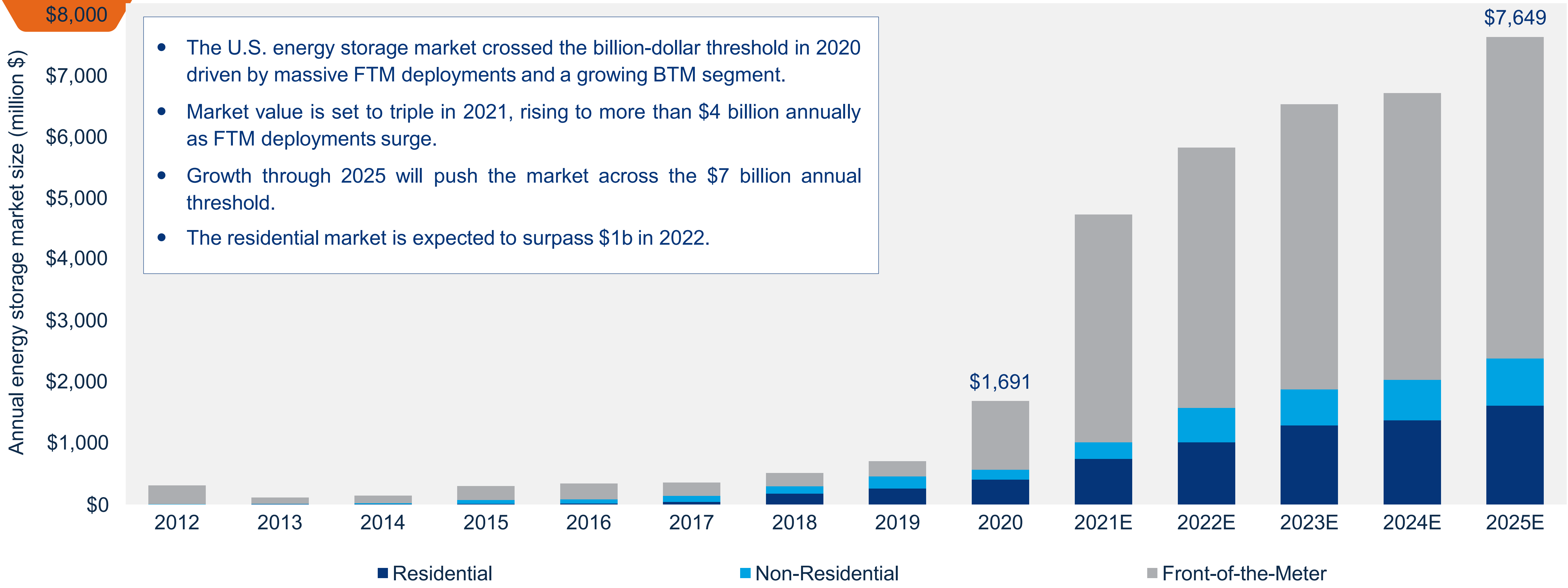
U.S. energy storage will be a $7.6 billion annual market in 2025

Market crossed $1.5 billion annual threshold in 2020

U.S. annual energy storage market size, 2012-2025E (million $)

woodmac.com

- The U.S. energy storage market crossed the billion-dollar threshold in 2020 driven by massive FTM deployments and a growing BTM segment.
- Market value is set to triple in 2021, rising to more than $4 billion annually as FTM deployments surge.
- Growth through 2025 will push the market across the $7 billion annual threshold.
- The residential market is expected to surpass $1b in 2022.



Wood Mackenzie P&R/ESA | U.S. energy storage monitor 2020 year in review

Source: Wood Mackenzie Power & Renewables. Note: Market size is reported as energy storage system deployment revenue (product of deployments and installed system prices).

Energy Storage Association

Policy Drivers of Energy Storage

VALUE and compensate storage flexibility

Policies

Deployment targets

Incentive programs

Tariff/rate design

Wholesale market products

Cost-benefit studies

Enable storage to COMPETE in all grid planning and procurements

Policies

Long-term resource planning

Distribution planning

Transmission planning

Renewables/clean energy standards

Wholesale market rules

Resource adequacy rules

Enable storage ACCESS to grid and markets

Policies

Interconnection processes

Multiple-use frameworks

Ownership rules

Codes & standards

~11 GW in Storage Targets

Energy Storage Incentive Programs

Oregon:
$2MM solar+storage program

Nevada:
$10MM solar+storage program

California:
Self-Generation Incentive Program ($800MM)

New York:
Bridge Incentive Program ($280MM) + NY-Sun program ($40MM)

Massachusetts:
Clean Peak Standard; SMART incentive program for solar+storage

Maryland:
Onsite storage tax credit ($3MM)

Energy Storage Association

FERC Order 841

Landmark 2018 rule enables storage participation in wholesale markets

- Presently in implementation, active between now and 2022 depending on RTO/ISO
- MISO requested 3-year extension on June 2022 deadline

Removes barriers - requires RTOs to "implement a participation model"

- Enables storage to provide all services it is technically capable of providing
- Implements parameters to reflect physical & operational characteristics of storage
- Removes barriers to participation for storage as small as 100 kW

Order 841 does not…

- Create or modify market products
- Amend interconnection, transmission planning, or other RTO functions
- Require larger changes to market functioning

PJM Capacity Accreditation

PJM updating accreditation for capacity market with Effective Load Carrying Capacity (ELCC) method

Most recent response filed 3/1, FERC order requested by 5/1

	Preliminary for 2023	Status Quo	Difference
Onshore Wind	13%	14.7%	-1.7%
Solar Fixed	29%	38%	-9%
Solar Tracking	54%	60%	-6%
4-hr Storage	79%	40%	+39%
8-hr Storage	95%	80%	+15%
Hydro Intermittent	44%	100%	-56%
Landfill Gas	62%	100%	-38%

Energy Storage Association

Energy Act of 2021

Better Energy Storage Technology (BEST) Act

- $201 MM/yr total appropriation
- Cross-DOE Energy Storage RD&D Program
- New Critical Material Recycling and Reuse RD&D Program
- Energy Storage Demonstration Projects; Pilot Grant Program
- Joint DOE-Defense Long Duration

Energy Storage and Microgrid Assistance for Rural Communities

Microgrid and Integrated Microgrid Systems Program

DOE Loan Program Modifications to Include Distributed Storage

Federal Opportunities in 2021

Storage ITC

- GREEN Act
- Energy Storage Tax Incentive and Deployment Act

FY 22 Department of Energy Appropriations

Section 301 Tariffs

Thank you!

Julian Boggs, State Policy Director

j.boggs@energystorage.org

NREL Energy Storage Research & the Storage Futures Study

Nate Blair

Group Manager

Distributed Systems & Storage Analysis

National Renewable Energy Laboratory

NREL
Transforming ENERGY

NREL Energy Storage Research and the Storage Futures Study

Nate Blair – PI Storage Futures Study
Group Manager, Distributed Systems & Storage

NREL at a Glance

2,250

Employees,
plus more than
400
early-career researchers and visiting scientists

World-class

facilities, renowned technology experts

nearly 820

Partnerships

with industry, academia, and government

Campus

operates as a living laboratory

Renewable Power

Solar
Wind
Water
Geothermal

Sustainable Transportation

Bioenergy
Vehicle Technologies
Hydrogen

Energy Efficiency

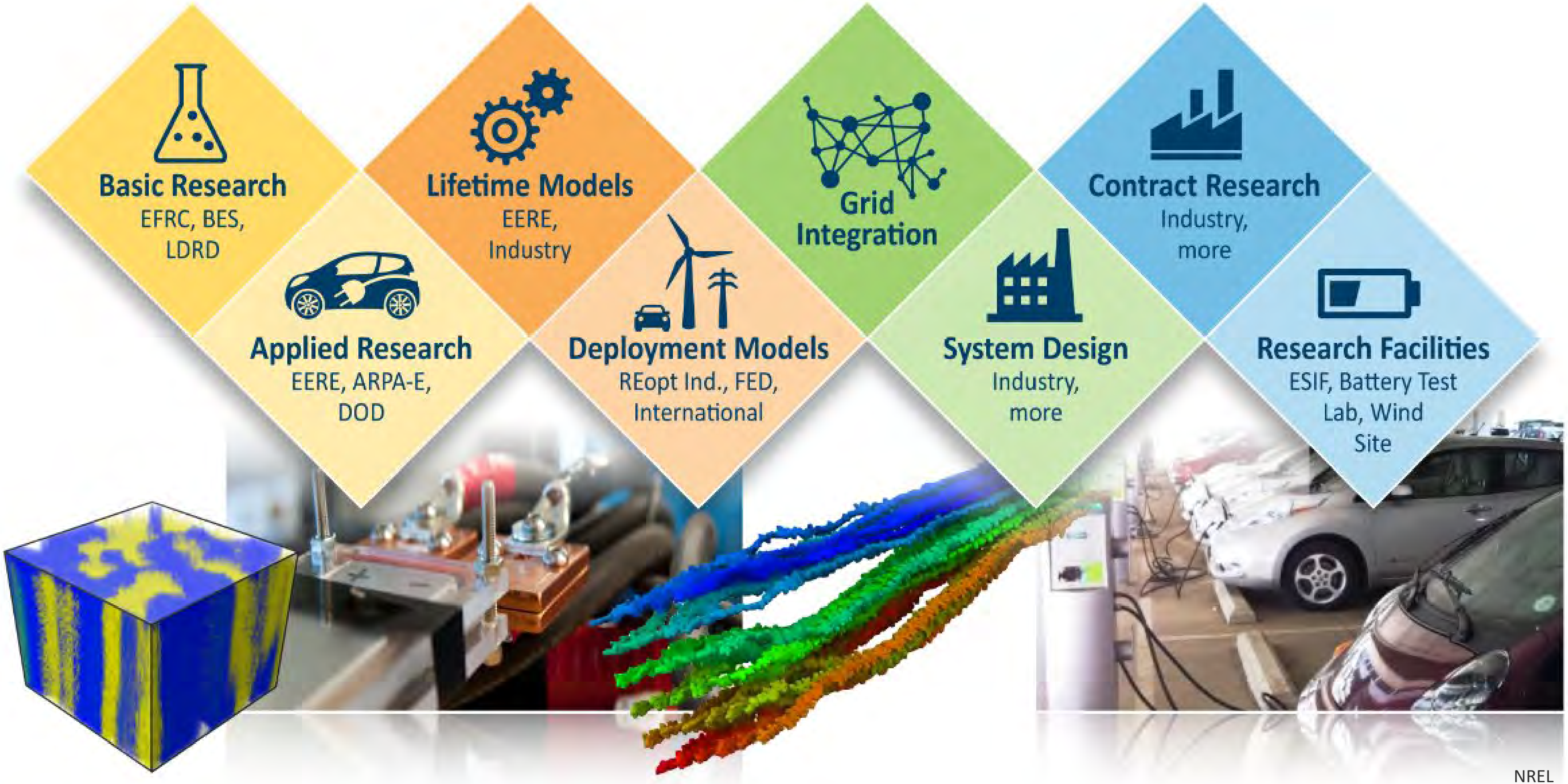
Buildings
Advanced Manufacturing
Government Energy Management

Energy Systems Integration

High-Performance Computing
Data and Visualizations

NREL's Science Drives Innovation

NREL's Broad Energy Storage Capabilities



Storage analysis broad areas of research

Decision-support
- Domestic Technical Support
- International Technical Support

Impacts Analysis
- Markets, policy, regulatory
- Environmental
- Circular economy

Application-Specific Analysis
- Distribution Grid Analysis
- Transportation Analysis
- Grid Modeling
- Resilience

Storage System Design & Optimization
- Hybrid Systems
- Detailed Battery Economic Modeling

Component Analysis
- Current and future storage technical attributes enable provision of grid services
- Cost and Economic Attributes

Supported by:

Robust laboratories for material experiments, component testing, grid-scale testing, buildings

Data, Partnerships with industry, Global Partnerships

Storage Futures Study

Supply

RE Techs Growth

- Cheaper Wind & PV
- Growing interest in all RE technologies

Energy Storage Tech

- Cheaper Li-ion Battery
- Many emerging storage technologies

Grid (Market)

- Growing Flexibility
- Potential for distributed generation and storage
- Potential impacts of (and barriers to) ES not well-understood.

Demand

- Net Load Profile changing due to electrification
- Anticipated EV impact

Growing interest within DOE to effectively invest in future energy storage R&D (i.e., the Energy Storage Grand Challenge)

SFS: Planned reports and discussed reports today

✓ = discussed today

✓ **The Four Phases of Storage Deployment:** This report examines the framework developed around energy storage deployment and value in the electrical grid.

✓ **Storage Technology Modeling Input Data Report :** A report on a broad set of storage technologies along with current and future costs for all modeled storage technologies including batteries, CSP, and pumped hydropower storage.

✓ **Grid-Scale Diurnal Storage Scenarios :** A report on the various future capacity expansion scenarios and results developed through this project. These scenarios are modeled in the ReEDS model.

Distributed Storage Adoption Scenarios (Technical Report): A report on the various future distributed storage capacity adoption scenarios and results and implications. These scenarios reflect significant model development and analysis in the dGen model.

Grid Operational Impacts of Storage (Technical Report): A report on the operational characteristics of energy storage, validation of ReEDS scenarioson capturing value streams for energy storage as well as impacts of seasonal storage on grid operations. Released late 2021

Executive Summary: A final summary report that draws on the prior three reports, generates key conclusions and summarizes the entire activity. Released late 2021

Four Phases: A Visionary Framework

- The Four Phases report is unlike the other complex modeling results that you will see in this presentation.
- To set the stage, this report synthesizes a large body of work into a straightforward *narrative* framework we anticipate will be helpful to stakeholders.
- The important conclusions are the trends and the drivers of deployment rather than the specific quantities and timing.

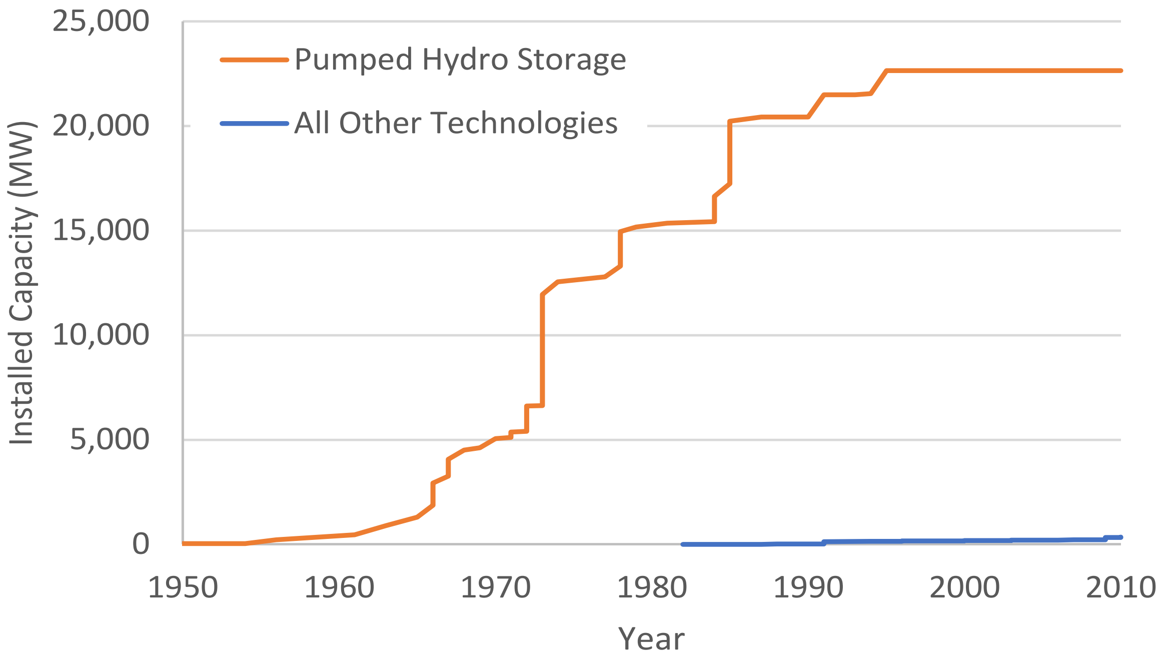
The Four Phases of Storage Deployment

Reminder of Key Takeaways

Phase	Primary Service	National Potential in Each Phase	Duration	Response Speed
Deployment prior to 2010	Peaking capacity, energy time shifting and operating reserves	23 GW of pumped hydro storage	Mostly 8–12 hr	Varies
1	Operating reserves	<30 GW	<1 hr	Milliseconds to seconds
2	Peaking capacity	30–100 GW, strongly linked to PV deployment	2–6 hr	Minutes
3	Diurnal capacity and energy time shifting	100+ GW. Depends on both on Phase 2 and deployment of variable generation resources	4–12 hr	Minutes
4	Multiday to seasonal capacity and energy time shifting	Zero to more than 250 GW	Days to months	Minutes

While the Phases are roughly sequential there is considerable overlap and uncertainty!

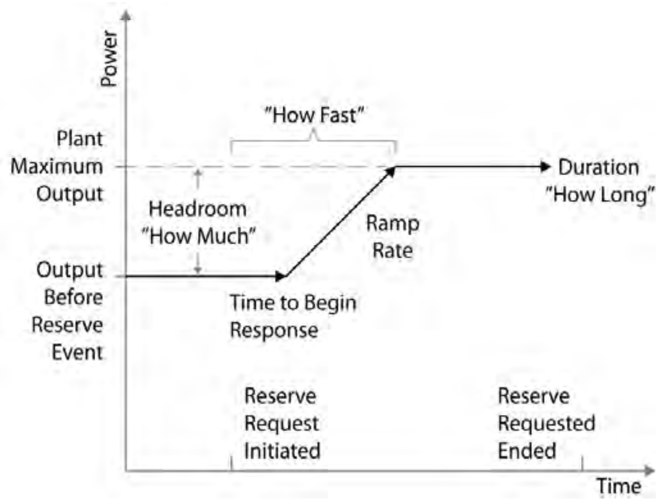
Historical Deployment



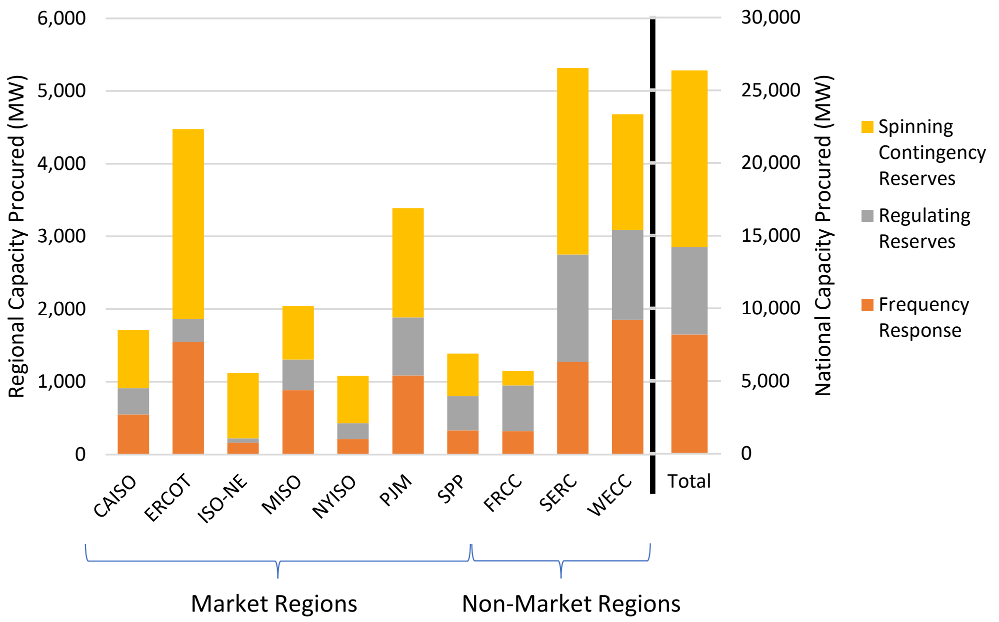
Pumped storage continues to play an important role, and there are likely new opportunities for additional deployments

Phase 1: Short-Duration Storage for Operating Reserves

An Important Entry Point, But Limited

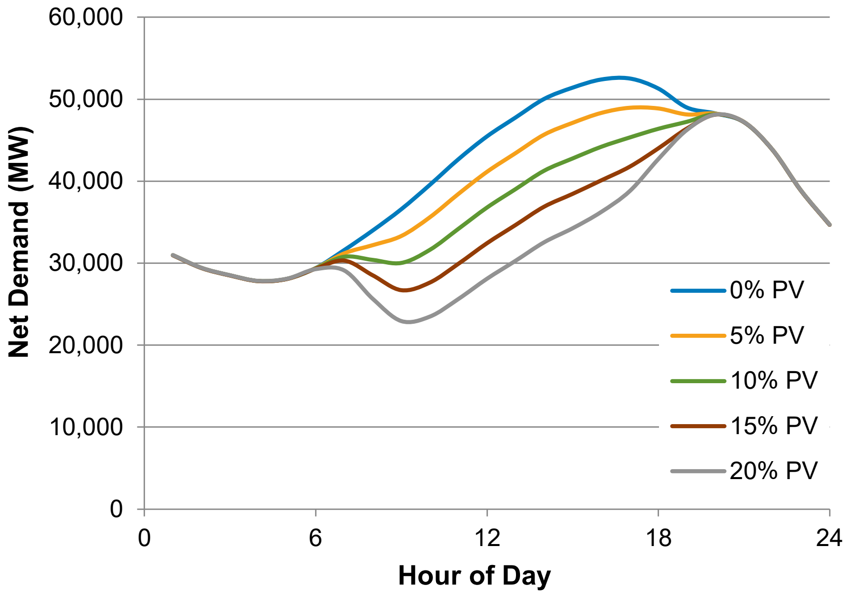


Characteristics of operating reserves

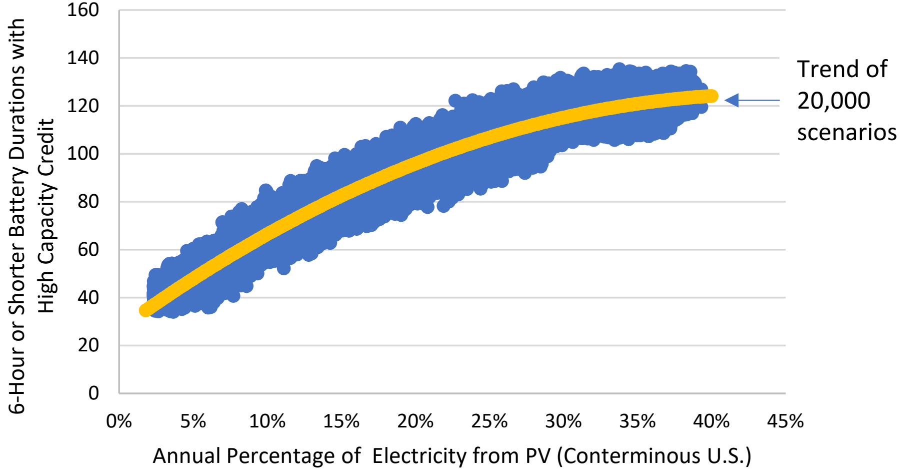


Current U.S. grid requirements for high-value operating reserve products potentially served by energy storage in Phase 1

Phase 2: The Rise of Battery Peaking Plants

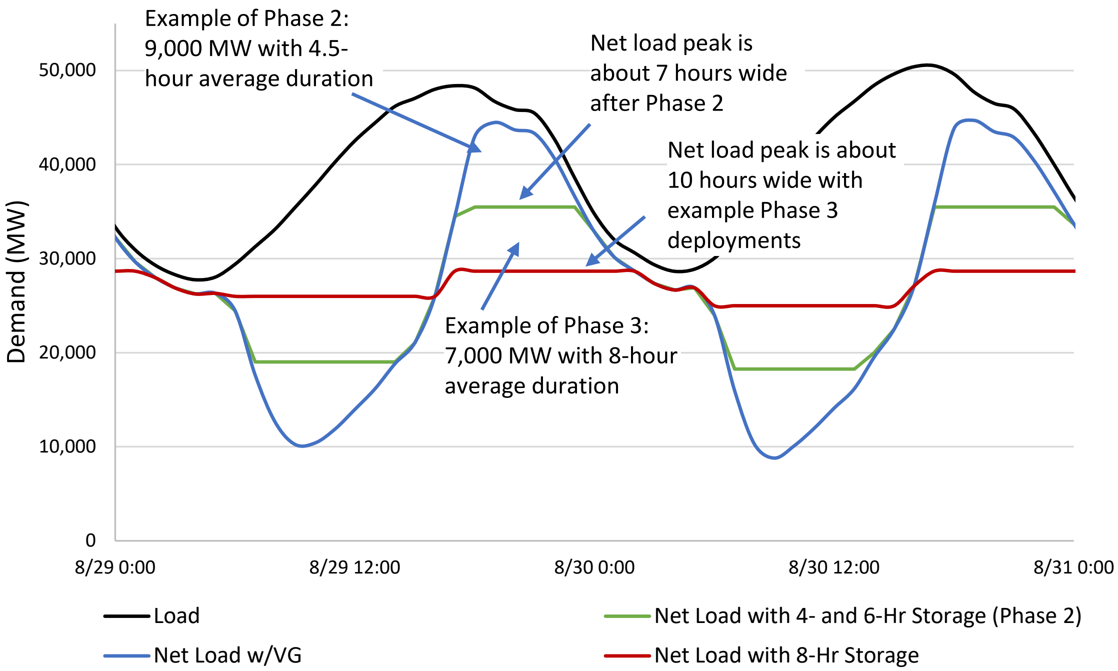


PV increases opportunities for storage as peaking capacity



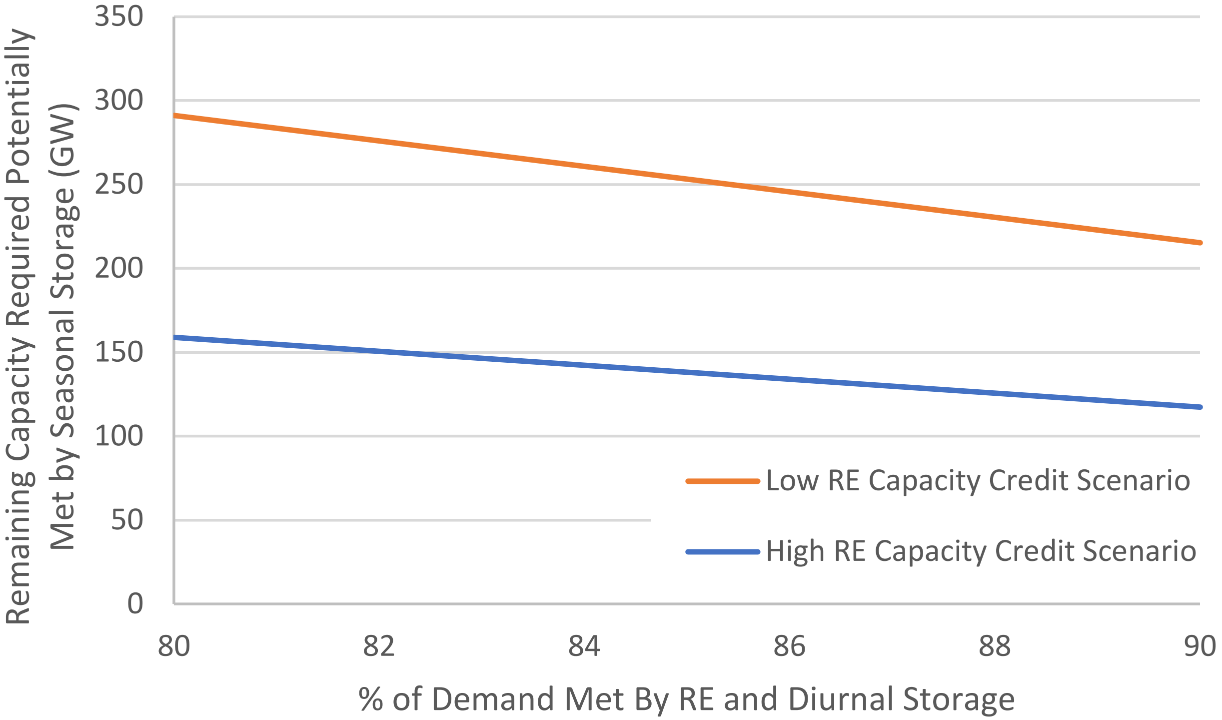
The potential opportunity of Phase 2: National potential of 4–6 hour batteries with high capacity credit

Phase 3: The Era of Ubiquitous Storage?



Longer peaks with greater storage deployment

Phase 4: The End Game with Multi-Day to Seasonal Storage



Bounding the size of Phase 4 by estimating the national residual capacity requirements under 80%–90% RE scenarios

The Four Phases of Storage Deployment

Key Takeaways

Link to Report: https://www.nrel.gov/docs/fy21osti/77480.pdf

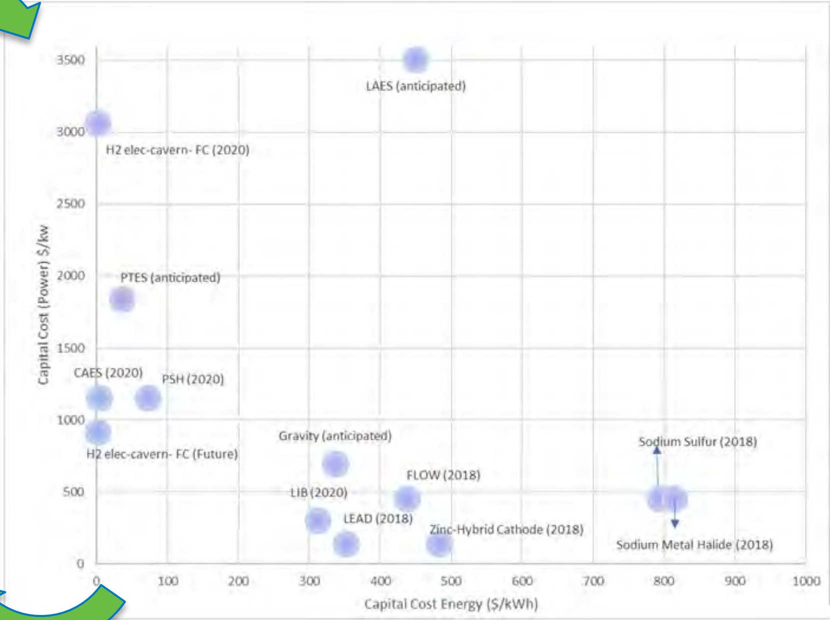
- Paper provides framework of four future phases of new energy storage deployment, that guides our understanding of the emerging and modeled energy future with significant new options, markets and value in combination with variable renewable energy.
- The four phases concept highlights small market for very fast responding services
  - Nearly all grid services can be met with devices that can ramp in the minute-to-hour time frame
  - Where fast response is needed, the market size is limited
- The key opportunity for storage is the vast need for capacity to meet peak demand periods.
  - With PV deployment, possibility of more than 200 GW of diurnal storage potential.
- Multiday and seasonal storage with deployments that could also be measured in hundreds of GW.
  - Driven by 100% RE or multi-sector decarbonization.
- Many technology options to balance supply and demand
  - We do not compare opportunities for storage to alternative flexibility options such as demand response
  - Need additional analytic needs for utilities and stakeholders to consider optimal least-cost portfolios.

Storage Technology Modeling Input Data Report

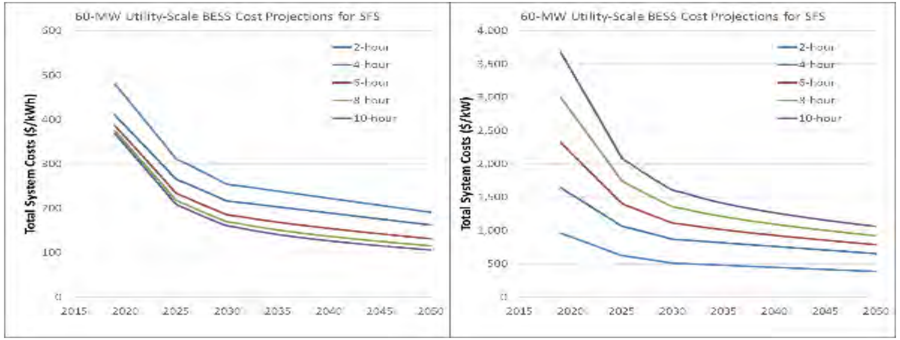
Reminder of Key Takeaways

1. Define key energy storage terms and concepts: round-trip efficiency, power capacity, energy capacity, depth of discharge, LCOS, etc.

2. Review current energy storage technology cost and performance

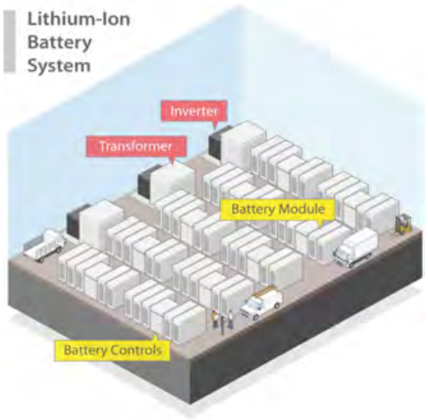


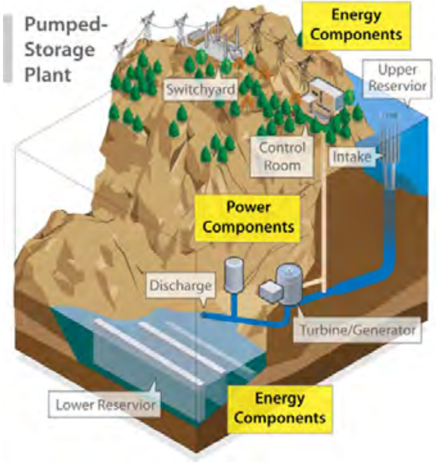
3. Develop future cost projections for use in ReEDS/dGen models: Grid-scale Batteries, distributed batteries, pumped storage hydro

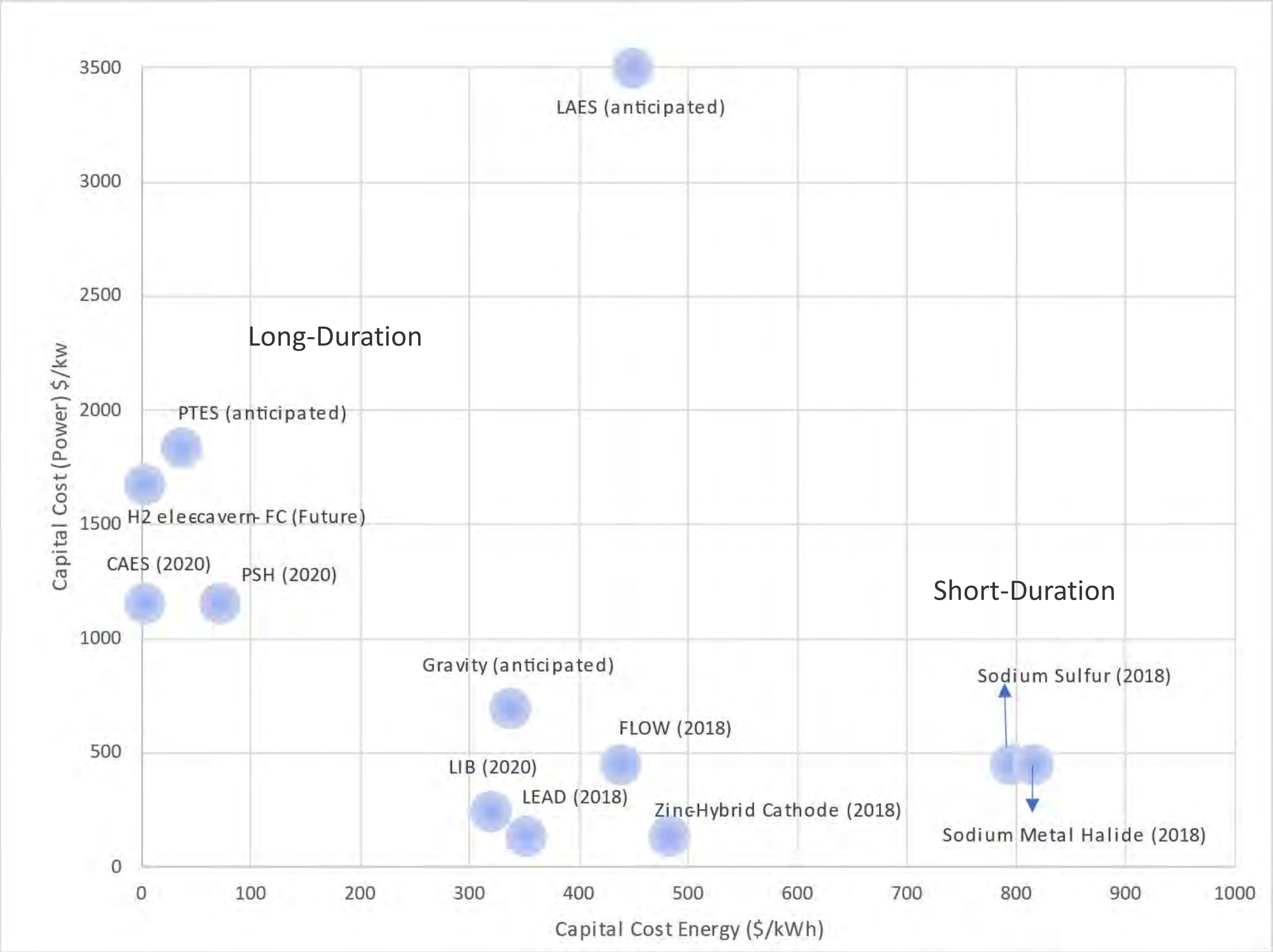


Data was assembled across commercial and emerging storage technologies

Storage Type/Technology	Primary Data Source
Thermal Storage	
Pumped thermal energy storage (PTES)	(McTigue et al. In Press)
Electrochemical Storage	
Lithium-ion battery (LIB)	Multiple sources; see References (p. 58)
Lead-acid battery	Mongird et al. 2020
Redox flow battery (flow batteries)	Mongird et al. 2020
Sodium sulfur battery	Mongird et al. 2019
Sodium metal halide battery	Mongird et al. 2019
Zinc-hybrid cathode battery	Mongird et al. 2019
Ultracapacitors	Mongird et al. 2019
Hydrogen storage (using electrolyzers, salt caverns, and stationary fuel cells)	Hunter et al. 2021
Electromechanical Storage	
Compressed air energy storage (CAES)	Mongird et al. 2020
Liquid air energy storage (LAES)	Olympios et al. In Press
Pumped-storage hydropower (PSH)	Mongird et al. 2020
Flywheel	Mongird et al. 2019
Gravity	Schmidt 2018



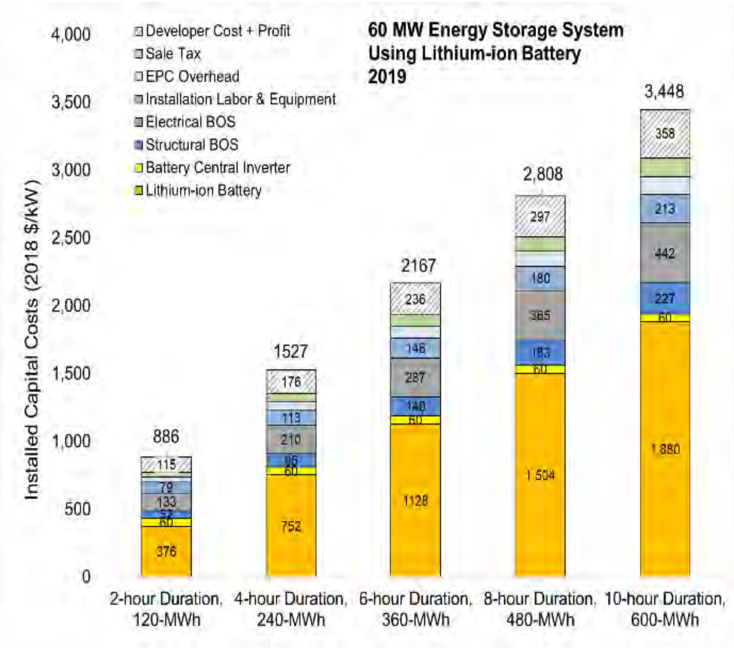


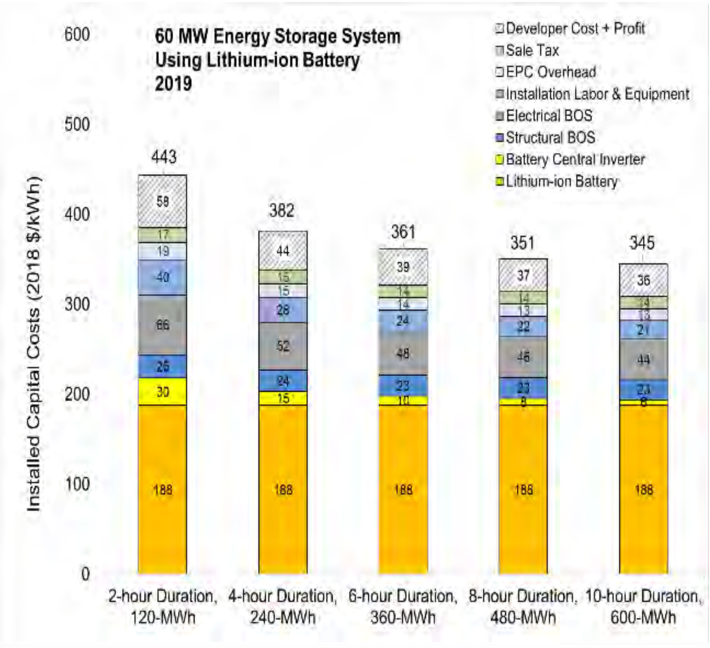


Capital Cost of Power vs. Energy

Current Utility-Scale Battery Costs

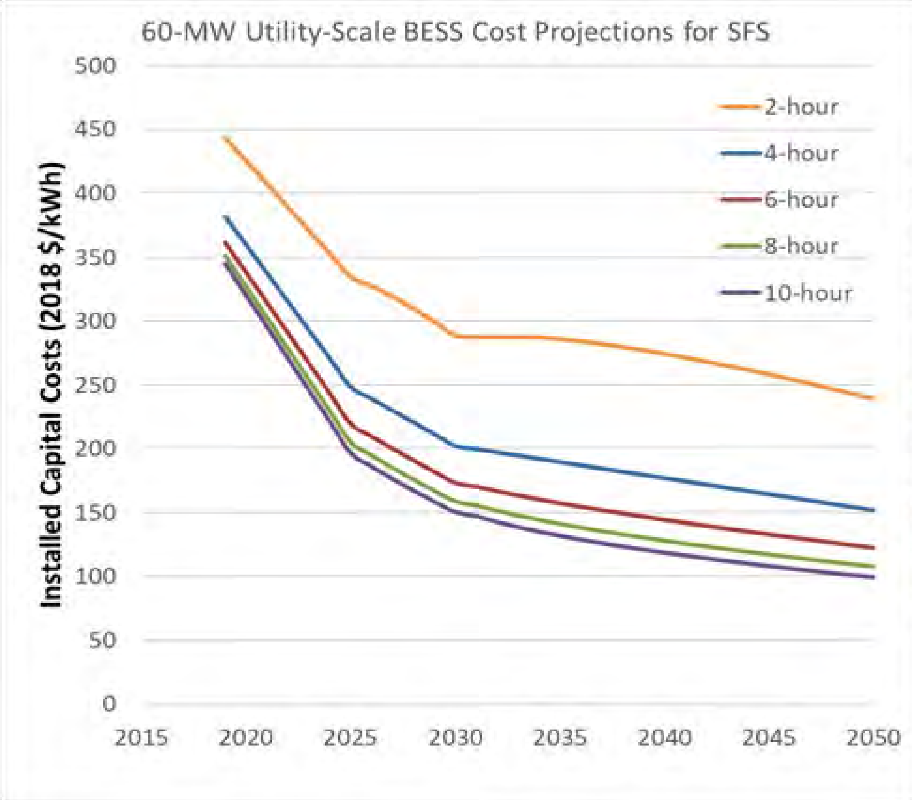
- Based on methodology used in NREL PV and BESS cost benchmarking study*
- Developed costs for 2/4/6/8/10-hour duration storage using NREL Utility-Scale BESS bottom up cost model
- Note the "2-D" nature of BESS costs, differences between $/kWh (energy) and $/kW (power) basis, at total and component level

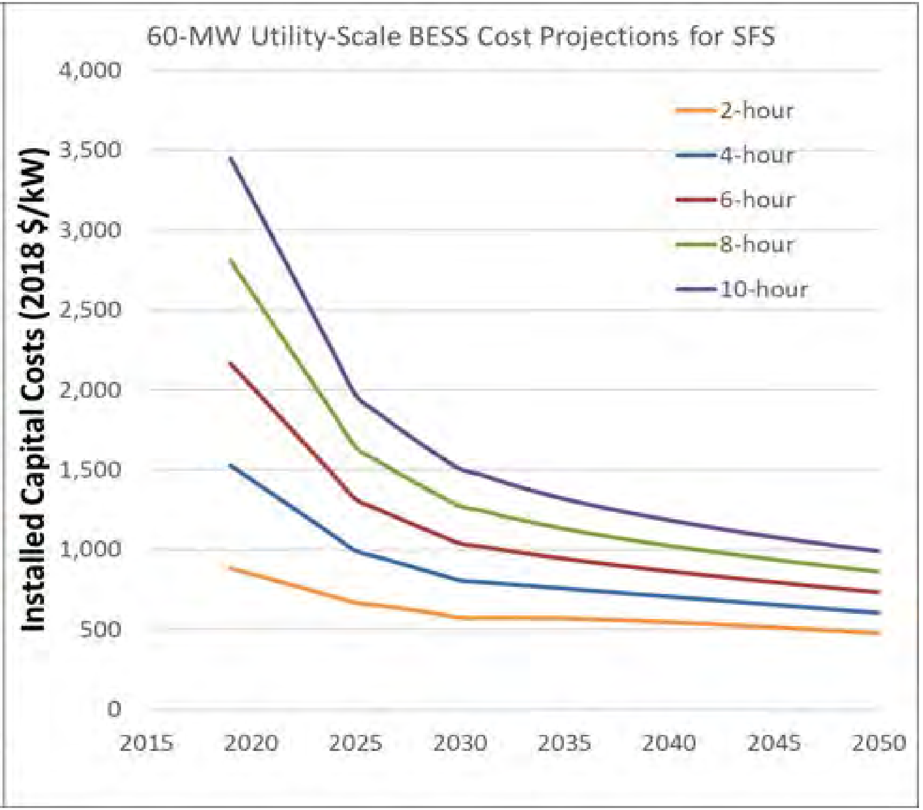




*Feldman et al. 2020 (forthcoming) U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2019, NREL/TP-6A20-75161

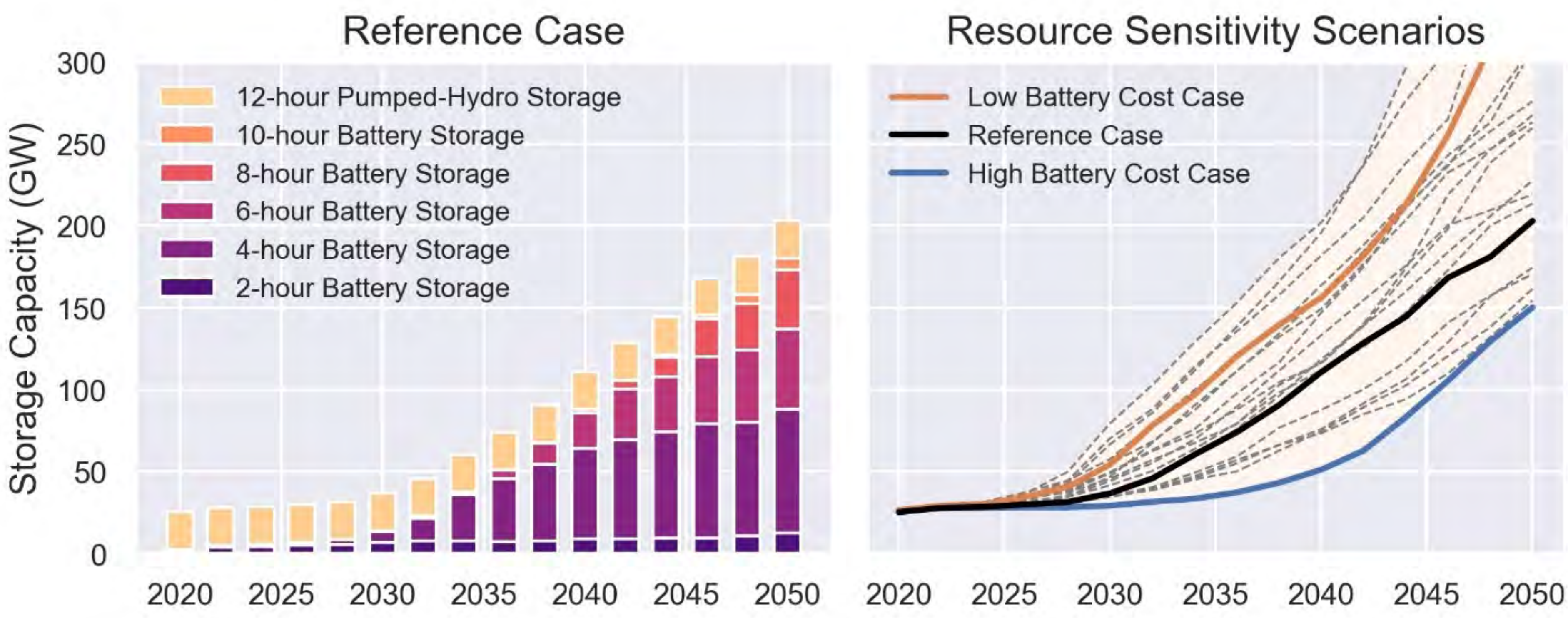
Future Battery Costs by Cost Scenario - Moderate





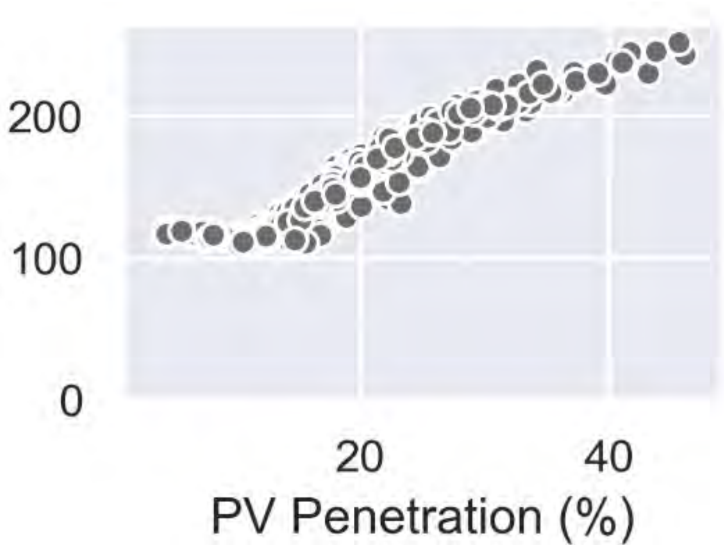
*https://atb.nrel.gov/

Modelled storage deployment in scenarios

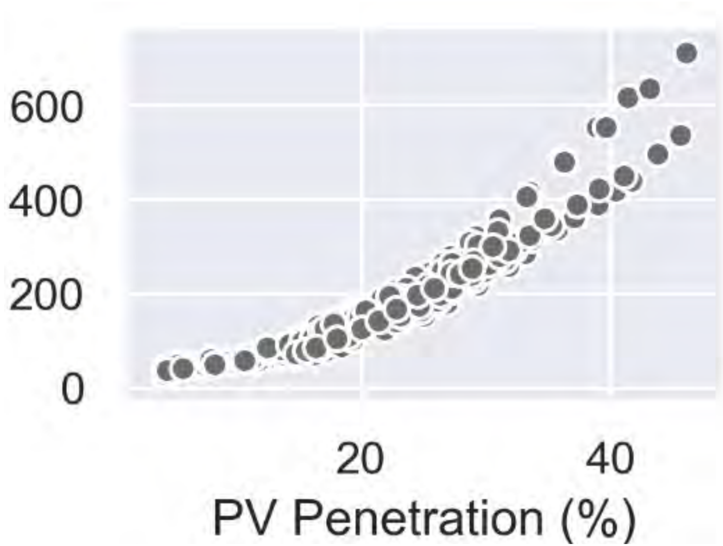


Storage Correlates with PV More than Wind

Peaking capacity potential (GW)
(determined by net load shape)



Energy time-shifting potential (TWh)
(determined by energy price profiles)



Questions and Discussion

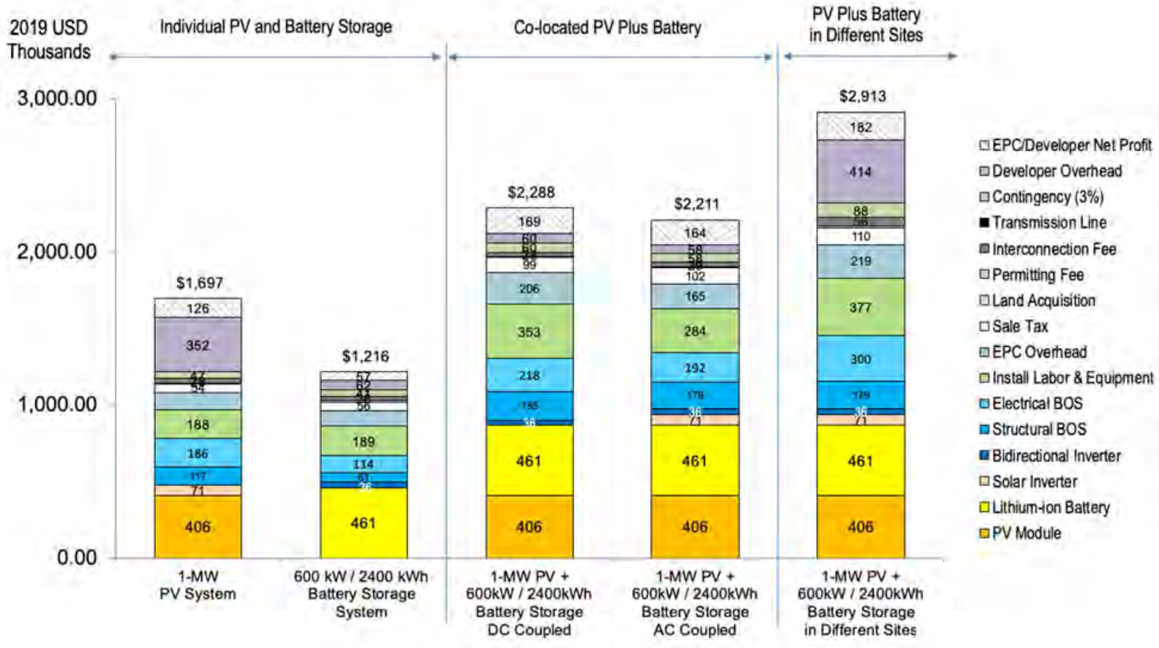
https://www.nrel.gov/analysis/storage-futures.html

www.nrel.gov

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Current Battery Costs – Residential

- Stand-Alone Battery Energy Storage System (BESS)
  - Based on methodology used in NREL PV and BESS cost benchmarking study*
  - Assumes $176/kWh battery pack (BNEF 2020)
  - Installation, overhead and profit margin assumptions aligned with NREL Residential PV model
  - Costs converted to linear equation based on battery power and energy capacity for use in dGen



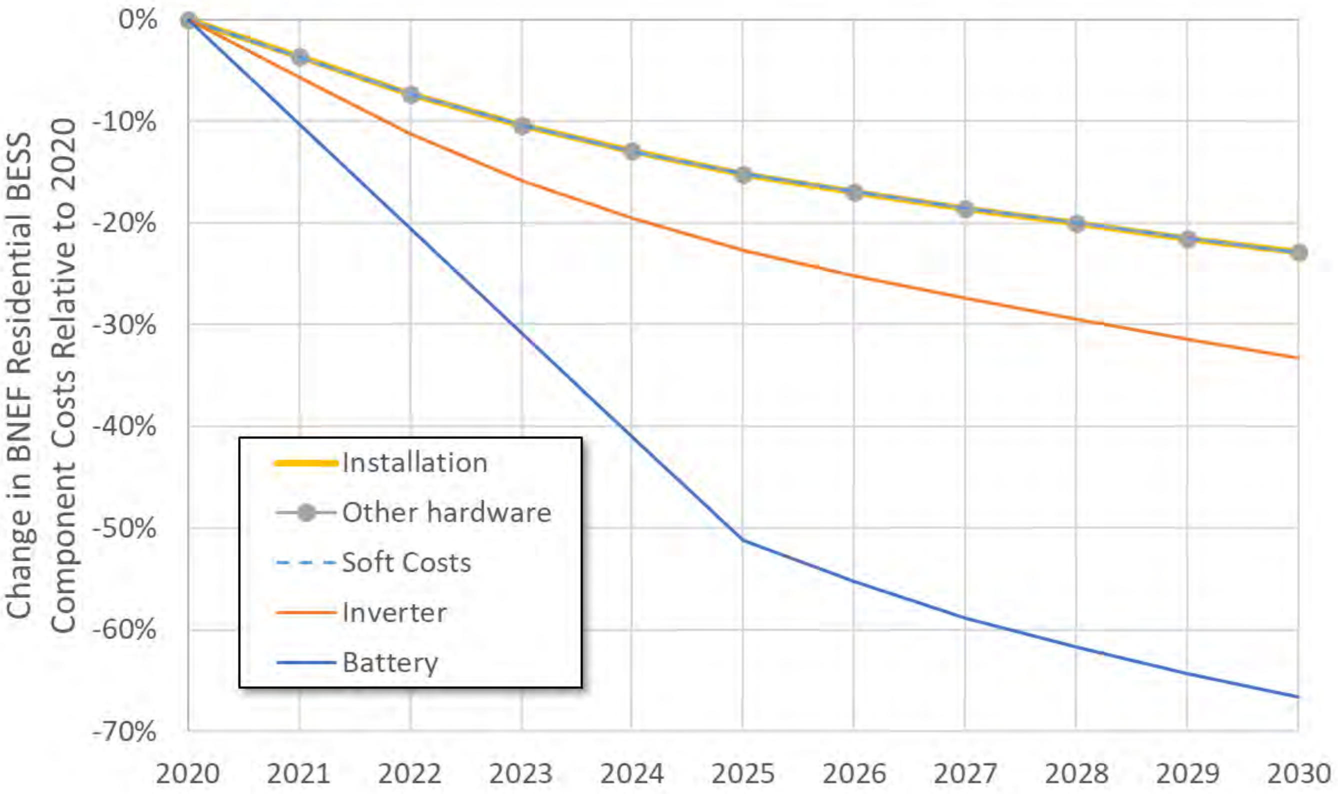
*Feldman et al. 2020 (forthcoming) U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2019, NREL/TP-6A20-75161

Grid-Scale Diurnal Storage Scenarios Key Takeaways

- Capacity value drives deployment, but energy arbitrage value is needed to realize optimal deployment
- Diurnal storage is more synergistic with PV penetration than with wind penetration
- Significant storage growth (>125 GW) in all scenarios
- Any storage technology that can meet the cost and performance values used in this paper will be competitive

Future Battery Costs by Component

- Battery pack costs decline much faster than other cost components
- Must account for this or will skew BESS costs as a function of duration
- Determined current year cost breakout by component for all durations and then applied cost reductions by component



MI POWER GRID

Making the Most of Michigan's Energy Future

New Technologies and Business Models

Break: 2:15 – 2:20 PM

Stakeholder Meeting 5: Storage

March 24, 2021

MPSC

Michigan Public Service Commission

Panel: Utility Storage Solutions – Experiences, Barriers, & Opportunities

Moderator

Inês Ribeiro Canella
Principal
Mosaic Environmental Consulting

Kirk Eisert
Engineer Principal
Indiana Michigan Power Co.

Noah Feingold
Senior Strategist, Electric Business Planning & Development
DTE Energy

Teresa Hatcher
Executive Director
Electric Regulatory & Strategy Implementation
Consumers Energy

INDIANA MICHIGAN POWER
An AEP Company

MPSC New Technology & Business Models Workshop Storage – 03.24.21

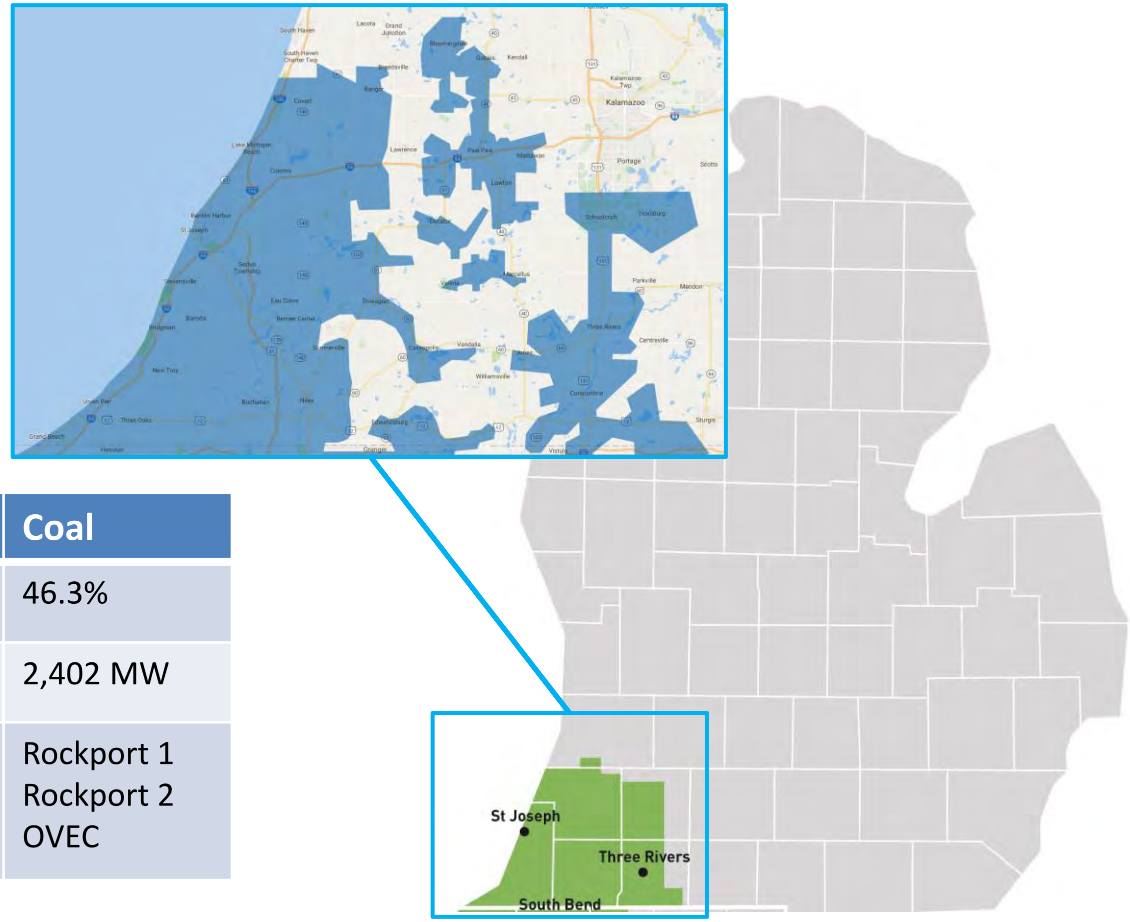
Presentation by I&M

An AEP Company

Indiana Michigan Power

I&M's Michigan Service Territory:

- Approximately 129,000 retail customers
- Located in southwest Michigan, serving communities in the counties of Berrien, Cass, St. Joseph, Van Buren, Kalamazoo and Allegan
- Transmission: 16 miles of 765 kilovolt (kV), 234 miles of 345 kV, 232 miles of 138 kV, 370 miles of less than 138 kV transmission facilities
- Distribution: 5,300 miles
- I&M is a member of PJM Interconnection, LLC (PJM)



	Nuclear	Solar*	Hydro	Wind	Coal
Capacity %	43.9%	0.7%	0.4%	8.7%	46.3%
Capacity	2,278 MW	34.7 MW	22.4 MW	450 MW	2,402 MW
Units	Cook Unit 1 Cook Unit 2	Five Solar Plants	Six Run-of-River Hydroelectric Dams	Wildcat Headwaters Fowler Ridge	Rockport 1 Rockport 2 OVEC

**includes the 20 MW St. Joseph Solar Farm, which will be online this Spring*

Clean Energy Future

AEP's VISION

We are redefining the future of energy and developing forward-thinking solutions that provide both clean and affordable energy to power the communities we serve. Our goal? Produce and deliver energy that empowers positive social, economic and environmental change.

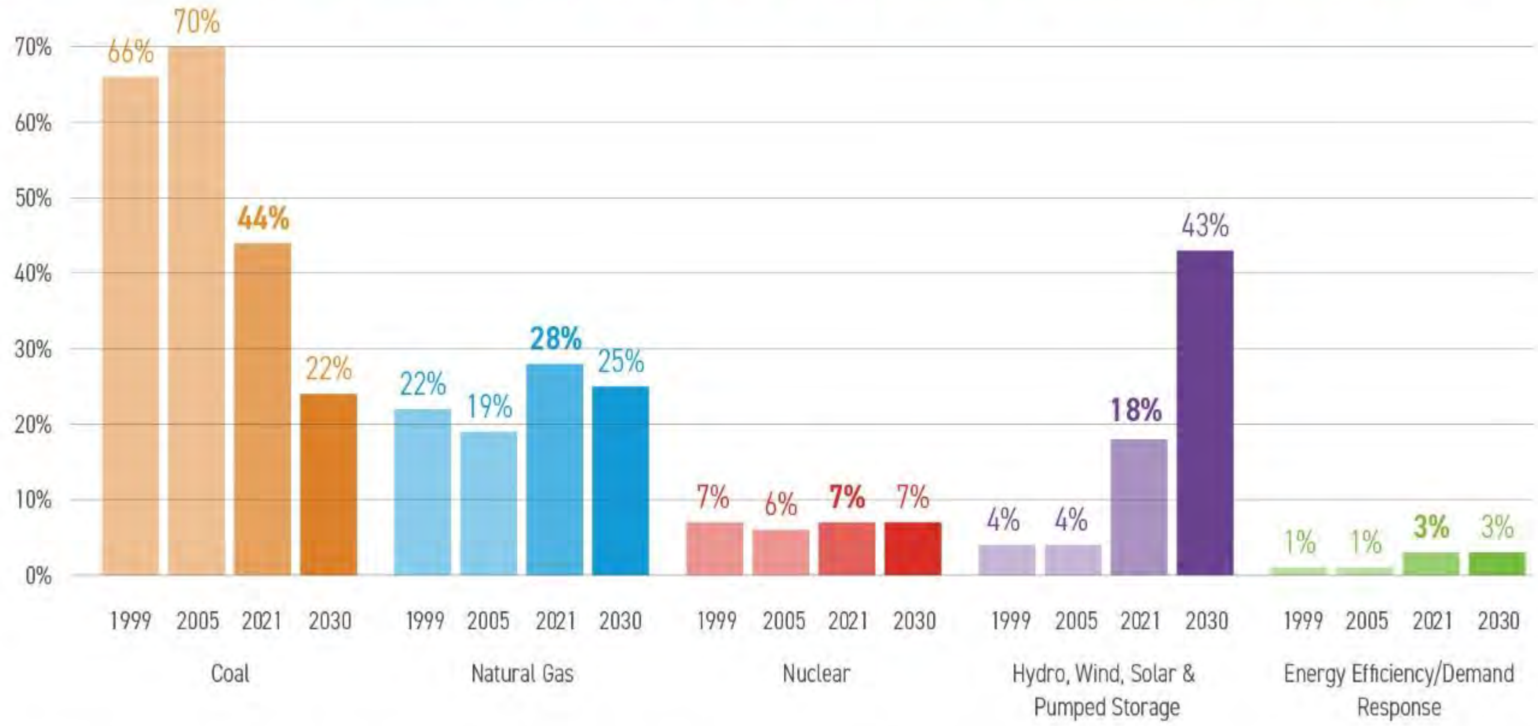
AEP's PLANS

-Net zero carbon dioxide emissions by 2050
-Adding more than 10,000MW of regulated wind and solar through 2030
-Investing $4.9 billion in renewable through 2025

I&M today

-85+% Carbon-free energy production
-500+ MW of renewables

TRANSFORMING OUR GENERATION FLEET - AEP'S GENERATING RESOURCE PORTFOLIO



2021 data as of 2/15/2021. 2030 includes IRP forecasted additions and retirements as well as subsequent public filings. Energy Efficiency / Demand Response represents avoided capacity rather than physical assets.

Why Storage is Important

Carbon fuels →	Resource evolution →	Renewable resources

- The advent of “big battery” technology addresses a key challenge for green energy – the intermittency of wind and solar.
- Battery storage becomes most cost effective when built at scale. Utilities can help accelerate the development of grid energy storage by leveraging economies of scale. Utilities can optimize location, sizing and timing of storage to ensure maximum reliability, resiliency and overall benefits to customers.
- Indiana Michigan Power is well positioned to play the role of asset owner and integrator; leveraging the capabilities of storage technologies to benefit our customers.

> **"If you’re playing the long game, there’s not many people that don’t think that storage is going to be a big part of the picture in a few years."**
>
> Glenn McGrath
> *U.S. Energy Information Administration*

Storage Use Cases

Utility Services
- T&D Spend Deferral/Reduction
- Renewable Generation Smoothing
- Utility Demand Response

Wholesale Market
- Wholesale Demand Response
- Energy Arbitrage
- Frequency & Voltage Regulation
- Resource Adequacy & Congestion Relief
- Spinning/Non-Spinning Reserves

End Consumer Benefits
- Bill Management
- Self Generation & Backup Power
- Transportation

- Batteries can provide multiple services to three stakeholder groups including across the entire utility spectrum of Generation, Transmission and Distribution
- Utilities are well positioned to value stack services (optimize value of storage systems by integrating multiple services)

Key Considerations for Current Storage Technology

- **The leading technology today is Lithium Ion although there is effort aplenty for new technologies** (eg.flow)
- **Safety/Environmental**
  - Lithium Ion Fires – mitigate with site design, system monitoring
  - Future technologies could decrease risks
  - Decommissioning
- **Cost**
  - Current **<u>all in</u>** installed capital cost is approximately $550-750/kWh for larger systems

    costs vary by scale and use case
  - Decommissioning costs can represent 10-26% of total cost of storage and arrive as soon as 10-20 years. Manual dismantling process (Energy Storage Association White paper dated 8/27/20)
  - Based on published cost projections mass grid storage deployment is 3-5 years away from having a CBA justifiable against traditional alternatives. Value stacking and incentives can improve the economics
- **Technology limitations**
  - Lithium Ion technology starts to become impractical for longer duration (>8hrs) systems due to cell balancing requirements

AEP's Experience and Approach

- We see battery storage as a key industry component going forward
- In the near term, system opportunities include targeted deployments and piloting of storage technologies for use cases where it could be a cost effective option to meet system capacity needs and reliability deficiencies.
- AEP is evaluating several battery storage opportunities across its service territories. Use cases include reliability improvements, T&D capacity deferrals, renewables smoothing/firming, and customer bill management. The company monitors cost, regulatory, and technology trends within the industry and continues to look for innovative, cost-effective solutions for our customers.
- AEP Reliability improvement in Pomeroy (1) and Minford, Ohio (2)
  - -Projects involves remote single phase circuits with little opportunity for creating a tiepoint
  - -1.6 MWh, 1MW battery acting as DACR during loss of source at each of 3 locations
- AEP Ohio Reliability/Resiliency improvement at Columbus Zoo
  - -Smart Cities initiative
  - -560kW/1200kWh battery coupled with 130kW solar
- I&M is ready to further explore this technology

Thank you!

Questions?

Energy Storage and Michigan

MI Power Grid Storage discussion

March 24, 2021

We see four key factors that will accelerate battery adoption as we progress through the next decade

Key factors accelerating battery adoption

Declining costs in Battery Technology

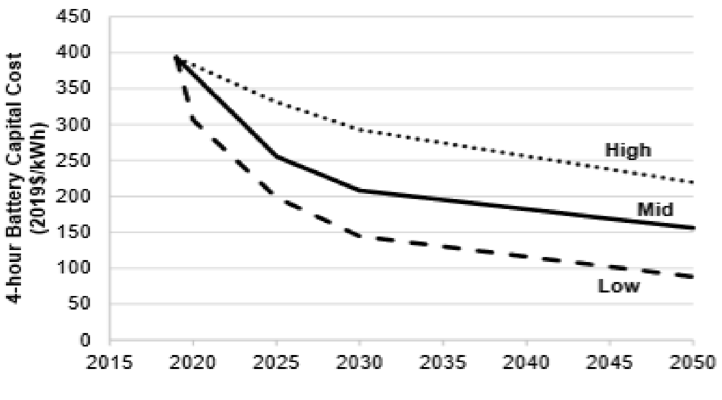
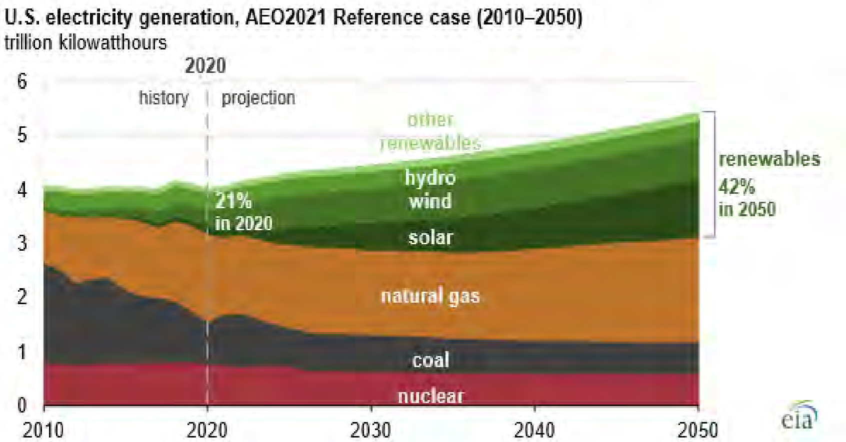


Figure ES-2. Battery cost projections for 4-hour lithium ion systems.

Source: NREL 2020 Battery project cost

Increasing Renewables



Source: U.S. EIA Annual Energy Outlook 2021 (AEO2021)

Capturing value across use cases

Market Design

After close to 50 years, Ludington continues to be a critical component in Michigan's electric system and exemplifies value propositions for battery deployment in Michigan

Ludington Pumped Hydro Storage

- Shared by Consumers Energy (51%) and DTE (49%)
- Generates >2 GW for over 6 hours
- One of the largest energy storage facilities in the world[1]

Key Benefits

- Provide system capacity
- Energy shifting to balance load and generation
- Integrate higher levels of renewables
- Reduce price volatility

Impact on Battery Deployment

- Help establish and refine market participation models for storage facilities in wholesale power markets
- Allow utilities to understand and capture value from energy storage in a comprehensive manner
- Demonstrate the usefulness of storage flexibility and adaptability with changing grid needs over time (e.g., increasing renewables)

1. At the time of its construction (1969-1973), Ludington was the largest pumped storage plant in the world

Source (image): https://www.newkirk-electric.com/projects/power-generation/ludington-hydroelectric-pumped-storage-dam#/

Still, even with the experience of Ludington, optimizing across use cases can be highly complex and will require the development of new processes and capabilities

There are potentially dozens of use cases and benefits to evaluate

- Transmission deferral
- Distribution deferral
- Congestion relief
- Resource adequacy/capacity
- Energy shifting/peak shaving
- Spinning and non-spinning reserves
- Frequency regulation
- Voltage support
- Rapid response
- Black start
- Renewable smoothing
- Near-firm renewable generation
- Time-of-use bill reductions
- Demand charge reductions
- Increased use of local renewables
- Backup power/reliability/ resiliency
- Air quality
- Support EV infrastructure
- Operational flexibility across grid assets
- Land use impacts
- Mobile storage solutions
- Microgrids
- ... and more

Areas of focus for system-wide battery deployments

- Creating agile processes to implement battery solutions
- Developing engineering, design, and construction standards and specifications to safely and efficiently construct battery systems
- Ensuring dependable operations and maintenance such that storage is available for its planned functions
- Understanding trade-offs and necessary prioritization of use cases will ensure prudent planning and adoption of storage
- Quantifying benefits (both implicitly and explicitly through market designs) will enable battery projects can extract maximum value and meet customer needs

DTE

The next 1-3 years are important to build the necessary skillset and experience to optimize across the wide range of value streams batteries offer

We are exploring and deploying several pilots to test use cases and grow our abilities to optimize storage projects

<u>Solar + storage pilot</u>

- Power quality
- Renewable integration
- Develop best practices for interconnection and safety policies for future projects
- Peak shifting
- Wholesale participation

<u>EV fast charging plus storage</u>

- Peak shifting
- Demand charge management
- T&D deferral testing

<u>Other current/prospective use cases to pilot:</u>

- Resilience and emergency restoration
- Non-wire alternatives
- Wholesale market participation
- Demand response
- Microgrids

Consumers Energy
MPSC New Technologies and Business Models Workgroup – Storage

Teresa Hatcher

March 24, 2021

Consumers Energy
Count on Us®

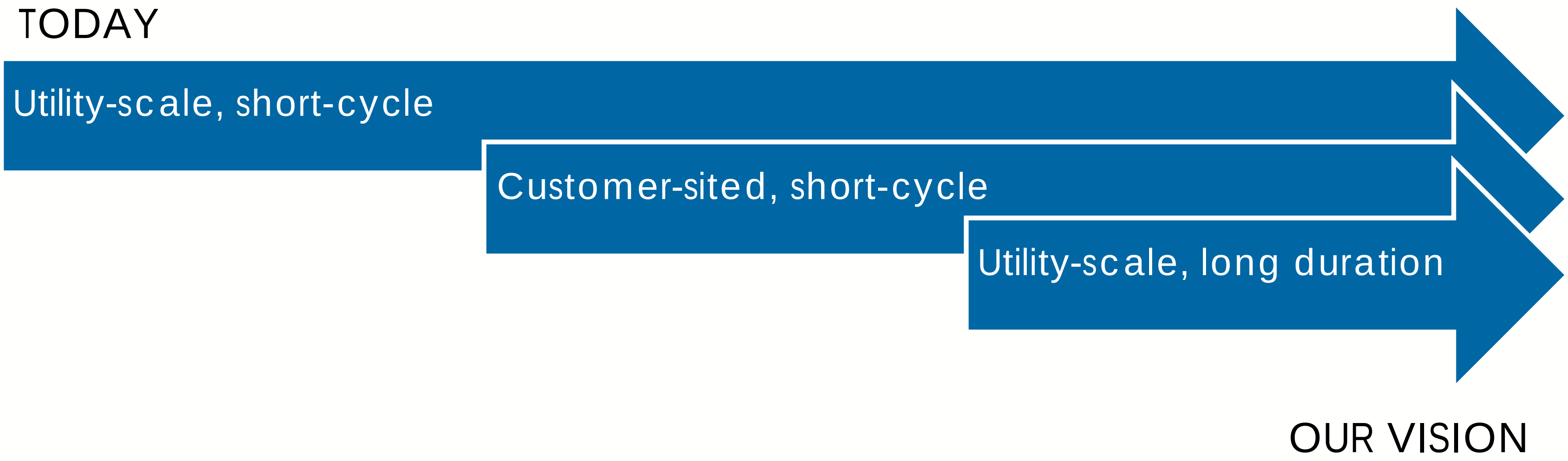
There are several use cases of storage, crossing traditional boundaries of utility planning and operations

- Electric Generation
- Electric Distribution
- Electric Transmission
- Natural Gas Storage
- Natural Gas Decarbonization

To date, we have gained experience with various utility-scale, short-cycle storage projects

Project	Location	Status	Use Cases
Parkview (storage + solar)	Kalamazoo	Installed	Smoothing; peak shaving; volt-var optimization; power factor correction; market interaction; frequency regulation
Circuit West (storage + solar, auto switching)	Grand Rapids	Installed	Smoothing; peak shaving; volt-var optimization; power factor correction; market interaction; islanding
Cadillac (storage + solar)	Cadillac	Construction	Smoothing; peak shaving; cost savings related to DC-coupling; solar + storage dispatchability
Airpark (storage)	Standish	Construction	Peak shaving; market interaction; non-wires - substation upgrade deferral; transportable to other locations
Armstrong (storage)	Battle Creek	Future	Islanding; outage mitigation; market interaction
ATS (storage)	Allegan	Future	Automatic load switching between circuits

We have several storage projects and pilots ongoing and planned over the next several years; our approach will evolve over time to consider emerging storage use cases



Regulatory and business model barriers are similar across various new and emerging technologies

Not only is technology advancement quickening, but customers are also adopting new technologies faster – agility in the regulatory process can help us capture new value from emerging technologies faster as well

- ✓ Pilot and demonstrate ideas at the speed of new technologies and changing customer preferences so that we can bring the right products to market at scale
- ✓ Be more modular and agile with our pricing to support customers that want to pay for what they value
- ✓ Shift our business models based on what customers truly value so that the value being captured is directly related to the value being created

GMP Energy Storage

Craig Ferreira
Innovation Development
Green Mountain Power

GMP Energy Storage

GREEN MOUNTAIN POWER

MI Power Grid
March 24, 2021

Craig Ferreira
Innovation Development

GMP ENERGY STORAGE PROGRAMS

➢ GMP Pilot Structure

Bring Your Own Device

Save money, cut carbon and improve reliability, while helping all GMP customers!

Tesla Powerwall

Reliable and safe electric battery storage.

GMP PILOT STRUCTURE

Pilot Filing

- Business plan for the pilot (who, what, where, when, why)
- 15 day filing period for comments
- Collaboration with external stakeholders and partners

Active Pilot

- 18-month enrollment period
- Status updates every 6 months
- Determine to tariff or cancel program at end of pilot

New Innovative Pilots

GMP shall file 15 days' advance notice with the Department of Public Service ("Department") and the Public Utility Commission ("Commission"), with a copy to Efficiency Vermont, before commencing pilot programs to provide the products or services referenced above.[1] The notice shall include a narrative explanation of the Innovative Pilot and how it is consistent with the eligibility requirements, the number of customers it will be made available to and how those eligible customers were selected, expected costs and revenues, why the proposal does not conflict with work performed by Efficiency Vermont, a certification that GMP has collaborated with Efficiency Vermont regarding the proposal in advance of the filing, and the frequency by which GMP shall provide status reports to the Commission and Department on the Innovative Pilot's progress which shall not be less than six months.

BRING YOUR OWN DEVICE PILOT

- **Upfront Incentive or Monthly Bill Credit**
  - $850 per kW Incentive
  - $150 per kW adder for solar constrained area of GMP grid
  - $11/kW/month
- **3:1 ratio of energy to power (3-hour resource)**

Customer Ownership

- Incentive pay back with avoided Power Supply costs
  - 10-year expected value stream

Eligible Devices

Batteries

Home battery systems used for battery back-up.

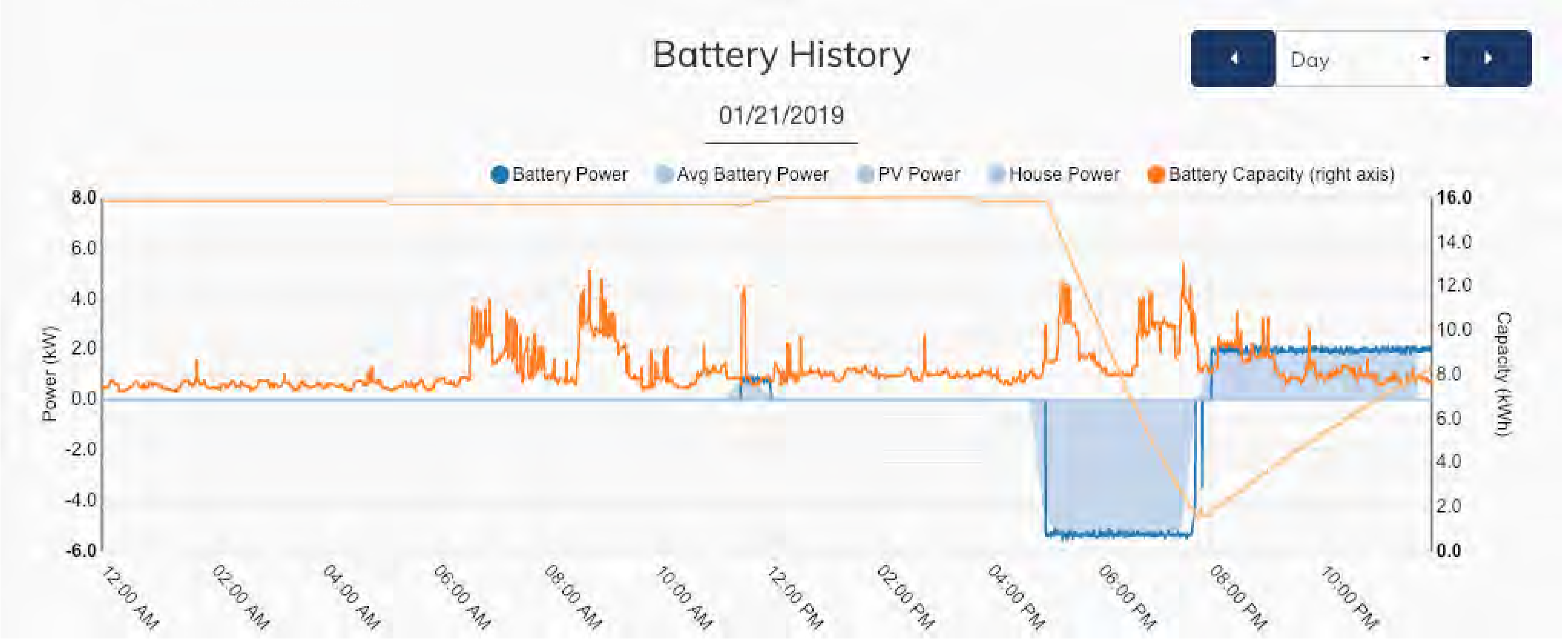
Vehicle Chargers

Water Heaters

BRING YOUR OWN DEVICE PILOT

Compatible Energy Storage

sonnen TESLA GENERAC PWRCELL solaredge



5-10 peak events per month

BRING YOUR OWN DEVICE TARIFF

- **Upfront Incentive Only**
- **3-hour resource (3:1 ratio of energy to power)**
  - $850 per kW Incentive
  - $100 per kW adder for solar constrained area of GMP grid
- **4 hour resource**
  - $950 per kW Incentive
  - $100 per kW adder for solar constrained area of GMP grid

❖ ~200 Customers enrolled

❖ Dropped support for other device types

❖ Dropped monthly bill credit option

❖ 5MW for 3 years before review

ORIGINAL GMP GRID TRANSFORMATION PILOT

Battery storage at home for $15/month or $1500 up front

GMP Ownership

- Rate Based

- Pay back with:
  - Avoided Power Supply costs
  - Customer payments

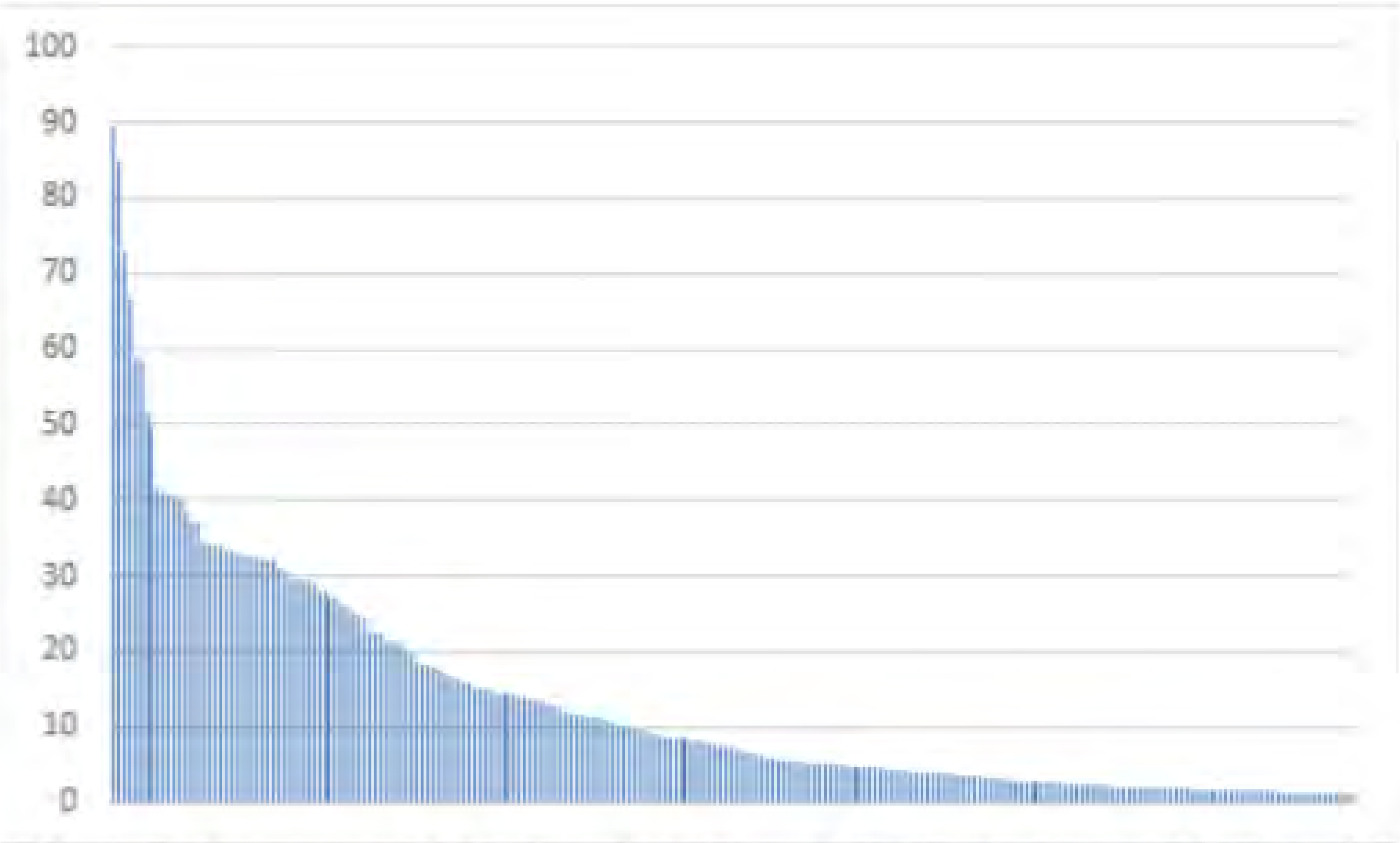
ENERGY STORAGE TARIFF

- Two Powerwalls/Whole-home Backup
- $55/month for 10 years or $5500 up front
- 27kWh/10kW per system
- Same structure as Pilot
- 5MW per year for 3 years before review

POWERWALL BACKUP PERFORMANCE

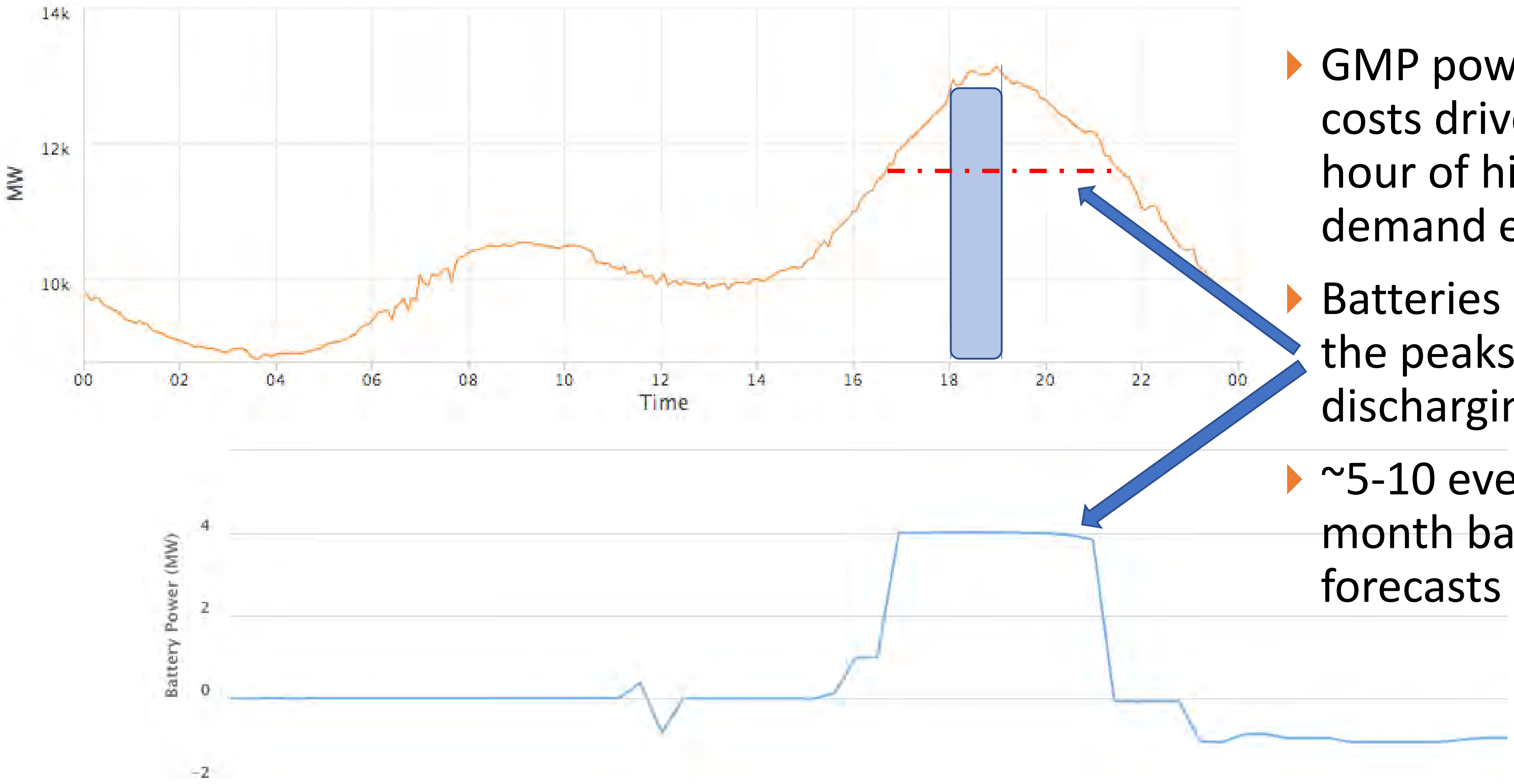
November 2018 Storm

- 2,901 Total Hours of Backup
- Average 13.4 Hours per Customer
- 89 Hours for a single customer



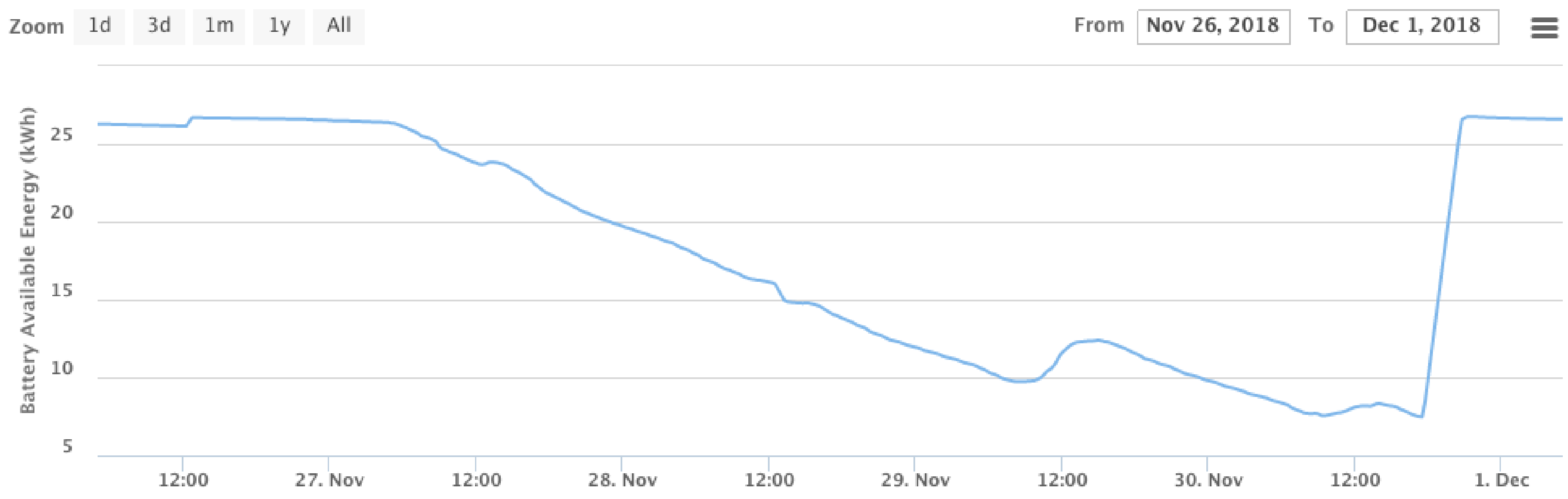
*Vertical axis represents the total number of hours of backup power provided by each Powerwall.

PEAK SHAVING 101: GENERATE SAVINGS FOR ALL CUSTOMERS



- GMP power supply costs driven by single hour of highest demand each month
- Batteries clip or lower the peaks by discharging
- ~5-10 events per month based on GMP forecasts

CUSTOMER STORIES



"The batteries pumped our water, ran our lights, appliances, TV, and computers, and even powered our electric snowblower, just as seamlessly as if we were connected to the grid"

- Gerry Hawkes, Woodstock: GMP customer who used storage and solar to stay powered during a 4-day outage

OWNERSHIP STRUCTURES

Utility Ownership

- Service/Maintenance responsibility on Utility, not customer
- Simple, cost-effective model for higher adoption rate
- Greater control of asset and flexibility for future needs on the grid
  - Maximizes value to utility customers (participating and non-participating)

In VT, GMP ownership structure spurred the energy storage market.

Customer/Third Party Ownership

- Service/Maintenance responsibility on customer
- Higher cost of entry
- Maintains ownership and freedom of future use for customer

BATTERIES IN ACTION

Think Big, Start Small and Scale Fast

Questions?
craig.ferreira@greenmountainpower.com

GREEN MOUNTAIN POWER
Generating Possibilities Together

MI POWER GRID

Making the Most of Michigan's Energy Future

New Technologies and Business Models

Break: 3:30 – 3:40 PM

Stakeholder Meeting 5: Storage

March 24, 2021

MPSC

Michigan Public Service Commission

The Future of Energy Storage: A Roadmap for Michigan

Tanya Paslawski

Senior Consultant

5 Lakes Energy

3.24.21

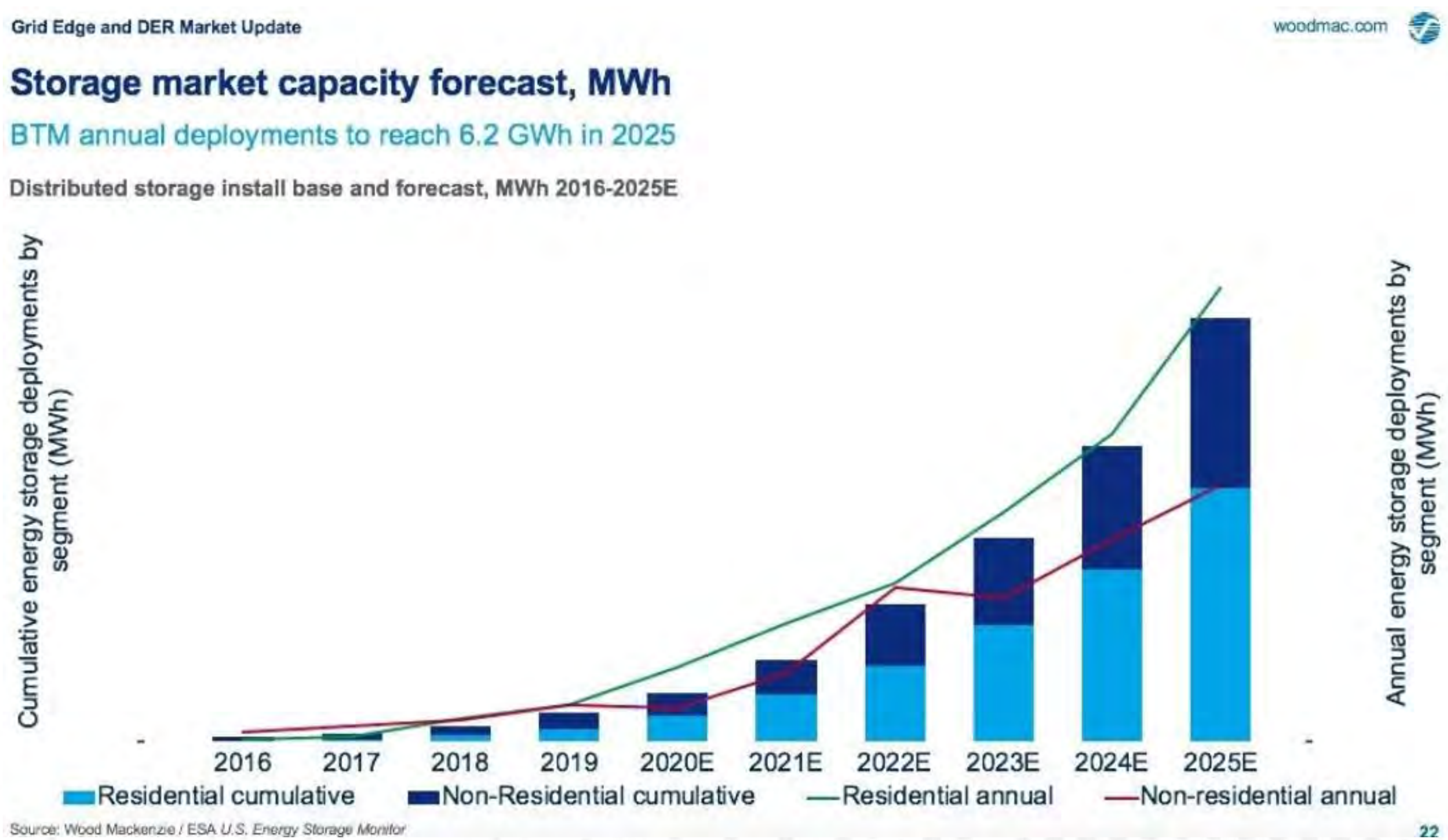
TANYA PASLAWSKI
Director, Strategic Initiatives

The Future of Energy Storage

A Roadmap for Michigan

Institute for Energy Innovation

WHY NOW?



Source: https://www.greentechmedia.com/articles/read/5-takeaways-on-the-future-of-the-u.s-distributed-energy-resources-market

DRIVERS

- Increase in renewable resources
- Technology advancements reduce cost and increase duration
- Policies to support Distributed Energy Resource deployment
- Carbon reduction goals
- Greater focus on resilience

GRANT FUNDED BY

EGLE

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

THANK YOU!

OBJECTIVES

- Review of reports from other states and industry literature
- Consider applications and values
- Identify benefits and quantify where possible
- Assess environmental benefits
- Model potential
- Survey of storage developers/convening
- Untapped market opportunities
- Policy recommendations

PARTNERS

Sustainability
MICHIGAN STATE UNIVERSITY

5lakes energy

michigan EIBC

MODELING

Identify potential for a representative set of cases.

2025

Based on current load profiles, rate design, and grid conditions

2030

Assumes increased renewables at 40%

2050

Assumes 100% carbon free (or close)

HOMER (BTM)

Optimization avoidance of demand charges, energy price arbitrage with storage and solar plus storage

STEP 8760 (BPS)

Optimization of clean resources and storage

MIEIBC Member Support

Gigawatt Level

Advanced Battery Concepts — Better Batteries, Better World©

Circle Power

form energy

Key Capture Energy

Michigan CAT

Volta Power Systems

Megawatt Level

APEX Clean Energy

ITC A Fortis Company | For the Greater Grid

Ranger Power

TIMELINE

Literature review and analysis
(Dec to March)

Modeling
(Dec to June)

Evaluation of environmental benefits and review of modeling results
(June to Sept)

Finalize roadmap
(Dec)

Dec 2020 | Mar 2021 | June 2021 | Sept 2021 | Dec 2021

Panel: Opportunities & Barriers for Energy Storage Deployment in Michigan

Moderator

Laura Sherman
President, Michigan Energy Innovation Business Council

Rachel Goldwasser
General Counsel & Vice President, Regulatory
Key Capture Energy

Jason Houck
Policy & Regulatory Affairs Lead
Form Energy, Inc.

John Mulder
Vice President - Sales
Volta Power Systems

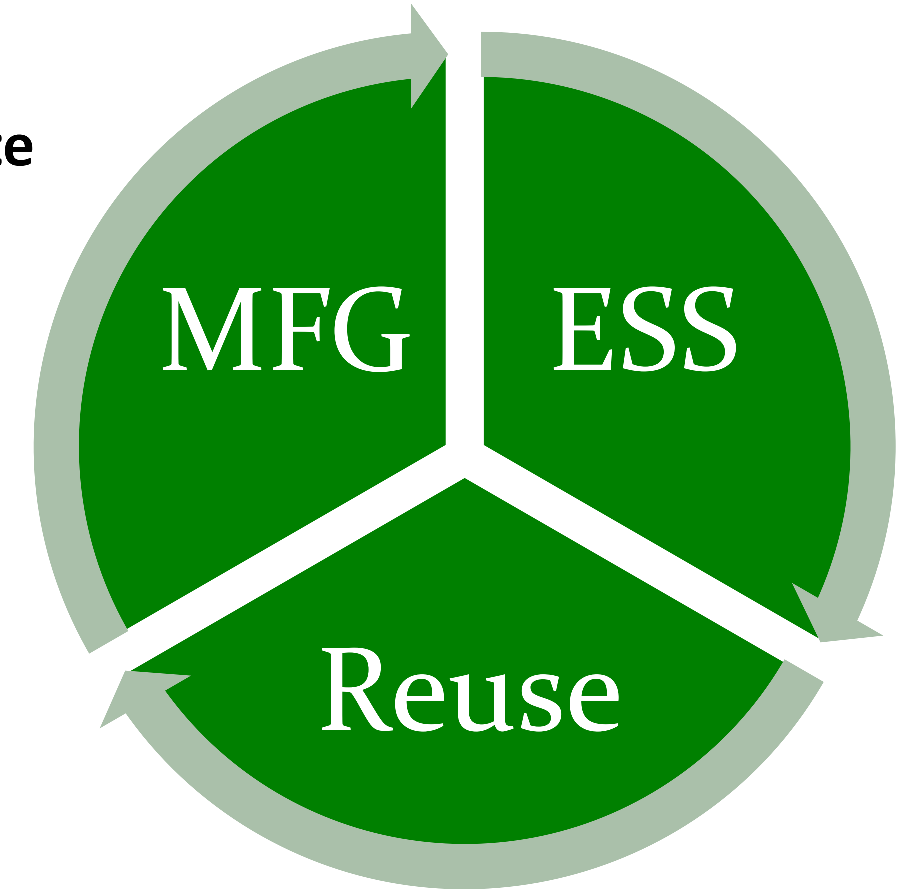
Kevin O'Connell
Advanced Energy Systems Manager
Michigan CAT & MacAllister Machinery

Reed Shick
Director of Research Development
Advanced Battery Concepts

INTEGRATED ELECTRICAL STORAGE SITE

- Integrated Energy Storage has a realistic path to achieve $0.02/kWh-cycle in an Evergreen facility
- Makes Renewable + Storage Lowest Cost Energy
- Anticipate Manufacturing and Storage at Single Site
- Support "Green" Storage
  - 100% Reusable/Recyclable
  - Safe in and around communities
  - Domestically Sourced
- Integrated ESS with Renewable Energy as Reliable Primary Energy Producer
- Integrated ESS to be able to enter PPA With Grid Providers
- Integrated ESS to be able to Sell to Whole Sale Market MISO

GreenSeal® Integrated Energy Storage Site



New Innovations in Thermal Storage: Maximizing the Benefits of Non-Traditional Storage

Eric Rehberg

Chief Engineer

Armada Power

armada POWER

New Innovations in Thermal Storage

Maximizing the Benefits of Non-Traditional Storage

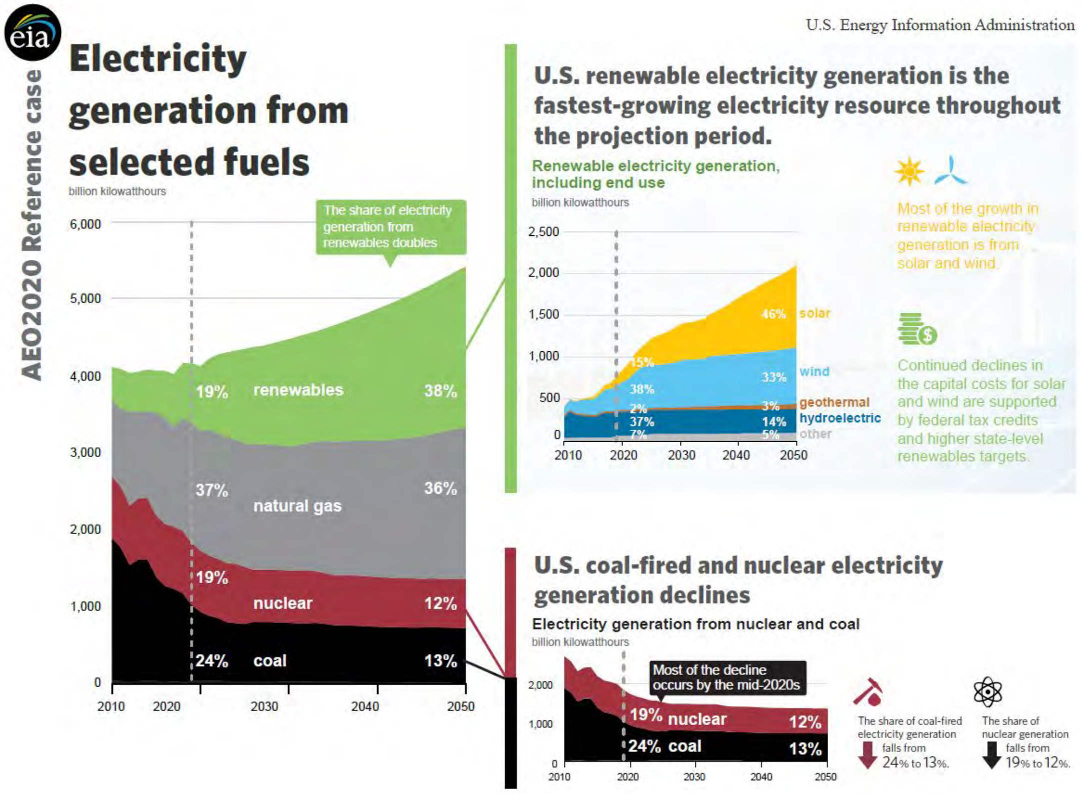
Speaker Intro

Eric Rehberg

Chief Engineer, Armada Power

- 15+ years energy industry experience
- 14 patents
- American Electric Power - R&D Engineer
- Battelle Memorial Institute - Principal Engineer
- Licensed professional engineer in the State of Ohio
- The Ohio State University: BS in Electrical and Computer Engineering

Generation Landscape Changing Fast



The need for low-cost energy storage to support renewables is growing

- The deployment of low-cost energy storage will increase the rate of renewables adoption - further increasing the need for low-cost storage
- Maximizing thermal storage along with electrochemical batteries creates hybrid benefits
- Flexibility to support different regulatory models is key

Storage is:

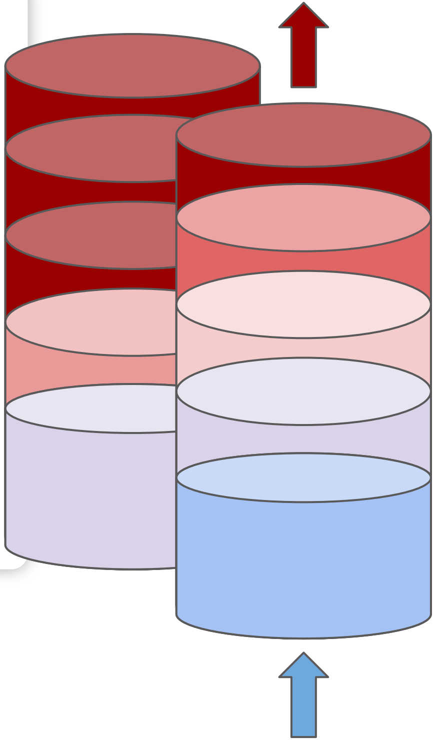
Most obvious and most fundamental is that energy storage is both an electricity resource (i.e., acts like generation) and a load (i.e., consumes electricity). This unique ability to act as either a generator or a load yields a very flexible asset that challenges traditional regulatory definitions and grid operating philosophies. This same flexibility makes energy storage valuable to investors, utilities, grid operators, and end-use customers due to the many services it can potentially provide. This flexibility also makes storage a natural complement to other rapidly growing renewable energy assets such as solar and wind. However, utilizing this flexibility and integrating storage with traditional utility-controlled assets poses new challenges and introduces complexities into grid (SEPA/ESA ID#111 - Executive Summary | Utility Business Models for Grid Connected Storage.)

Thermal Storage - storage not a battery

- Using excess electricity for heating or cooling is the historic view of thermal storage.
- However, new technologies allow for thermal storage to be used for grid purposes.
  - Water heaters with **milisecond control**
  - Cold storage (Ice Energy)
  - Pre-heating with solar
  - Pumped Hydro
- Lowest cost way to store energy

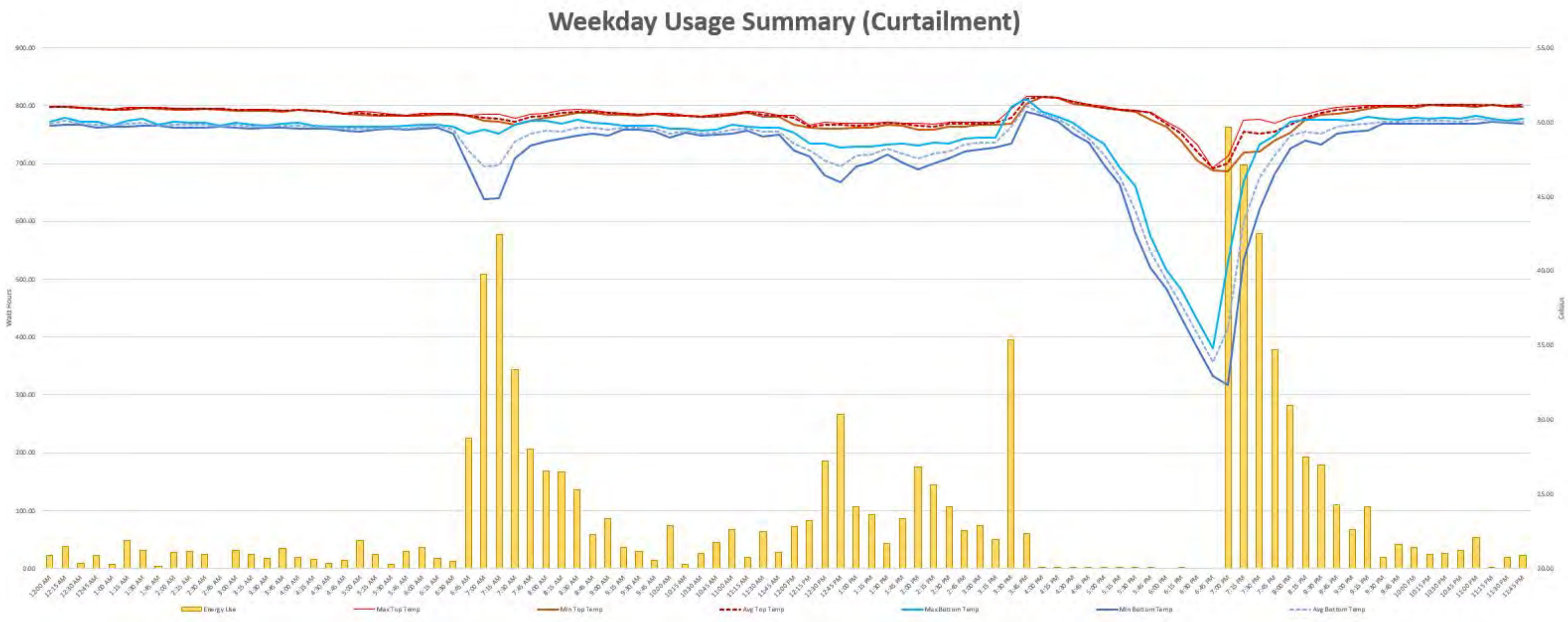
Why Water Heating?

- Second largest residential load
  - 17% household energy use[1]
- Underutilized existing asset
  - 40M+ electric WH in US[1]
- Non-invasive control (people don't notice)
- Fast millisecond response time



[1] U.S. Dept of Energy

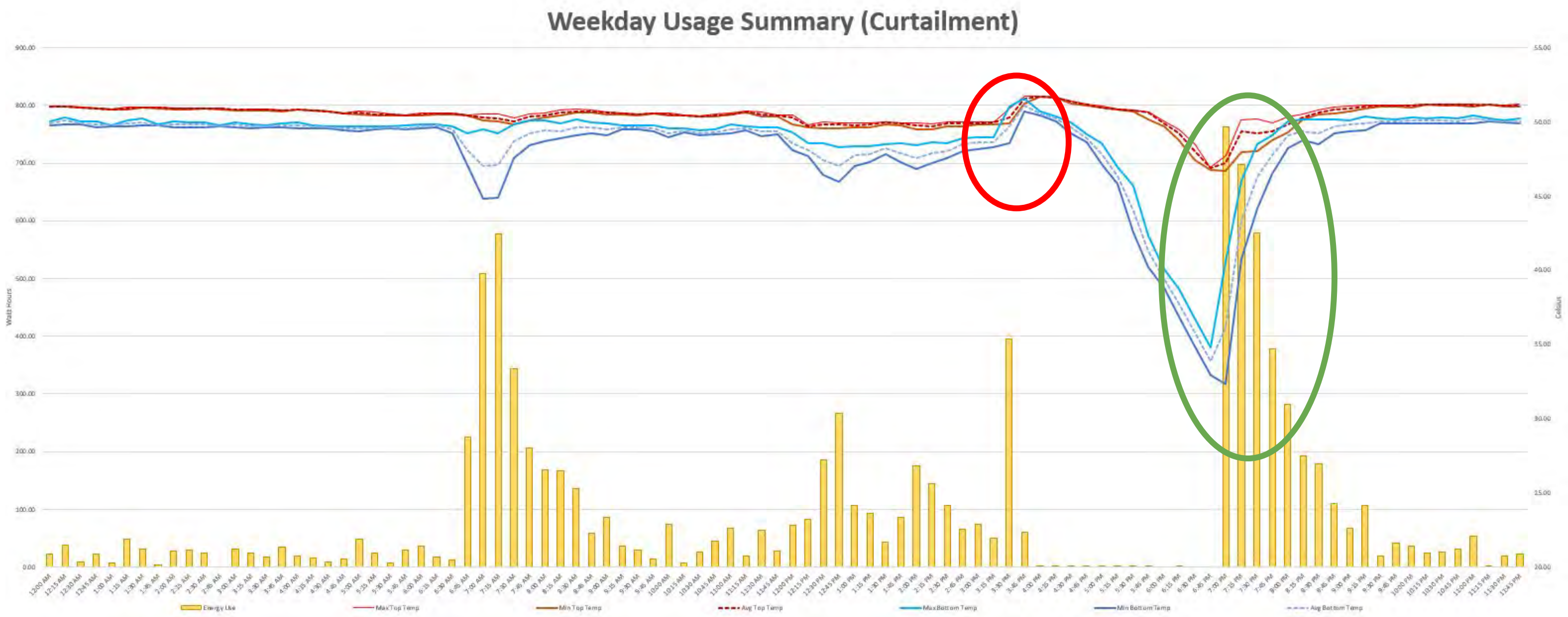
Daily Peak Avoidance



Demonstrated 3 and 4 hour TOU peak avoidance windows

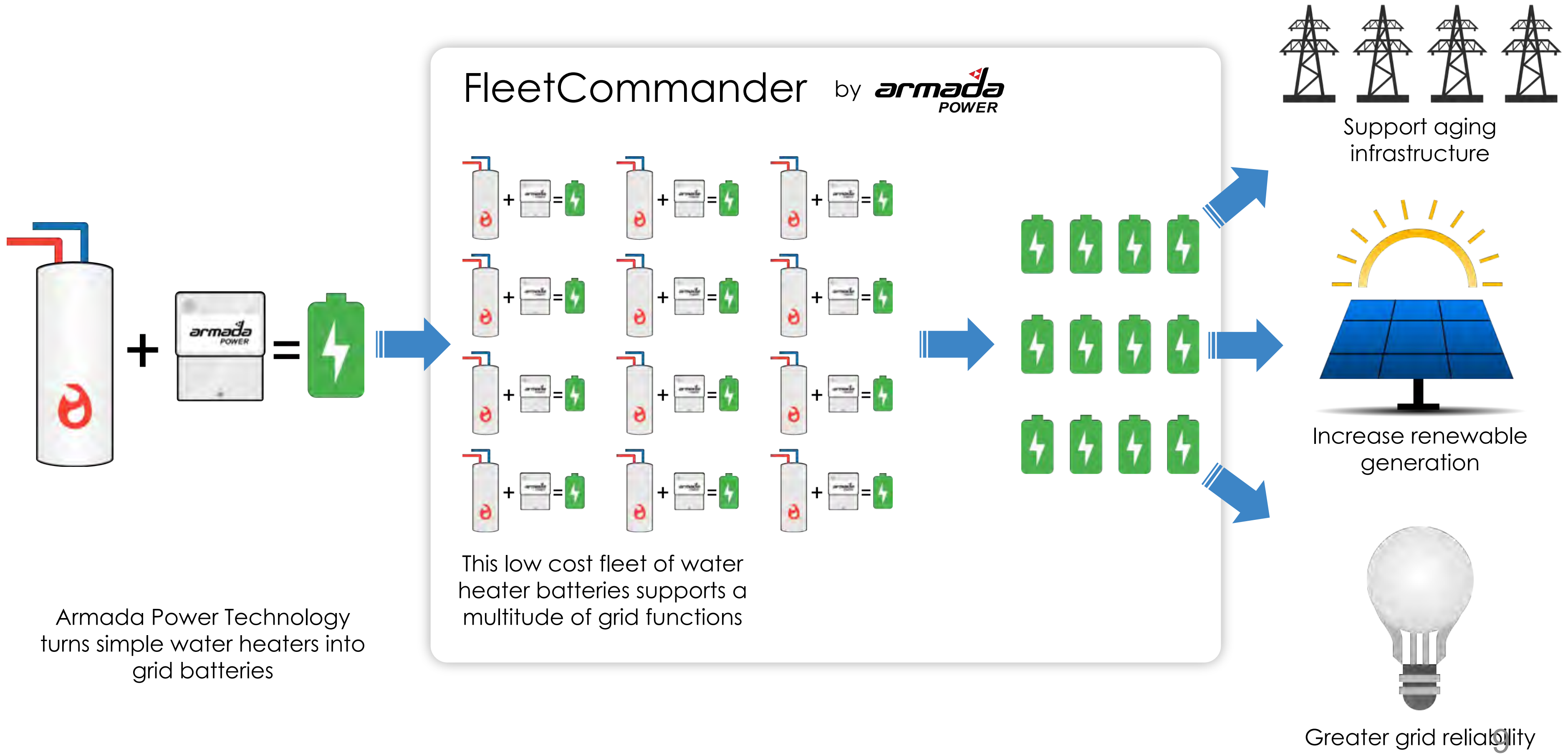
Combined with DR events as needed

Tank Optimizations



- Preheat to top of mechanical thermostat limit
- Fleet level rebound control to avoid setting later peak

Fleets of Water Heaters are Grid Resources



Grid Scale Impacts

Storage covers a broad value stack:

- Demand Response
- Time of Use Optimization
- Fast Frequency Regulation
- Renewables Integration
- Cold Load Pickup
- Droop Control
- Local Voltage Response

- Solar sponging
- Extends battery life
- Hybrid system of thermal plus electrochemical storage can enable new grid applications

armada POWER

Considerations for a good thermal storage program

Strong cybersecurity countermeasures

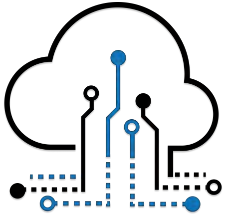
Quality data for measurement and verification (revenue grade)

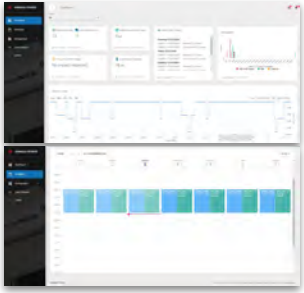
Algorithms and sensors to preserve customer comfort

Utility grade hardware with long life components

Utility control of alternative storage versus a battery - is the storage there when it is needed?

Can fast responding thermal storage be used to augment batteries and extend the battery life?





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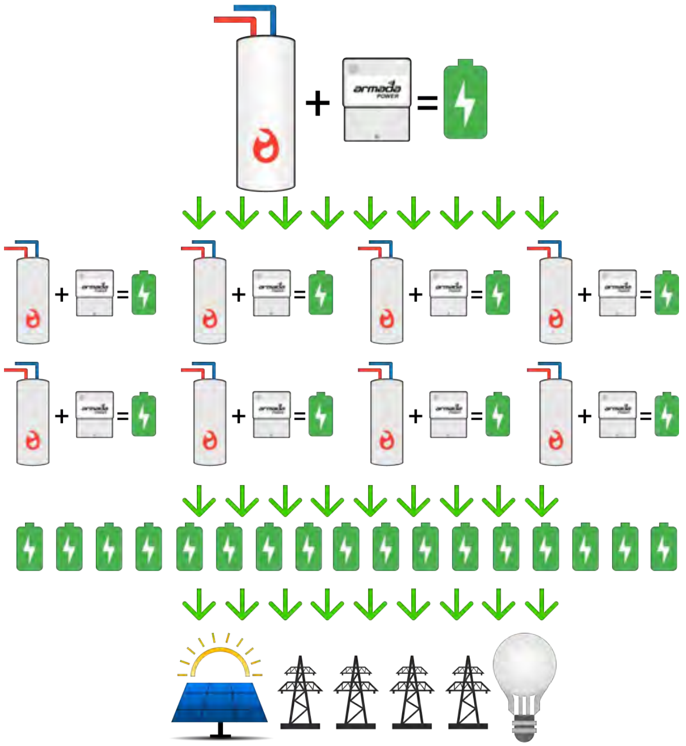
Regulatory consideration of thermal storage grid assets that are behind the meter

- Thermal Storage needs to be defined under FERC Distribution Plant, Distribution Station Equipment or Software definitions for accounting purposes.
    - Can a behind the meter technology be utility owned for grid function?
- Program options for a utility to use utility owned/subscribed software to aggregate customer owned storage.
    - A software solution with a PSC approved customer enrollment program where the customer gives the utility the device control.
    - It's important the utility have the control to ensure the storage is there when needed rather than voluntary. That separates storage from DLC or DR programs.
- Separate storage functionality from energy efficiency.
    - Thermal storage uses through HVAC, water heaters, etc. are different from energy efficiency.

Final Points

- An all renewable grid is going to need storage - a lot of storage
- Batteries are going to be key, but they could use some help with controllable load
- Thermal storage options like water heaters are an excellent controllable load
- Controls need to be secure, have quality data, and algorithms that manage both customer comfort and grid needs




THANK YOU
eric@armadapower.com

MI POWER GRID

Making the Most of Michigan's Energy Future

New Technologies and Business Models

Closing Comments

Stakeholder Meeting 5: Storage

March 24, 2021

MPSC

Michigan Public Service Commission

Thank You and Please Stay Engaged!

- Thank you for your participation
  - Share your thoughts through:
    - Meeting survey
    - Meeting chat
      - Remains open for comments or discussions after meeting.
      - Easier to access with the Teams App
    - Stakeholder comment section of workgroup website
      - Send a document to be posted to the comment section via email to Joy Wang at WangJ3@Michigan.gov
- Please stay engaged
  - Sign up for the listserv if you have not already
    - Go to MI Power Grid New Technologies and Business Models workgroup page
    - Scroll to bottom to add email
  - Attend future meetings
    - Next meeting on April 7 from 1 – 5 PM
    - Topic: Combined Heat and Power
  - Speak at a future meeting
    - Limited slots available for stakeholder input/experiences
    - If interested, email: Joy Wang at WangJ3@Michigan.gov

Thank you!