Powering positive change

The Hatch H.G. Acres symposium

April 15-16, 2025 | Hotel X, Toronto, Canada

Your guide to the event: Scan the QR code for speaker bios, topic previews, and the complete agenda

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#Poweringpositivechange #HatchSymposium

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Power packed technical tutorial – Energy storage

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Electrical Engineer, Hatch

Agenda

1	Energy Storage Technologies	*45 mins*
2	BESS Suppliers	*20 mins*
3	Break	
4	BESS Use Cases & Project Considerations	*45 mins*
5	BESS Operations & Maintenance	*20 mins*
6	Discussion	

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Safety Share

Electric Scooter & E-Bike Safety

- These batteries are highly **mobile** and **do not include advanced management systems** like what we will be discussing today. Prone to damage and exposed to elements
- Safety Tips (per NFPA):
  - Only use batteries and devices that are listed by a recognized testing lab and labelled accordingly (UL/ULC 2272, CSA).
  - Do not overcharge
  - Only use charger that came with battery
  - Keep at room temperature when possible, do not charge below 0C or above 40C
  - Store away from exit doors and anything that can catch fire

C US c LISTED

Electric Scooter & E-Bike Safety

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Experience Across All Phases of BESS Projects

Australia-Asia PowerLink Project Delivery Team
Sun Cable, Australia

BESS as Non-Wires Solution for HVDC Line Reliability
Confidential, USA

Utility Battery Study, St. Lucia Electricity Services Ltd. and St. Vincent Electricity Services Ltd.
Rocky Mountain Institute – Carbon War Room, Saint Lucia

Feasibility Study and Owner's Engineer
Yukon Energy Corporation, Canada

Bid Preparation Support and Preliminary Engineering for IESO ELT1 & LT1 Projects
Various Clients, Canada

Owner's Engineering Services for Iron-Air Battery Pilot Project
Form Energy/Great River Energy, USA

Technical Due Diligence, Grid-connected BESS Project
Confidential Client, USA

Owner's Engineering
Brookfield Renewable Partners

Inuvik BESS OE and Microgrid Controller Supply
Northwest Territories Energy, Canada

CONCEPT | FEASIBILITY | ENGINEERING | CONSTRUCTION | OPERATION

Owner's Engineering
GigaStorage, Belgium & Netherlands

Renewable + BESS Prefeasibility Studies for Remote Canadian Indigenous communities
Various, Canada wide

Standards Development for High Penetration Renewables
Newfoundland & Labrador Hydro, Canada

Independent Engineering Review of 35 MW Pre-Construction Grid-Tied BESS
Confidential Client, Chile

Summerside Sunbank Project: 21 MW Solar + 10 MW/20 MWh Battery Storage Microgrid, Detailed Engineering
Aspin, Kemp and Associates & The City of Summerside, Canada

2 MW/8 MWh Flow Battery Installation, Preliminary Engineering, Bid Package Development, and Engineering Cost Estimate
Lindsay Storage LP, Canada

Battery Energy Storage Subject Matter Expert & Owner's Engineering Services
Saskatchewan Power Corporation , Canada

Battery Energy Storage System Procurement for 5 Remote Villages
Hydro Quebec, Canada

Raglan Mine Microgrid Feasibility Study, Detailed Engineering, and Operations Support
Tugliq Energy Co. and Glencore. Canada
Phase 1: 2012-2015, Phase 2: 2017-2019

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Energy Storage Technologies & Market

Basics & Terminology

ESS: Energy Storage System (**ALL** energy storage technologies)

BESS: **Battery** Energy Storage System (**Usually** refers to lithium ion only)

Batteries have both a **MW** (power) and **MWh** (energy) rating. Energy rating is dominant and they are **coupled** through the C-Rate relationship.

$$\text{C-Rate} = \frac{Discharge\ (or\ Charge) Rating\ (MW)}{Energy\ Capacity\ Rating\ (MWh)}$$

$$\frac{100\ MW}{200\ MWh} = 0.5\ \text{C OR C/2}$$

"2 Hour Battery"

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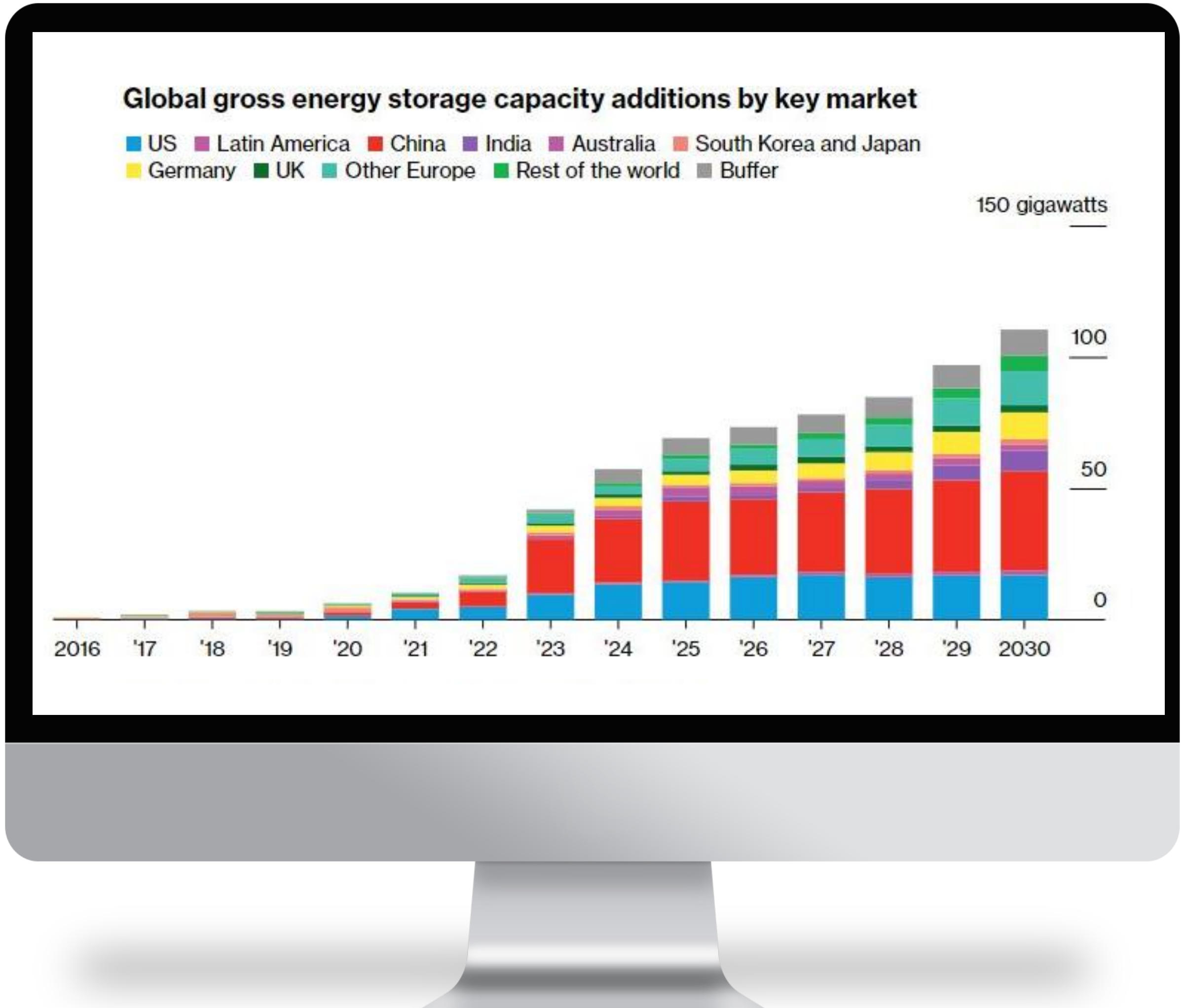
Global ESS Growth

- **175 GWh** of energy storage in 2024 (53% growth)
- **1,900 GWh** expected by 2030
- Key markets:
  - USA
  - China
  - Europe

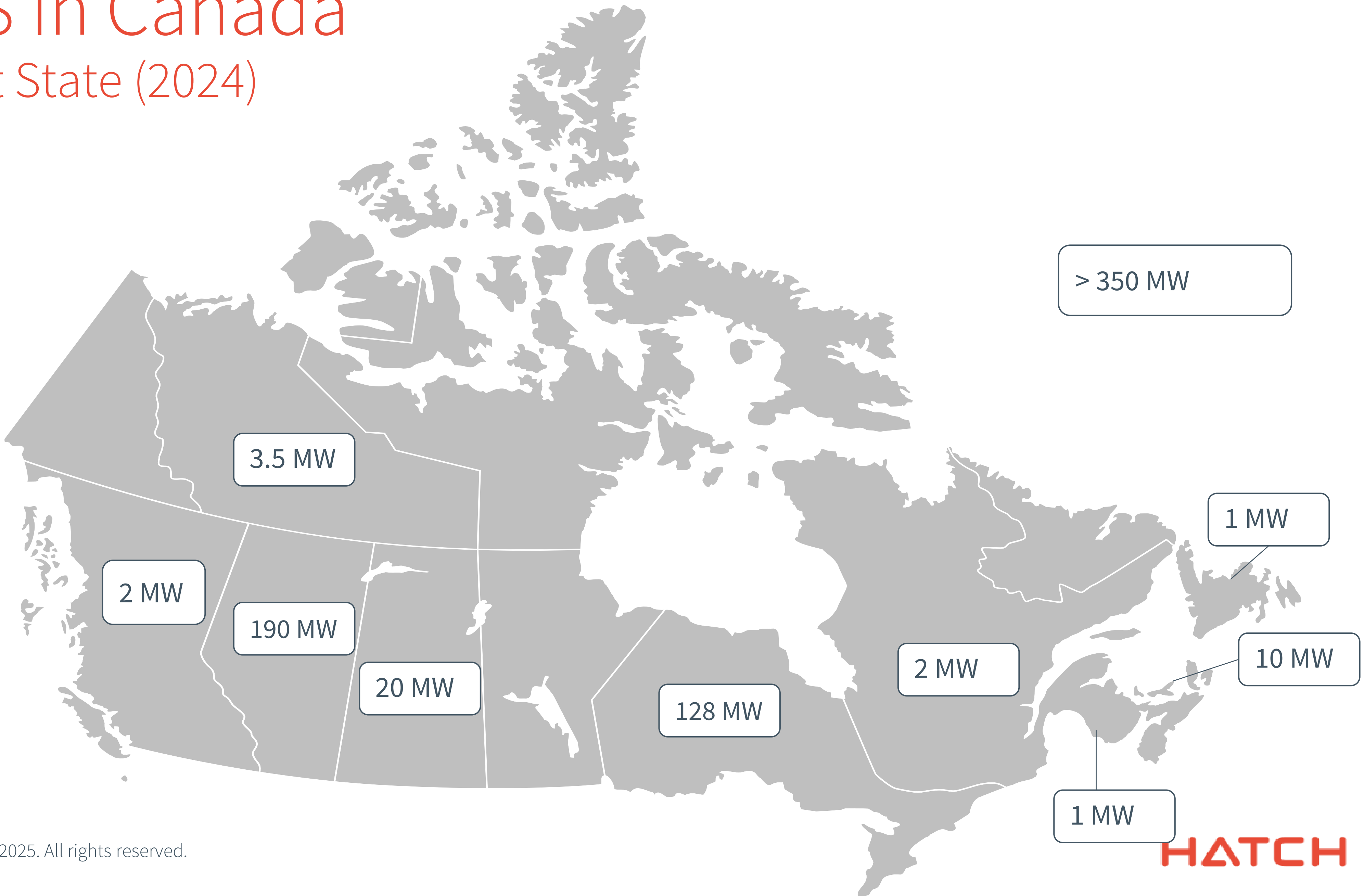
90%



[2H 2023 Energy Storage Market Outlook | BloombergNEF (bnef.com)]

BESS In Canada

Current State (2024)



Drivers for Growth

- Increasing global electricity demand and widespread **electrification**
- Increased **renewable integration** and focus on decarbonization
- **Value stacking** is becoming increasingly possible
- **Declining Costs** driving competitiveness
- Li-ion Battery technology readiness is **established**

Types of Energy Storage Technologies

Gravitational Storage
- Pumped Hydro
- Tower building crane
- Advanced rail car

Thermodynamic Storage
- Compressed air
- Liquid air
- Compressed CO_2

Electrochemical Storage
- Lithium-ion batteries
- Flow batteries (redox)
- Metal-air batteries

Thermal Storage
- Solid state
- Phase change material
- Molten salt

Chemical
- Hydrogen
- Ammonia

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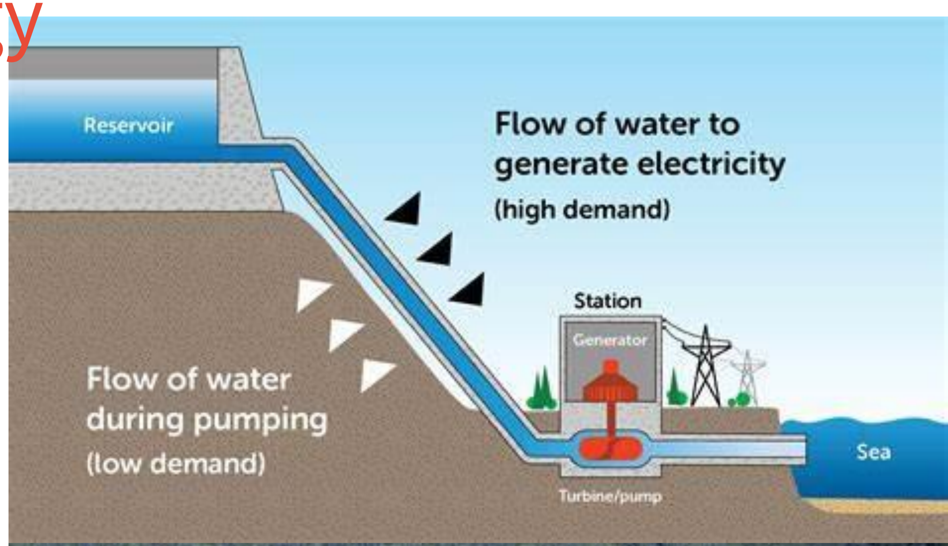
Pumped Hydro
The “original” energy storage technology

Key Characteristics	
Efficiency	Moderate
Storage Duration	Months+
Electrical Response	Slow responding
Construction	Intensive
Technology	Fully commercialized
Highly geographically dependent, extensive permitting & environmental	



Lithium-Ion Batteries

Fastest growing ESS technology

Key Characteristics	
Efficiency	High
Storage Rating	Hours (~8 hours)
Electrical Response	Rapid responding
Construction	Modular, simple
Technology Readiness	Fully commercialized
Degradation considerations, temperature management focus, fire risk	

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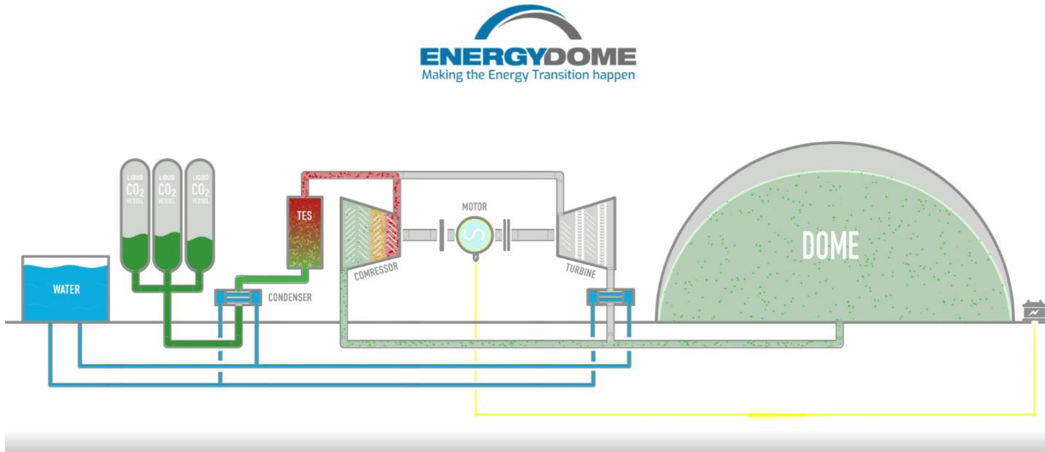
Flow Batteries
Liquid-based long duration storage

Key Characteristics	
Efficiency	Moderate
Storage Rating	6-24 Hours
Electrical Response	Moderate speed
Construction	Modular or “plant”
Technology Readiness	Commercialized suppliers
Environmental considerations, limited bankable suppliers	

Compressed Gas
Gas-based long duration storage

Key Characteristics	
Efficiency	Low
Storage Rating	6-24 Hours
Electrical Response	Slow
Construction	Centralized plant
Technology Readiness	Leverages proven equipment
Complex maintenance, can be coupled with thermal storage	

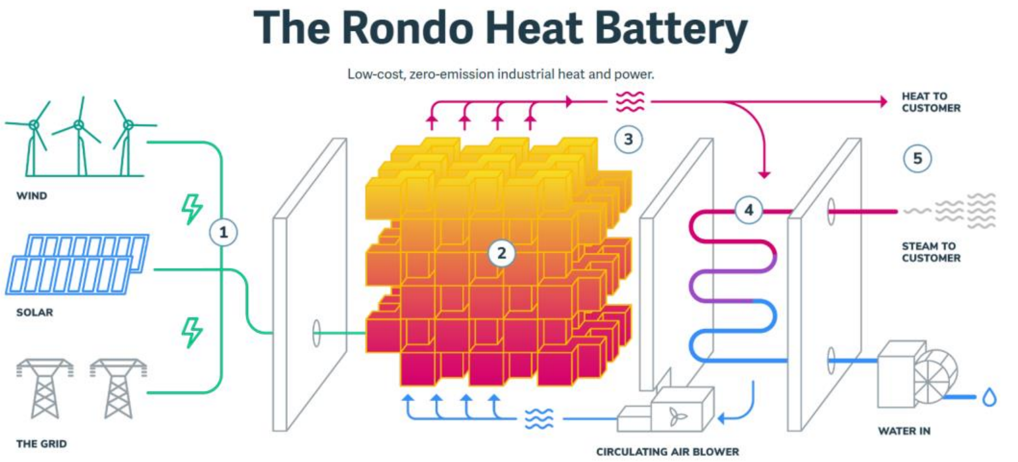


Thermal Storage

Ideal for heat-only storage

- Molten Salt
  - Technology leverages molten salts to store heat from excess electricity
- Solid State
  - Stores heat in solid state materials (ceramics, bricks, salt, sand, etc.)
  - Advantages are simpler materials handling; heat transfer may be poorer
- Phase Change Material
  - Emerging technology
  - Leverages energy released during phase change
- Applications:
  - Industrial processes
  - District heating

Molten Salt Tanks

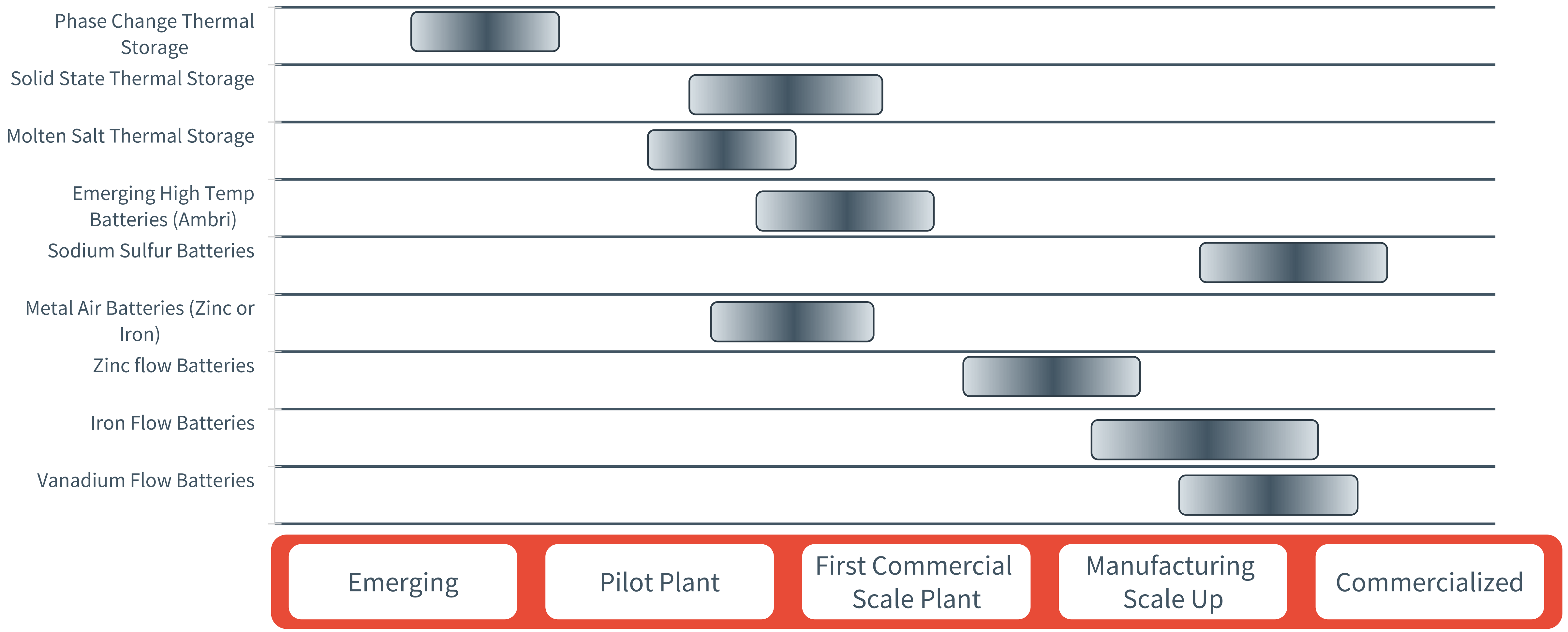


Alternative Metal Batteries

Focus on low-cost metals, emerging “LDES”

- Sodium-Sulfur, Iron-air, Zinc-air
  - Focused on **oxidization and reduction** of key metal
  - Complex mechanical systems: Pumps, scrubbers, hydrogen management, high temperature heaters, etc.
- Aiming to be **Long Duration Energy Storage** key players
- Developing technologies, many in pilot phase

Non-Lithium Technology Development



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Lithium-Ion Batteries 101

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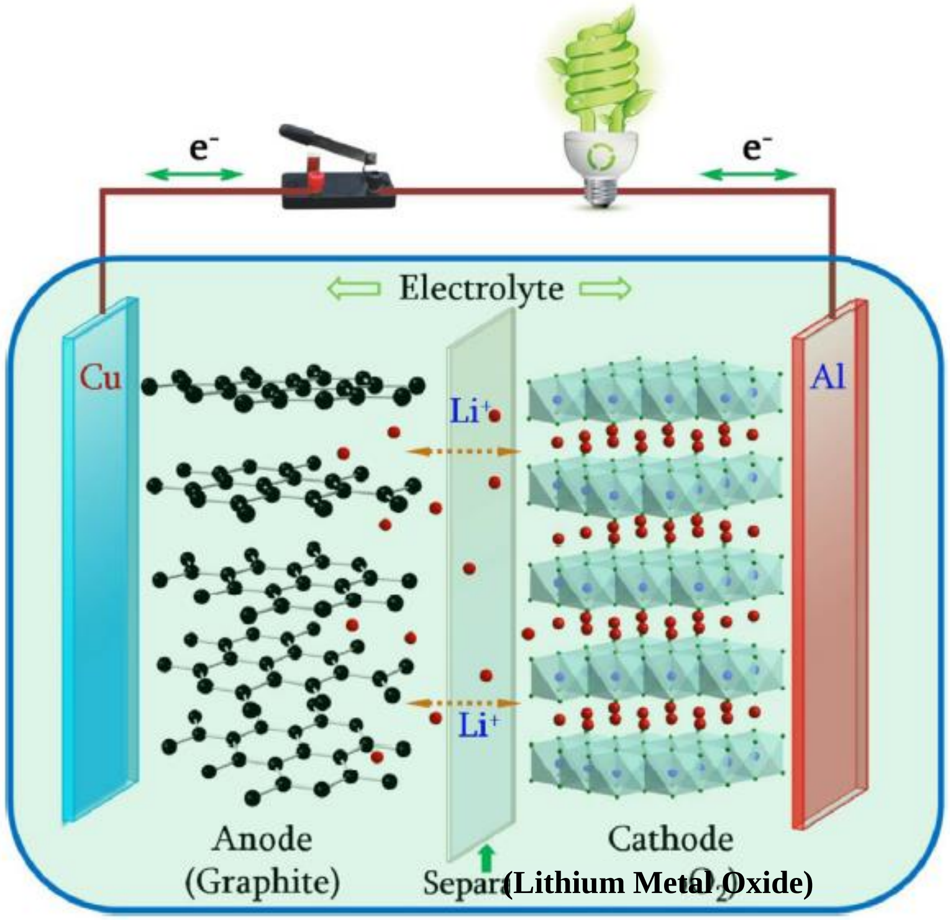
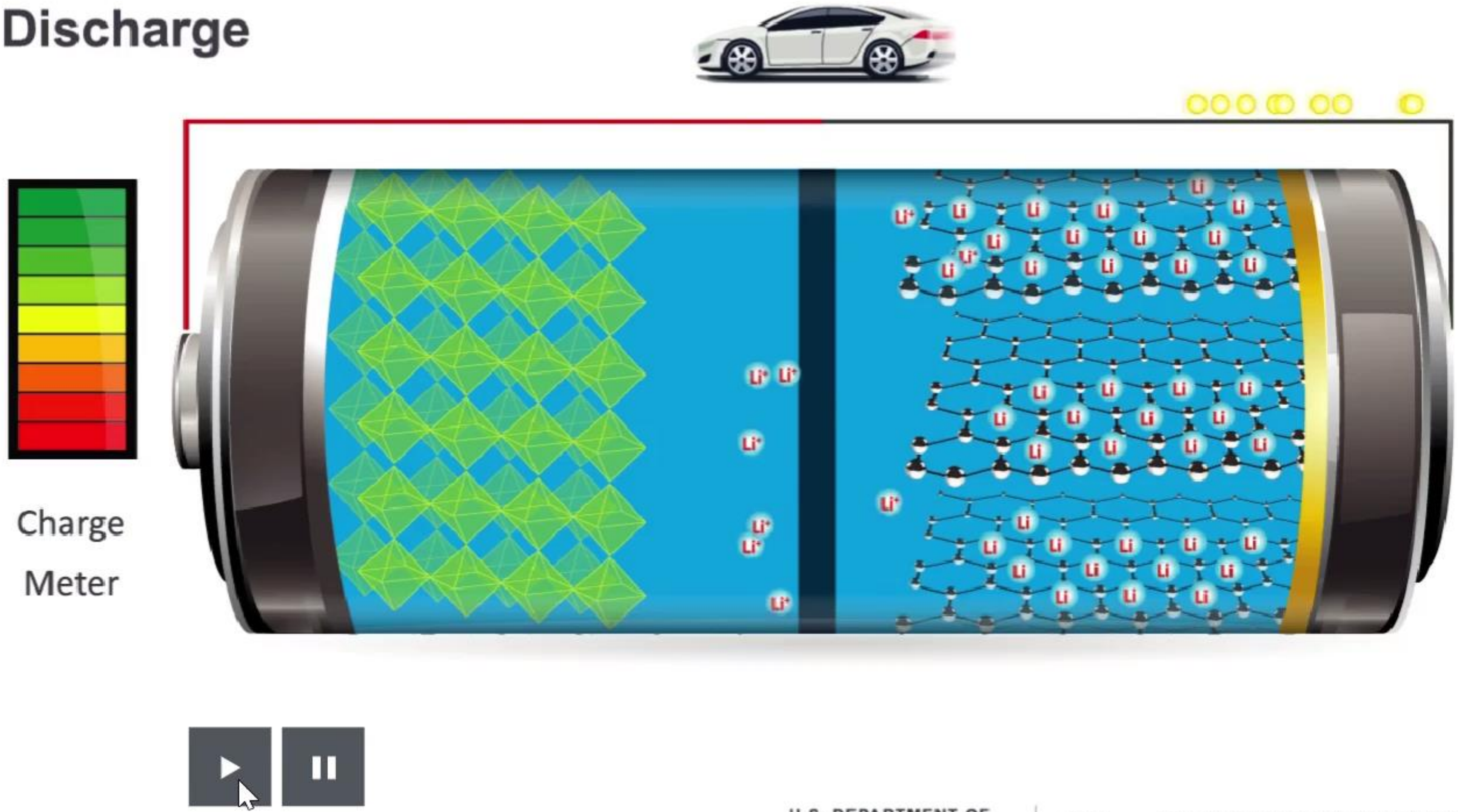
The Storage Mechanism

Unique Features of Li-Ion Batteries

- Lithium is the active material for both electrodes
- Insertion reaction where lithium is inserted into the layered electrodes
- During charging lithium is inserted into the graphite electrode
- During discharging lithium is inserted into the metal oxide electrode



Discharge



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Common Li-Ion Chemistries

Electrodes

Lithium Cobalt Oxide (LCO)	Lithium Iron Phosphate (LFP)	Lithium Manganese Oxide (LMO)	Lithium Nickel Cobalt Aluminum Oxide (NCA)	Lithium Nickel Manganese Cobalt Oxide (NMC)
Original Electrode, less common with higher performing and more stable chemistries developed	Leading chemistry for stationary use cases & indoor installations	Early developed electrode material, niche applications today	Higher cost, but longer lifespan, higher performance	Moderate cost, and good performance, more common for EVs

Cathode Chemistry Comparisons

Consideration	NMC	NCA	LFP
Application	Tailored for high power or high energy systems. Tend to be more suited for energy applications.	Good energy and power capabilities. Tend to be more suited for power applications.	Good Power Capability
Materials	Nickel, manganese and cobalt	Nickel, aluminum and cobalt	Cobalt & Nickel Free
Footprint	**Highest** Energy Density	Moderate Energy Density	Lowest Energy Density
Safety	Modest thermal runaway temperature	Modest thermal runaway temperature	Higher thermal runaway temperature (Safest)
Lifespan	Lower cycle life	Moderate Cycle life Long Calendar Life	Longest cycle life
Suppliers	More common in EVs. Historically had led stationary storage	Least Suppliers	Most Suppliers and leading stationary storage technology

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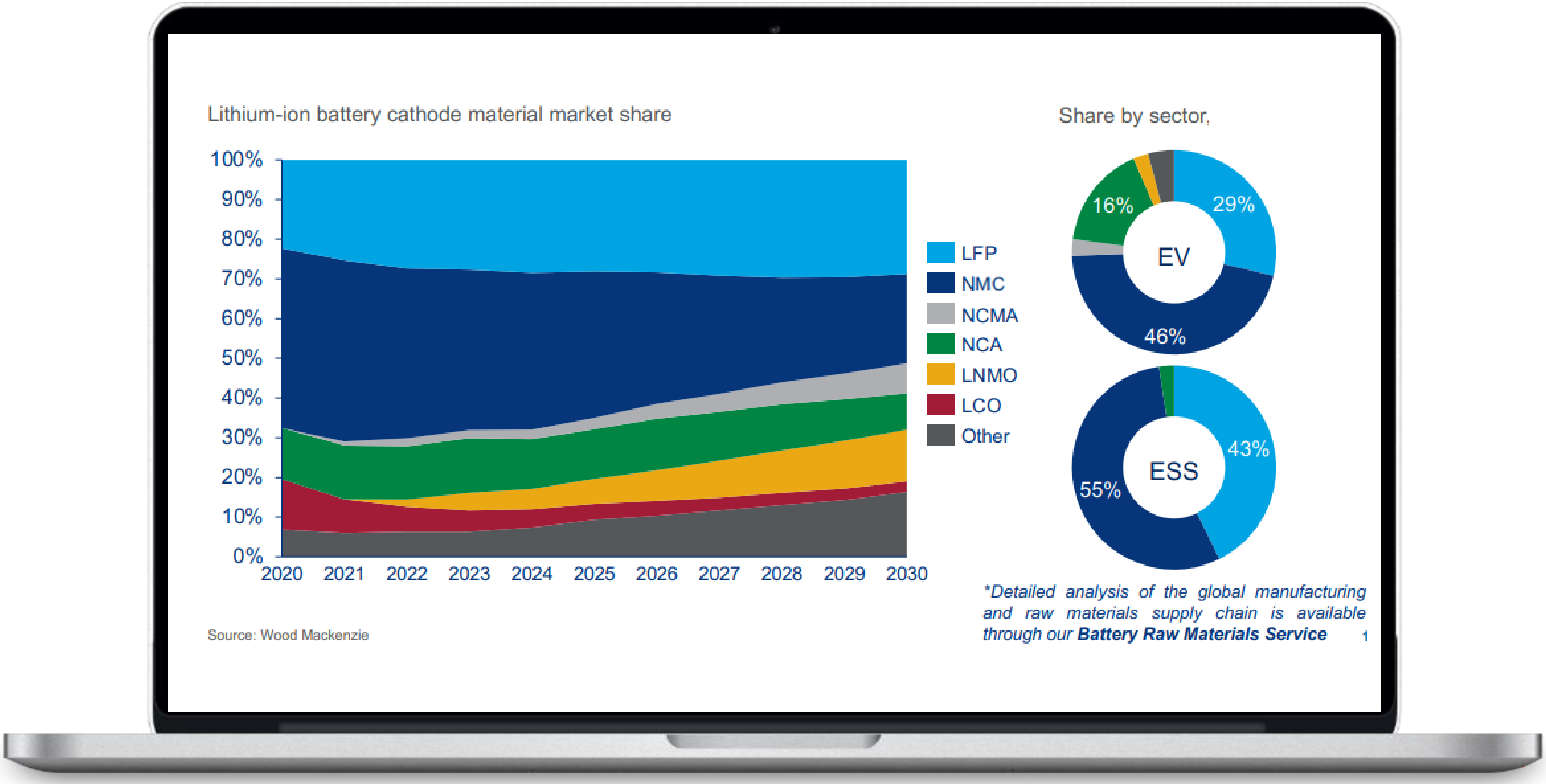
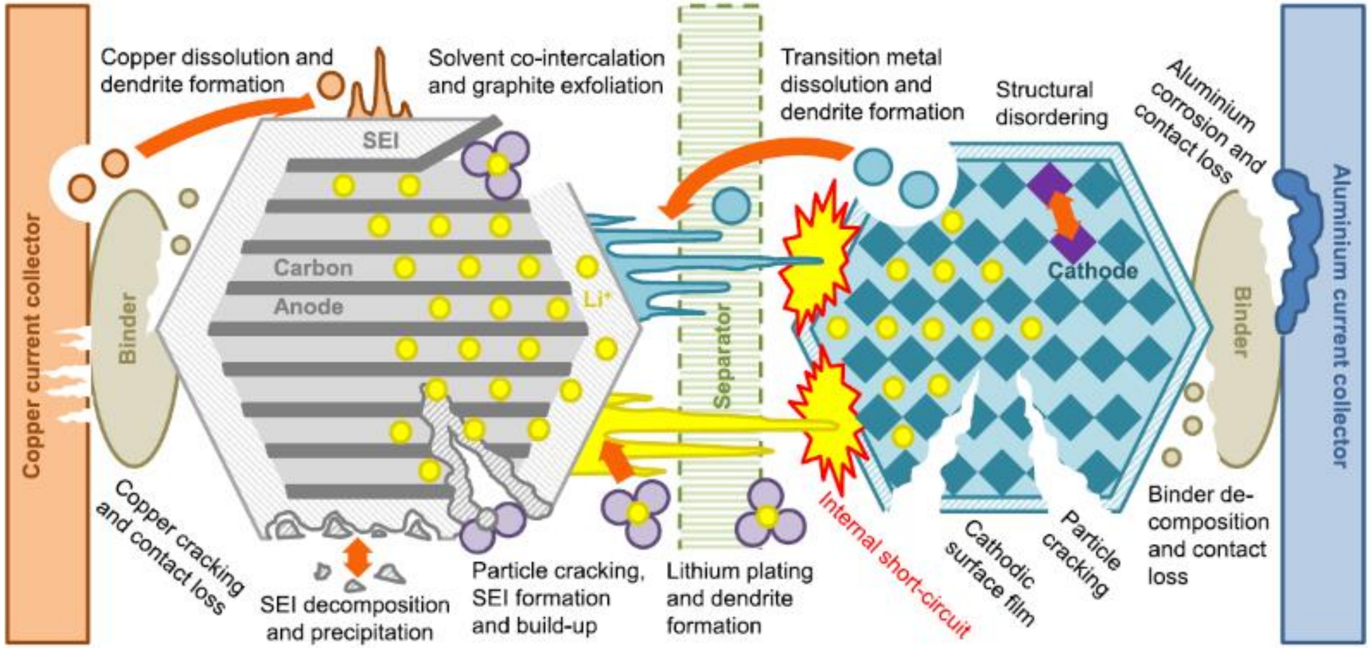
Lithium-ion Battery Types - Market Share



Li-Ion Battery Degradation

- Degradation is a function of chemical changes in the battery cells that reduce capacity and add resistance
- Over life of the battery, degradation reduces the energy that can be stored
    - Power is not affected
- Degradation is driven by many external factors
    - Calendar Aging
    - Cycling
    - Overbuild
    - Operating at high/low temperature
    - Overcharging/Overdischarging
    - High charging rate



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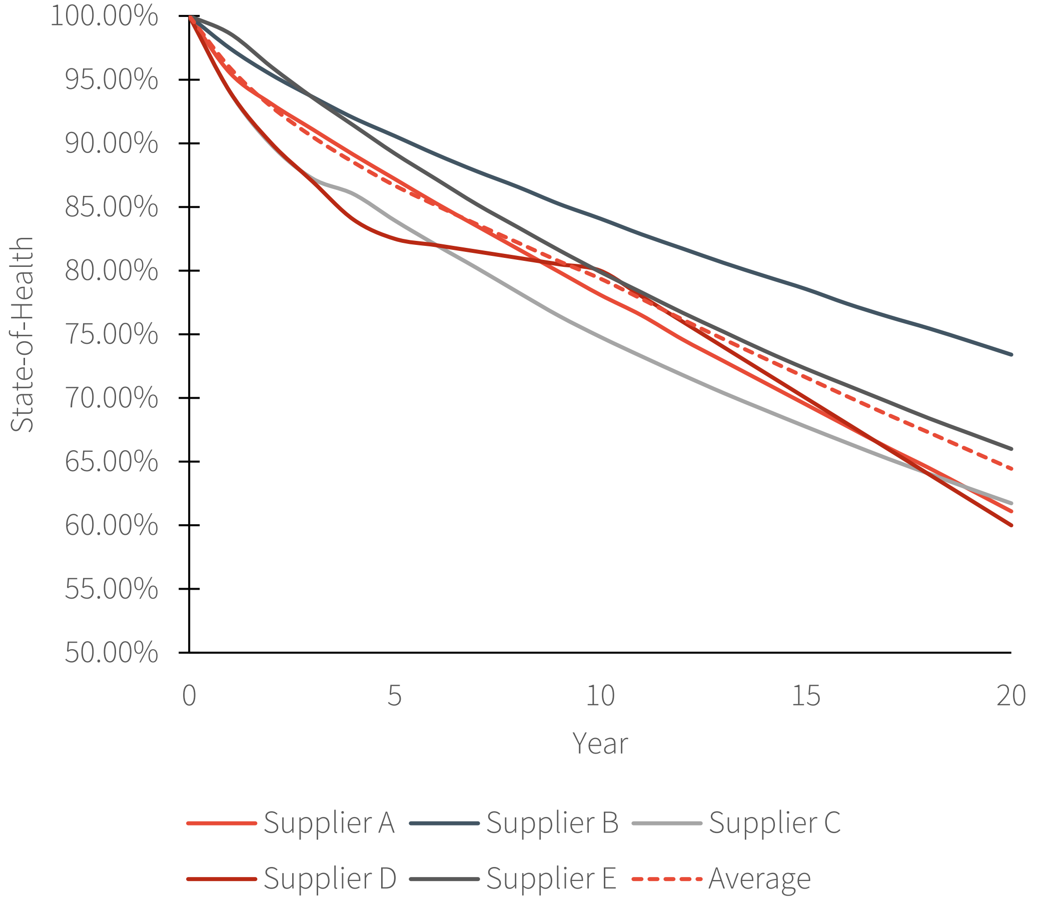
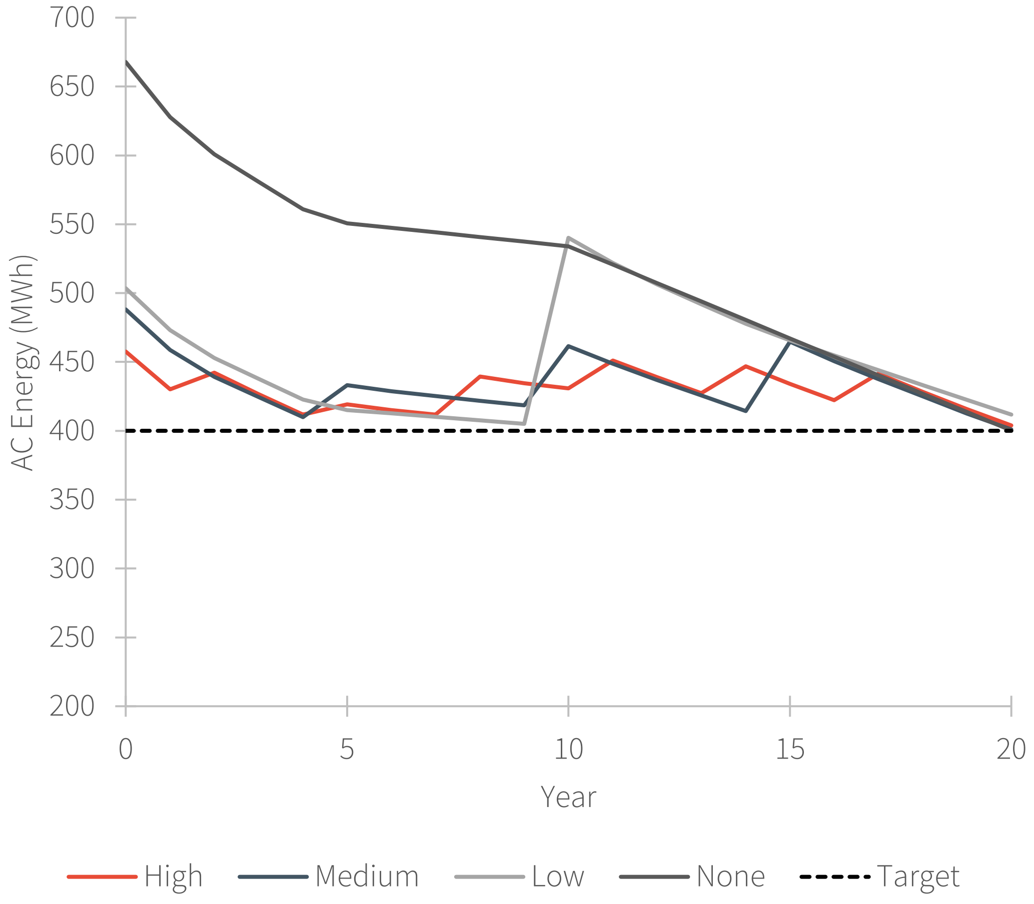
BESS Degradation Management



- Degradation varies from product to product
  - Between suppliers
  - Based on usage plan
  - Supplier’s data set
- Forecasted degradation is not always warranty degradation curve
- Degradation should be monitored annually (or semi-annually) to ensure it aligns with guarantees /forecast
  - Done through a controlled capacity check test

State-of-Health is the ratio of Available Energy and the initial installed energy

Augmentation Strategies



- Just-in-time augmentation
  - Tailor approach based on observed degradation
  - More complex due to continued construction
- Augmentation every 5 or 10 years
  - Balances initial CAPEX with sustaining CAPEX
  - Tailored to observed degradation
  - Requires some construction during operation
- No augmentation – 100% overbuild
  - Reduces risk and complexity of construction
  - Reduces uncertainty for future CAPEX
  - Overbuild may be conservative if degradation is less than predicted
    - May be insufficient if degradation is high
  - High CAPEX

BESS Components

Core Battery System Assembly

Individual Cell

Module

Cabinet/Container
Set Up

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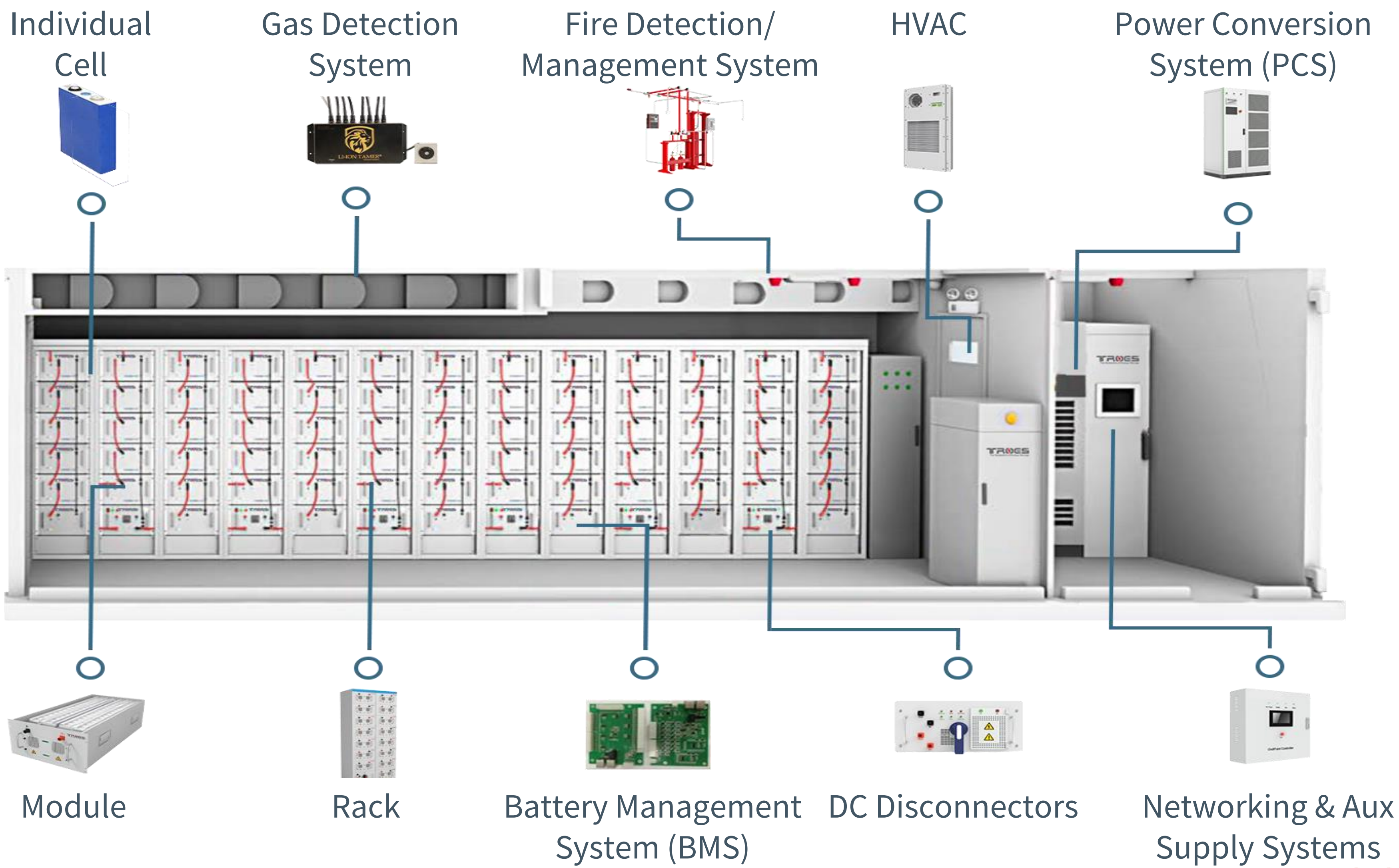
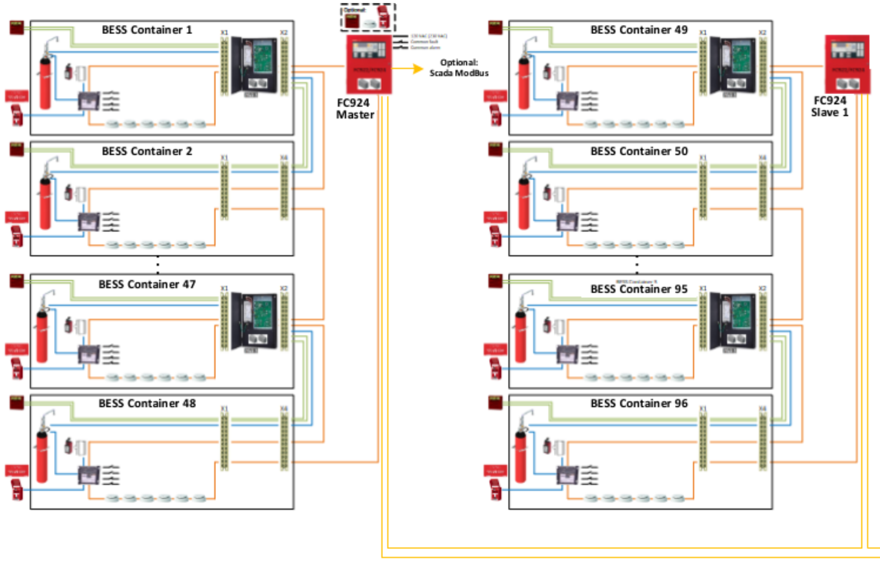
Key System Components



What is Battery Energy Storage? Inside the System Structure (troescorp.com)

Fire & Gas Detection/Management

- Safety critical subsystem that is **parallel to** BMS
- Fire safety is managed at the cell, module and enclosure level
- Often include:
    - Heat detection
    - Smoke detection
    - Hydrogen detection



APS McMicken Fire

- 2019 Fire at Arizona Public Services McMicken BESS
- Walk-in containerized design, with inert gas/clean agent fire suppressant
- Key Lesson Learned:
  - Reduce Risk of Cell-to-Cell and Module-to-Module cascading
  - Ventilation Systems:
    - Original Design turned Ventilation Systems OFF in thermal runaway
    - Created build up of flammable gas
  - Fire Suppression Strategies
    - Need continued cooling to stop thermal runaway
  - Emergency Response Planning

APS DNVGL Report 7-18-20a FINAL

Power Conversion System

- Main grid interface for BESS systems
- Often modularized (100 kVA to 1.5 MVA)
- Increasingly complex grid-interactive capabilities
- Solar inverter ≠ BESS inverter
- Max size ~5 MVA
- Integration considerations:
  - Reaction speed
  - Filtering, Overshoot
  - Harmonics
  - Microgrid control functions vs. primary inverter controls

EPC Power

ABB

Power Electronics

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What BESS Facilities Look Like

Operational 18 MWh facility,
0.3-0.5 hectares
1 football field

Operational 100 MWh facility,
1-1.5 hectares
2-3 football fields

500 MWh facility,
2-3 hectares
4-5 football fields

BESS Suppliers

BESS Suppliers vs Integrator

Supplier	Integrator
Full wrap manufacturer	Procures all items
Likely to partner with an PCS/MVT supplier	Integrates together
Standardize design	More customizable
Inhouse controller	Likely to outside controller
Less prominent in Canada	More prominent in Canada
Ex. Tesla, BYD, CATL,	Ex. Trugrid, Flexgen, etc

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BESS Suppliers vs Integrator

Key differentiators	Supplier	Integrator
Customizable		✓
Engineering Time	✓	
Schedule	✓	
Certifications	✓	
Easy Integration	✓	
Reduced Risk on Owner		✓
EPC Scope		✓

BESS Suppliers – Large Scale

- Powin
- LG Energy
- Gotion
- EVLO
- Fluence
- Alfen
- Cornex
- Tesla
- CATL
- BYD
- Wartsila
- Hithium
- Huawei/Fusion Solar
- Siemens
- Sungrow
- Mitsubishi

Key Drivers

Most vendors are working towards the same thing:

- Energy Density
- Grid Compliance Standards
- Fire Protection
- EMS offering

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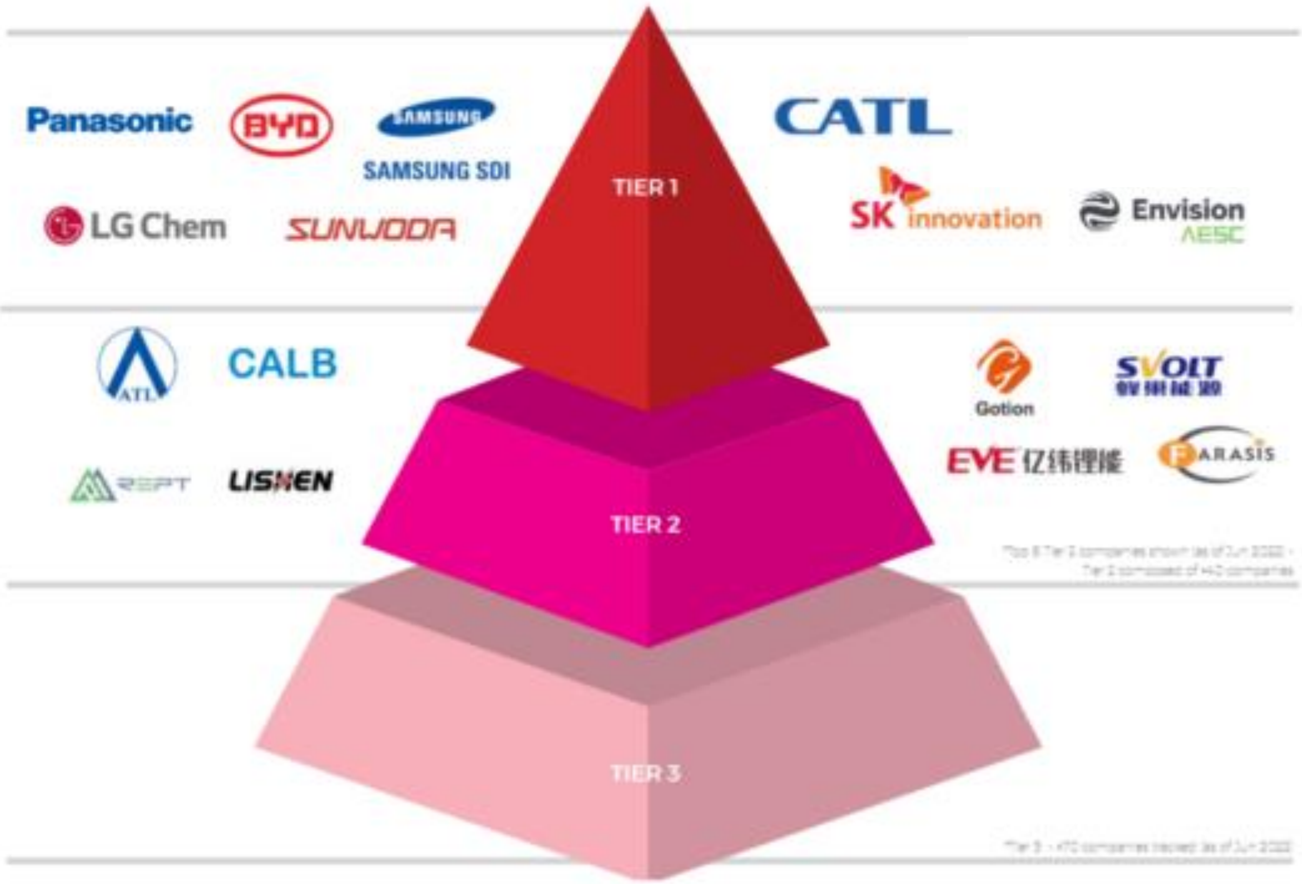
Cell Providers



[First homegrown European battery company to qualify as Tier One supplier - European Battery Alliance (eba250.com)]

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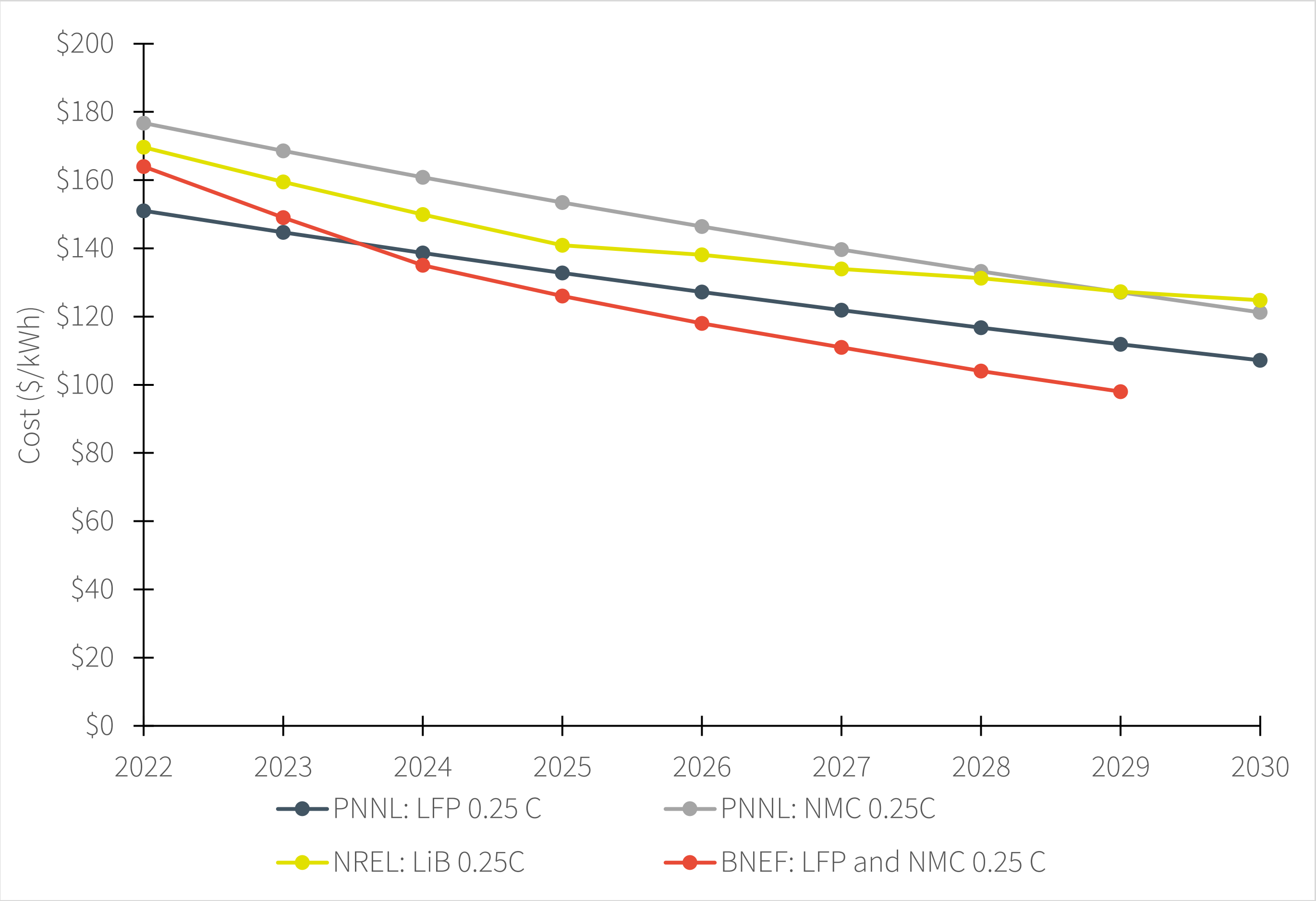
Li-Ion BESS Cost Benchmarks



Bloomberg New Energy Finance (BNEF)
(DC system, LFP & NMC)

- 2023: $149 USD/kWh
- 2026: $118 USD/kWh
- 2029: $98 USD/kWh

Pacific Northwest National Laboratory (PNNL)
(DC system, LFP)

- 2023: $145 USD/kWh
- 2026: $127 USD/kWh
- 2029: $112 USD/kWh

National Renewable Energy Laboratory (NREL)
(DC system)

- 2023: $160 USD/kWh
- 2026: $138 USD/kWh
- 2029: $127 USD/kWh

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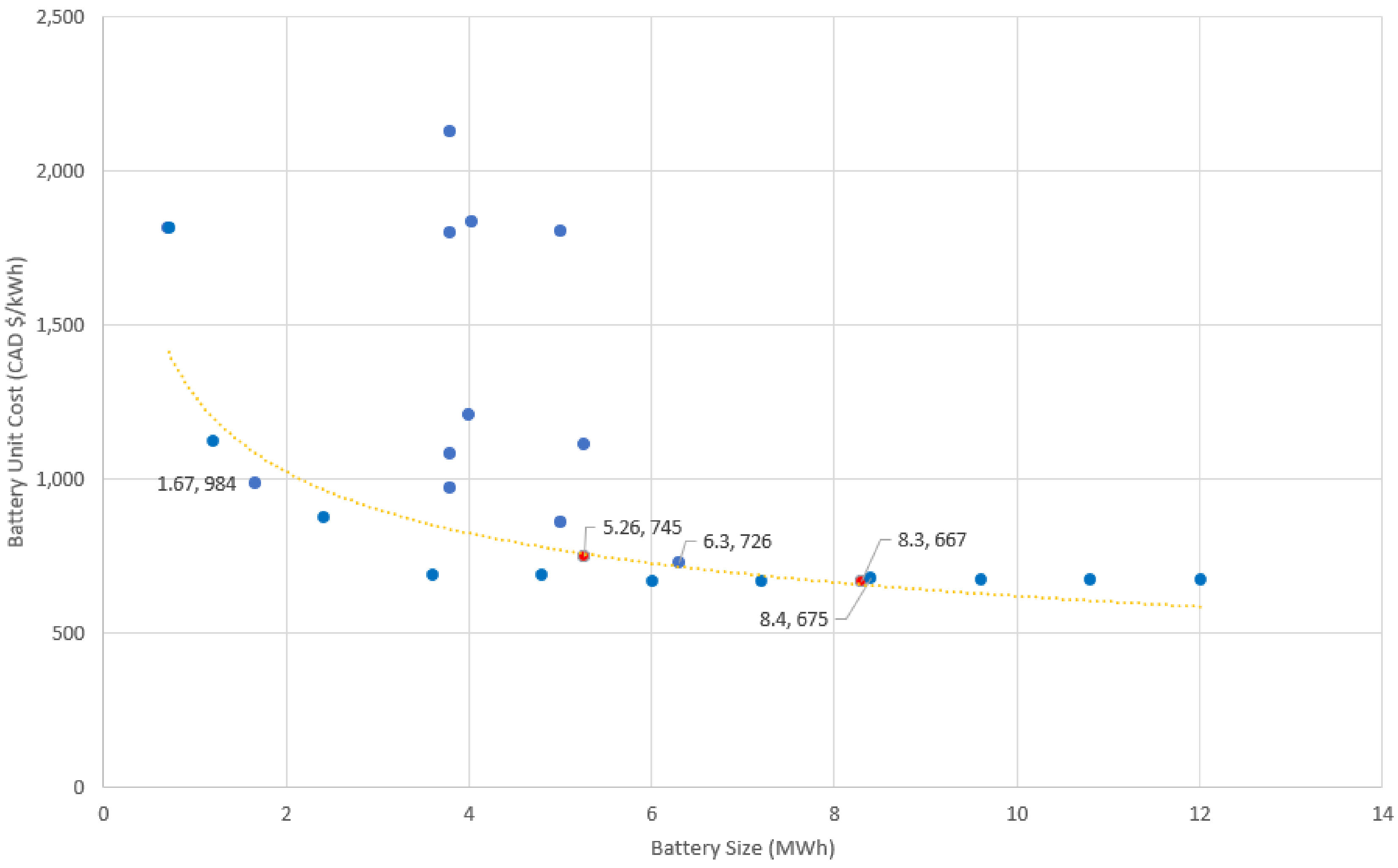
Li-Ion BESS Costs from Hatch Project Database



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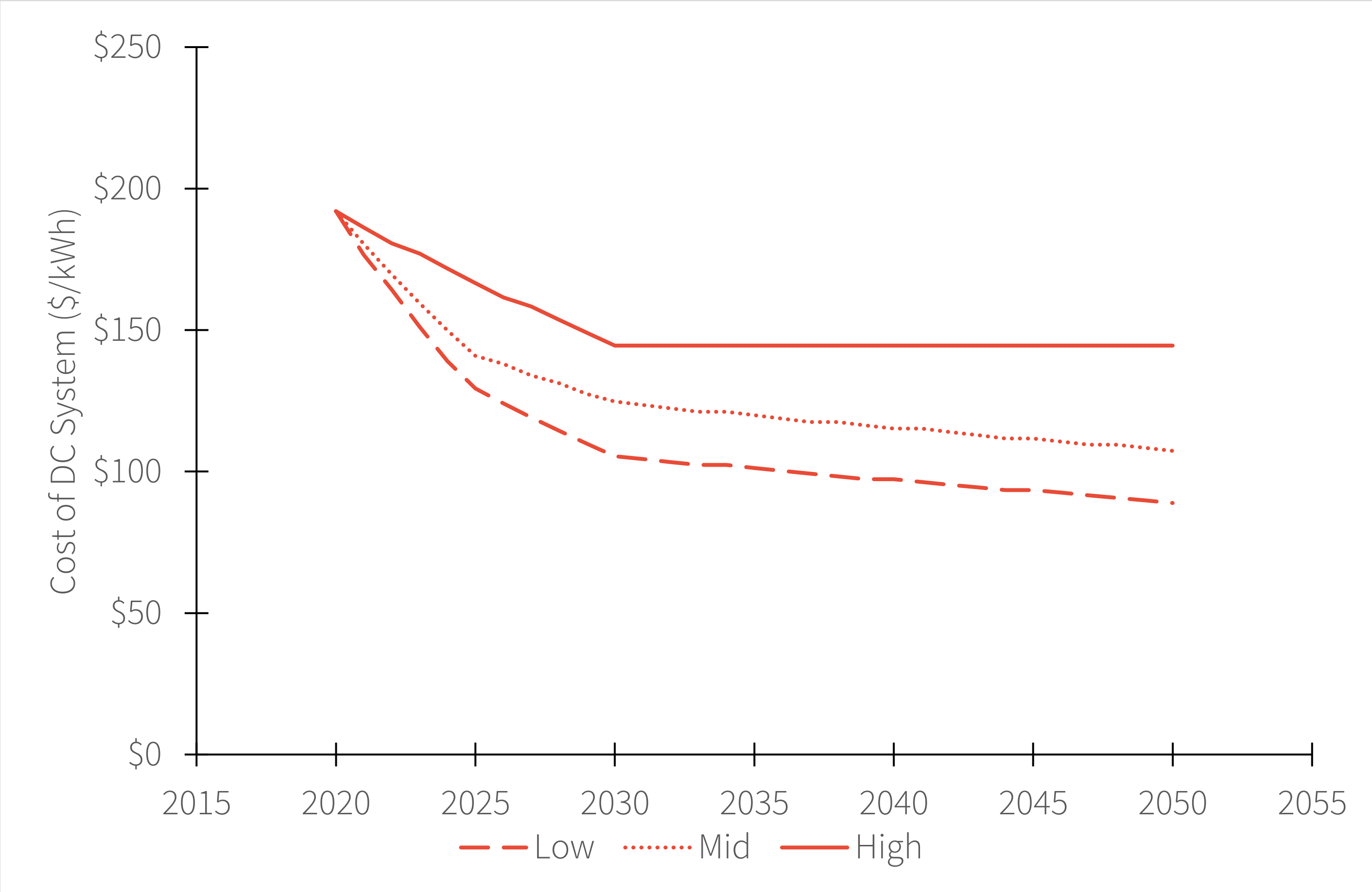
Li-Ion BESS Long Term Forecasts



NREL Energy Storage Cost Prediction
NREL Solar + Storage Cost Estimate

Beyond 2030:

- Low Scenario Costs: $90 - $110 USD/kWh
- Costs expected to decline at significantly slower rate

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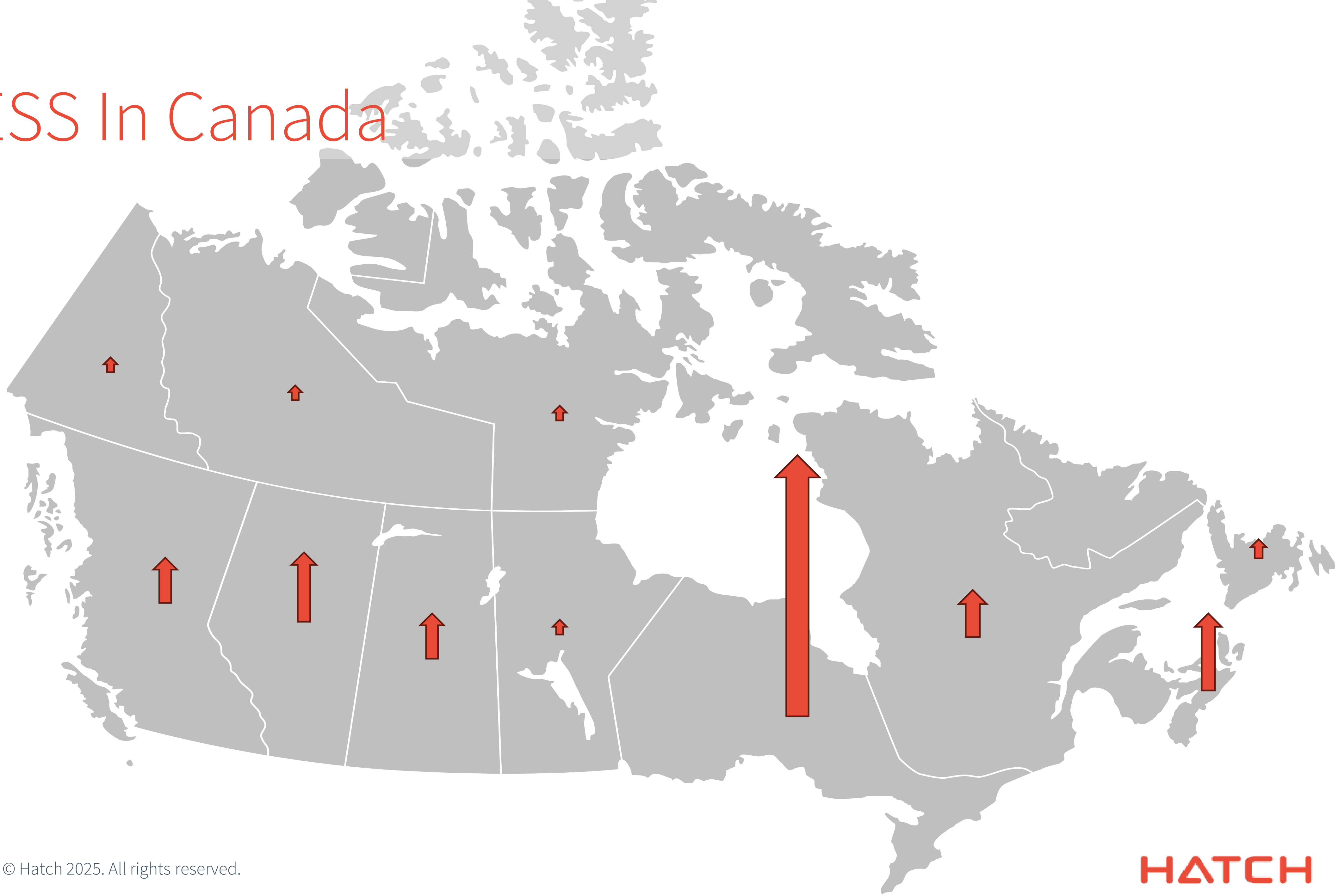
BESS In Canada



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Key Canadian Markets

Atlantic Canada

- NS: 3 x 50 MW/200 MWh BESS across province
  - Owned by NSP
- PEI: Co-Located Solar + BESS
  - 21MW Solar + 10 MW BESS
- Renewable Integration
- Grid Support & Reliability
- Capacity

IESO

- Grid Capacity to meet peak demand
  - Due to growing electricity load
  - Through a capacity payment agreement
- Energy Arbitrage
  - Shifting
- Operating Reserve
- Awards in 5 MW – 300 MW range

Key Canadian Markets

Saskatchewan

- Utility Owned Transmission Connected-BESS
- 20 MW BESS
- Used for Renewable Integration & Grid Flow Management

British Columbia

- Microgrid batteries planned in remote communities (<10 MW)
- 50 MW as early as 2027
- Up to 500 MW of additional capacity by 2030

Key Canadian Markets

Northern Territories

- Utility Owned Transmission Connected-BESS
- Either full BESS sites or co-located BESS and Wind
- For grid stability and less load on their diesel generator assets
- Great for smaller communities

Key USA Markets

CAISO

- BESS capacity grew from about 500 MW in 2020 to 5,000 MW in May 2023
- Ancillary services
  - Regulation Up/Down
  - Spinning & Non-Spinning Reserve
  - Hybrid & NGR
- Resource Adequacy Program

ERCOT

- Fastest growing market for BESS in North America
- ERCOT is an open merchant market
- Ancillary services
  - Regulation Up/Down
  - Responsive Reserve Services
  - ERCOT Contingency Reserve Services
  - Non-Spinning Reserve Services
- Energy Arbitrage

Other Markets/Use Cases

HVDC Operating Support

- BESS co-located with Converter Stations
- Uses ESS as a Transmission Asset
    - Support Grid Forming
    - Frequency and Voltage Support
    - Provide back-up for mono-pole or bi-pole trip
    - Potentially participate in local markets connected to HVDC

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BESS Use Cases & Project Considerations

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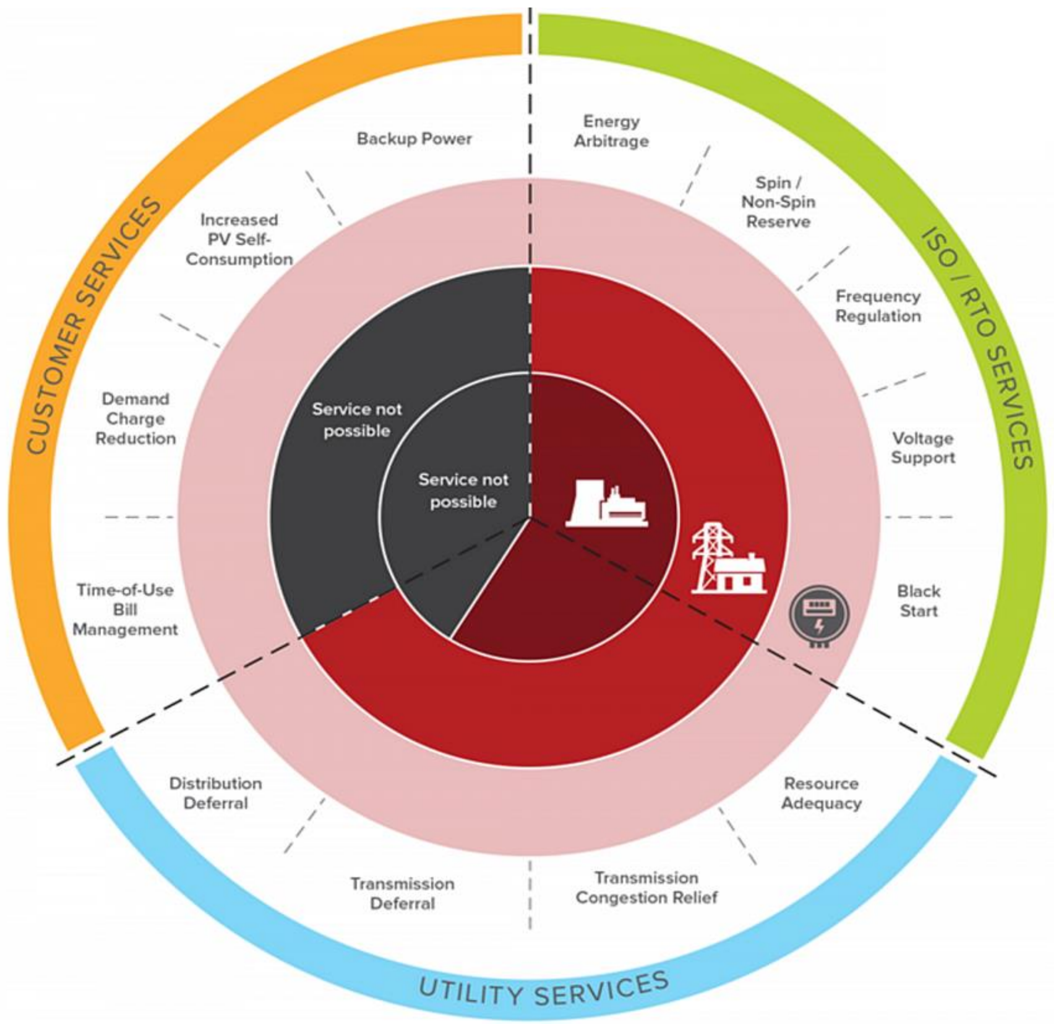
What can a BESS be used for?



Credit: RMI, 2015

Residential Customers

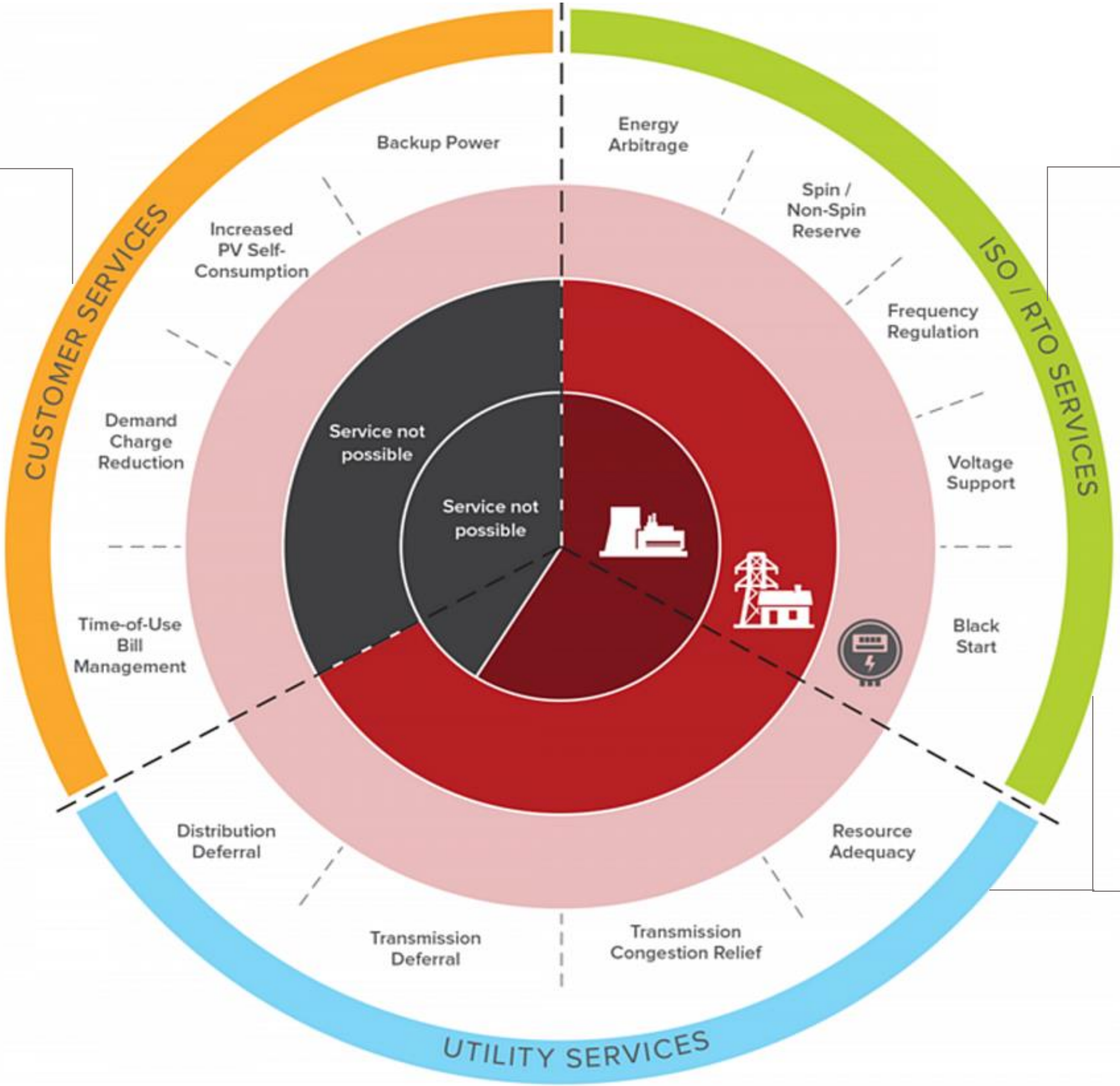
Commercial & Industrial

Datacenters

Transmission Operators

Grid Operators

Developers



Vertically Integrated Utilities

Regional Utilities

Municipal Utilities

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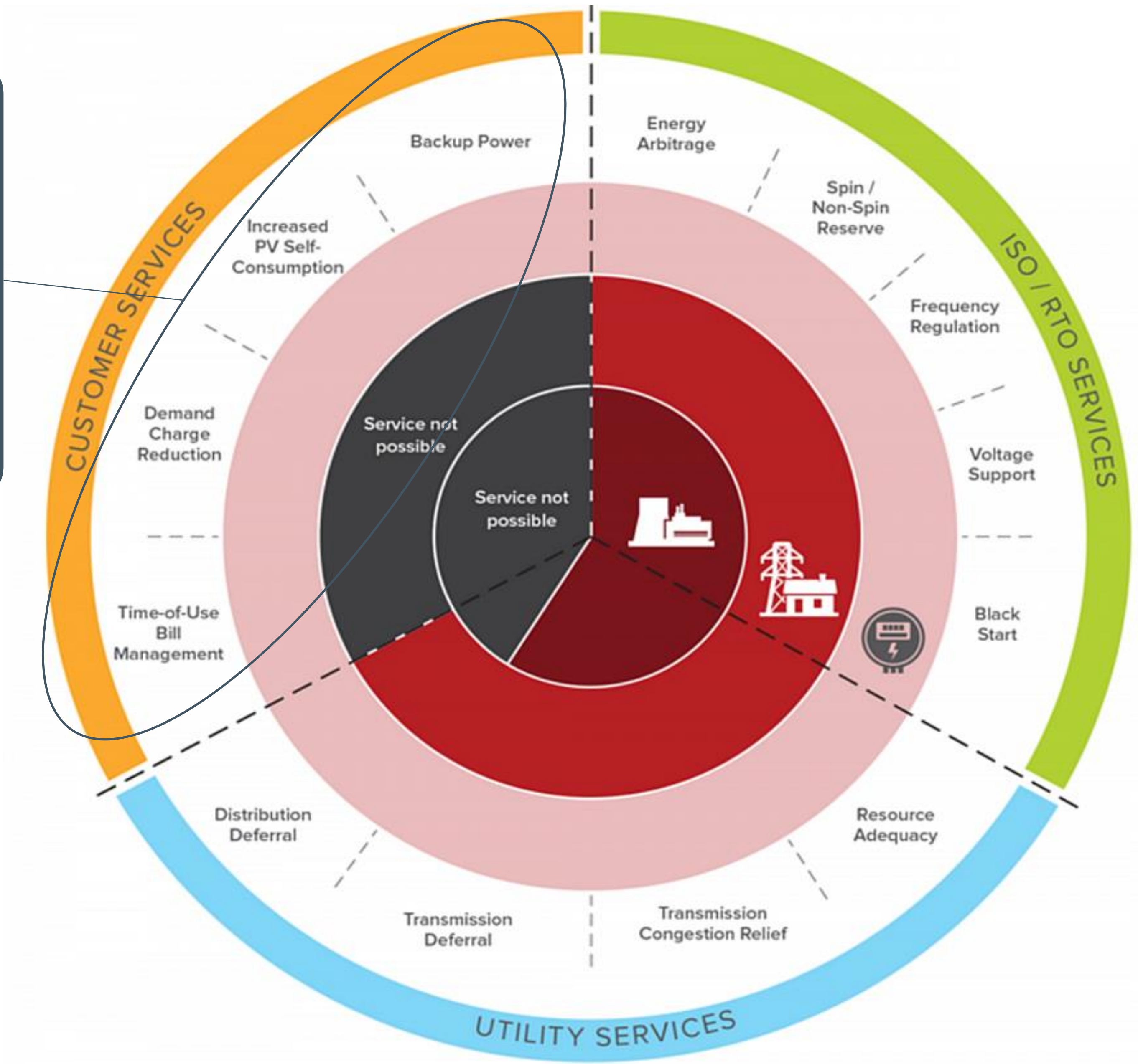
- Saving $$ on electricity bills
- Backup during an outage
- Supporting small-scale renewable energy integration
- kWh to multi-MW scale



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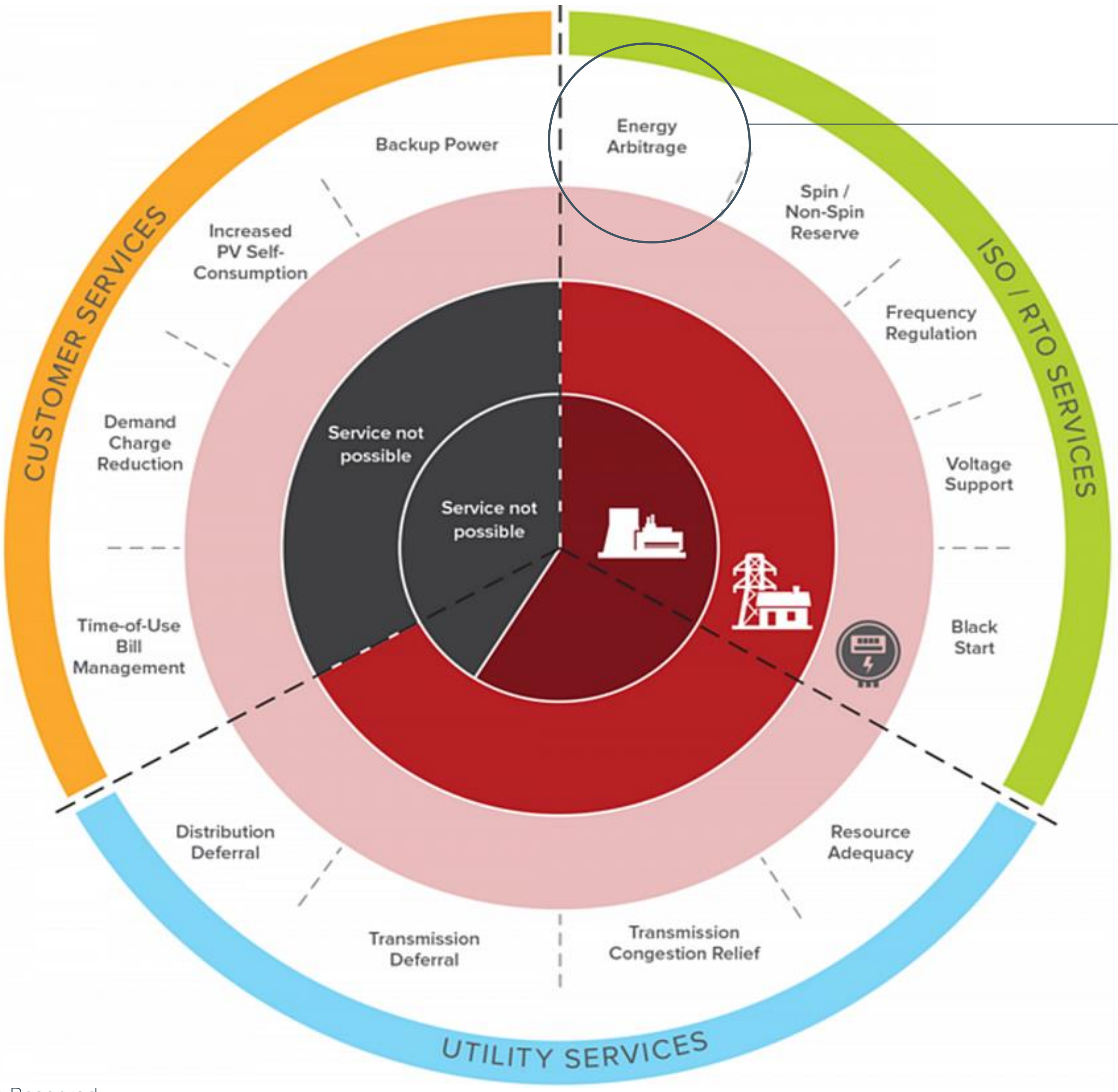
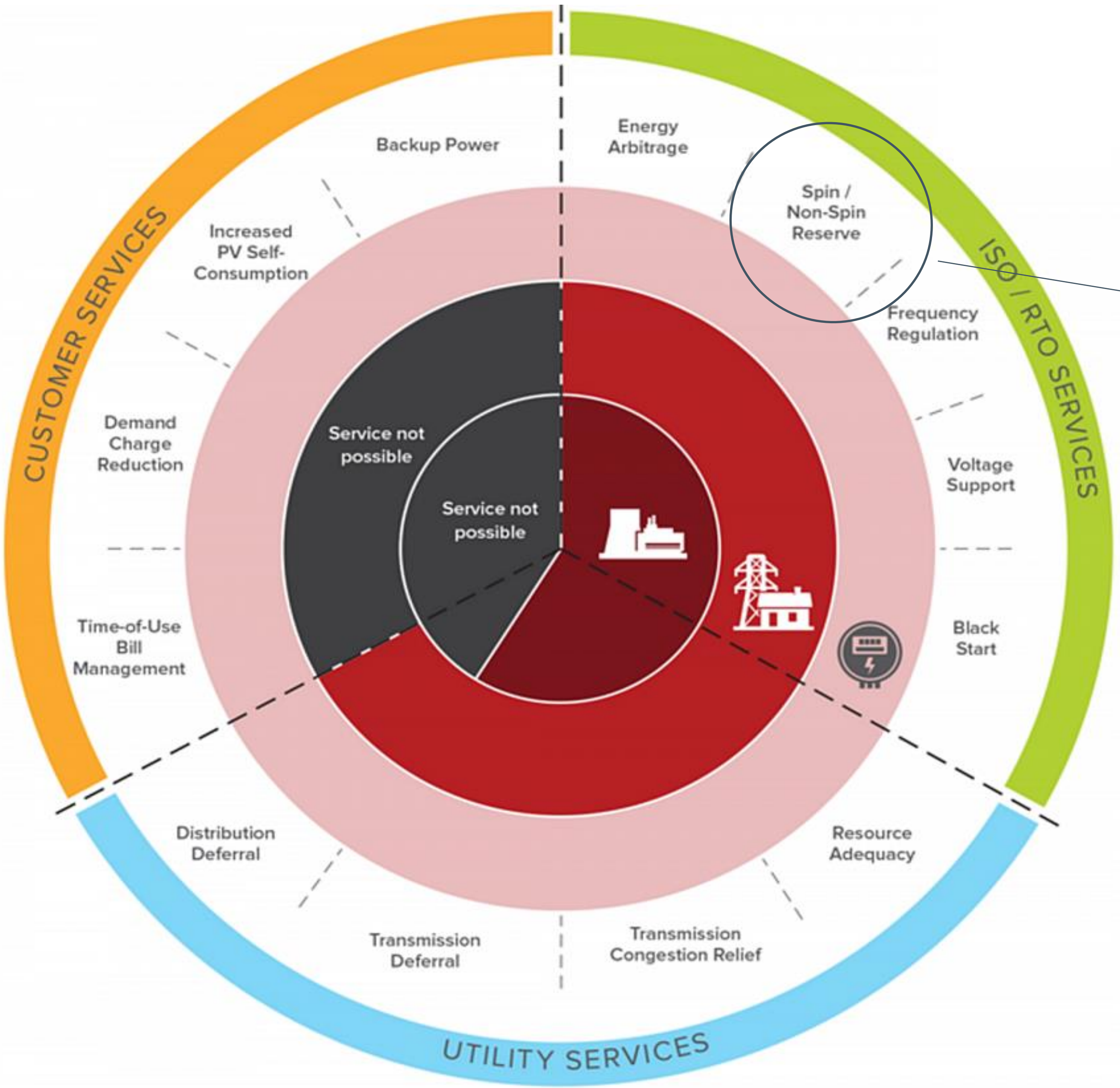


Energy Arbitrage

- Shifting energy from low to high demand periods
- Frequent developer application



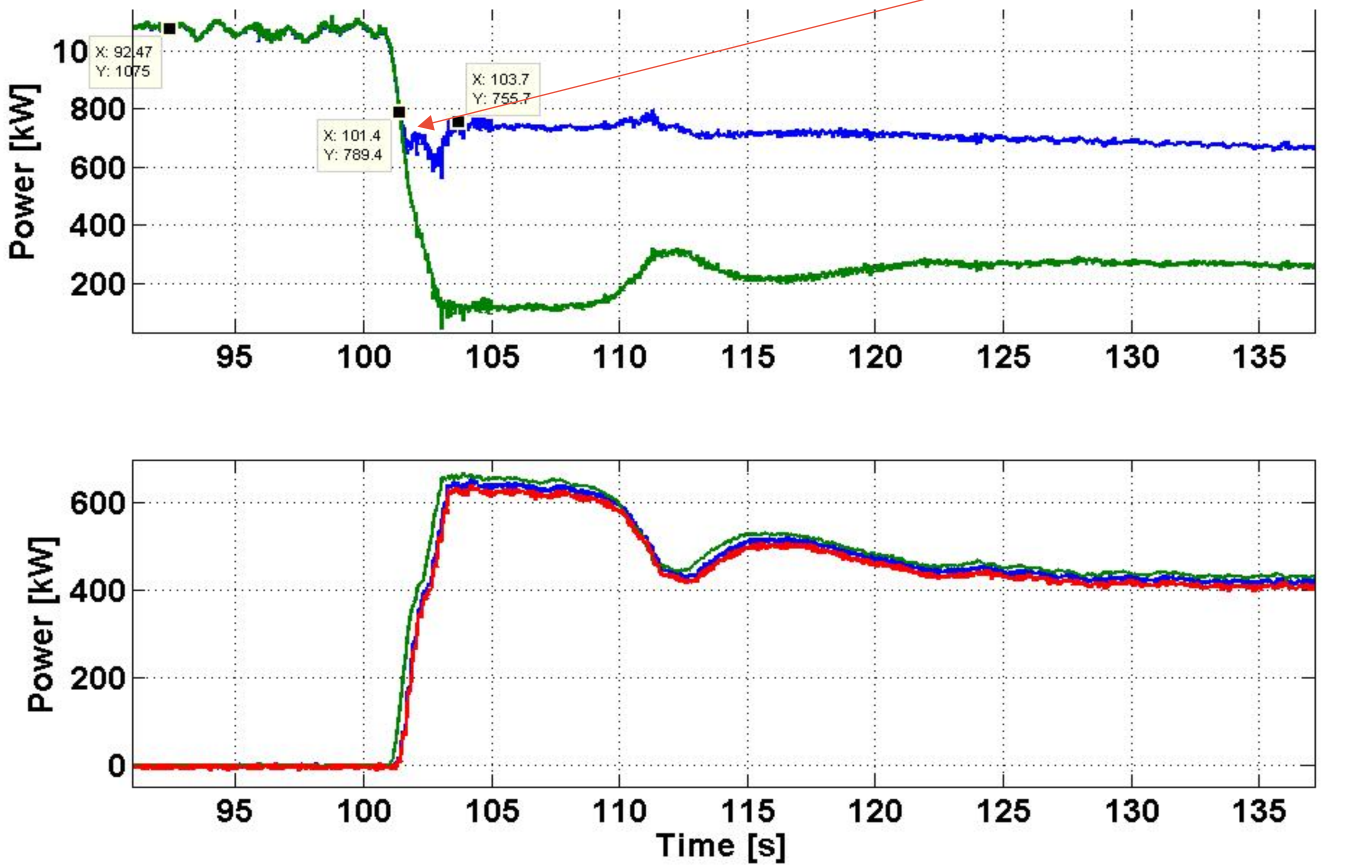
Spinning Reserve

- Aligned with capacity market
- BESS ability to have immediate, standby power without ramp up

Spinning Reserve

Other Generation

Battery



Loss of generation leads to trigger of BESS discharge and custom reaction to allow other generators to come online. Note potential <16ms response time from PCS.

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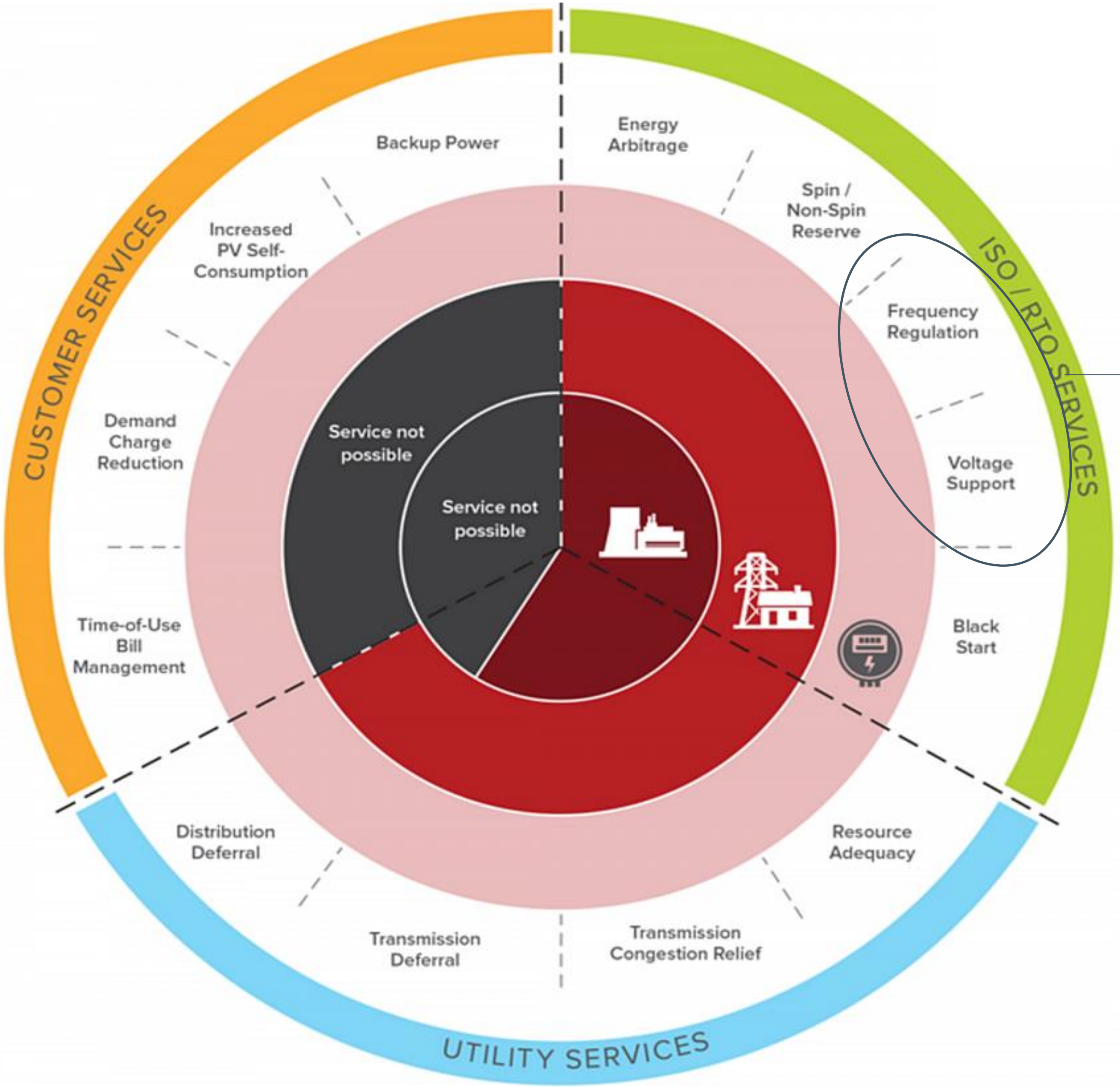
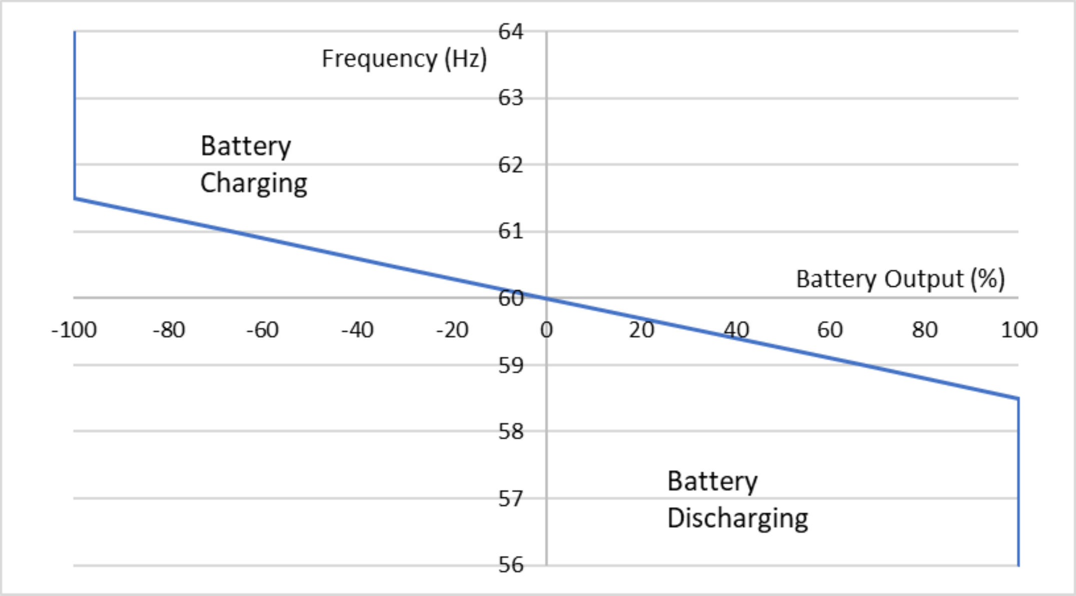


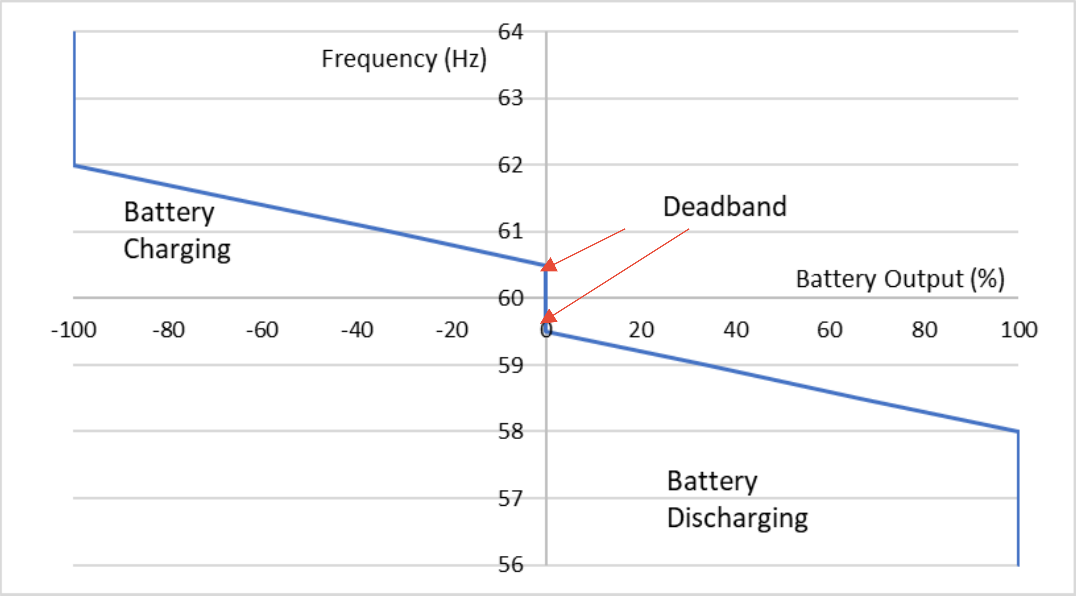
Power Quality Support

- Voltage and frequency support
- Core characteristic of power conversion system

BESS Frequency Control

- Frequency: Droop - Isochronous - kW Dispatch
- Voltage: Droop – kVar Dispatch
- Can be implemented on PCS





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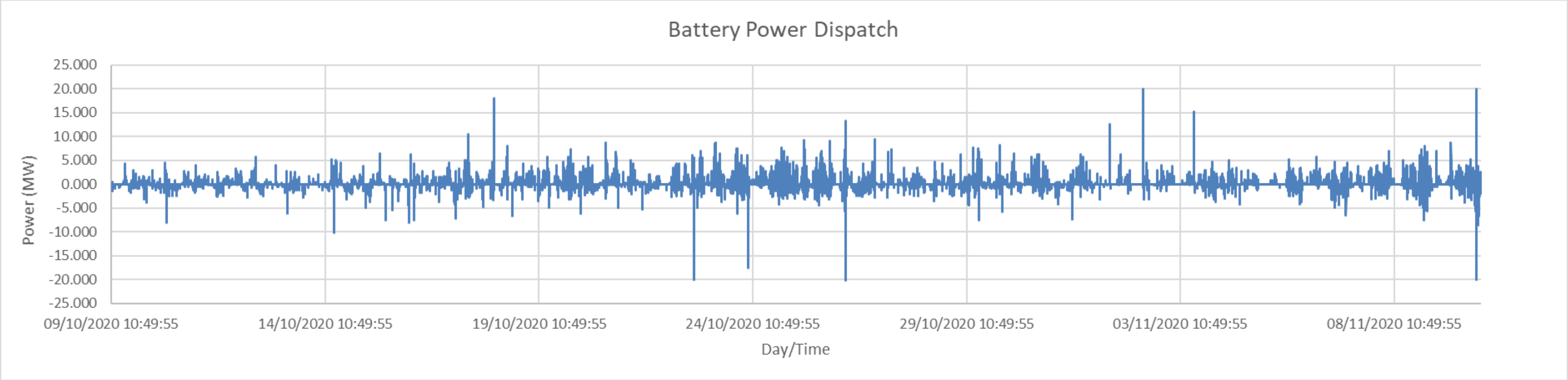
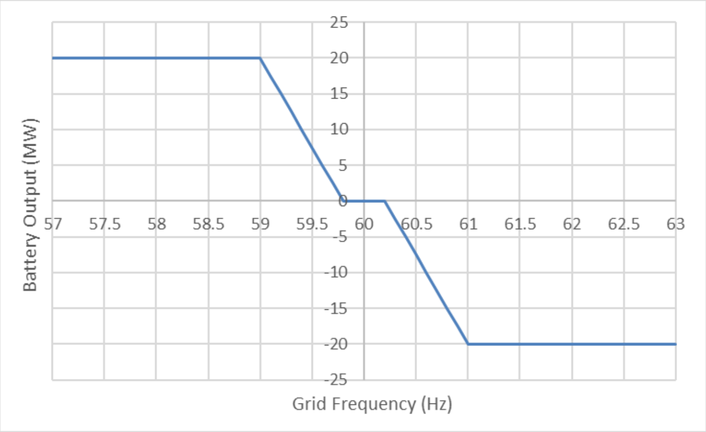
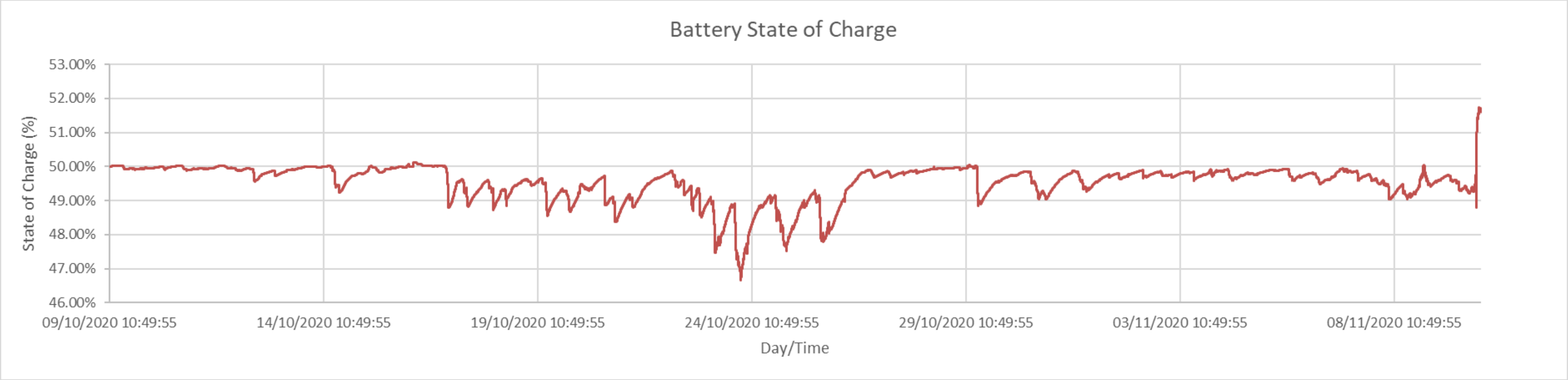
Frequency Control – Aggressive

- +- 0.2 Hz deadband
- Full output at 59 & 61Hz
- 21.0 MWh discharged per month







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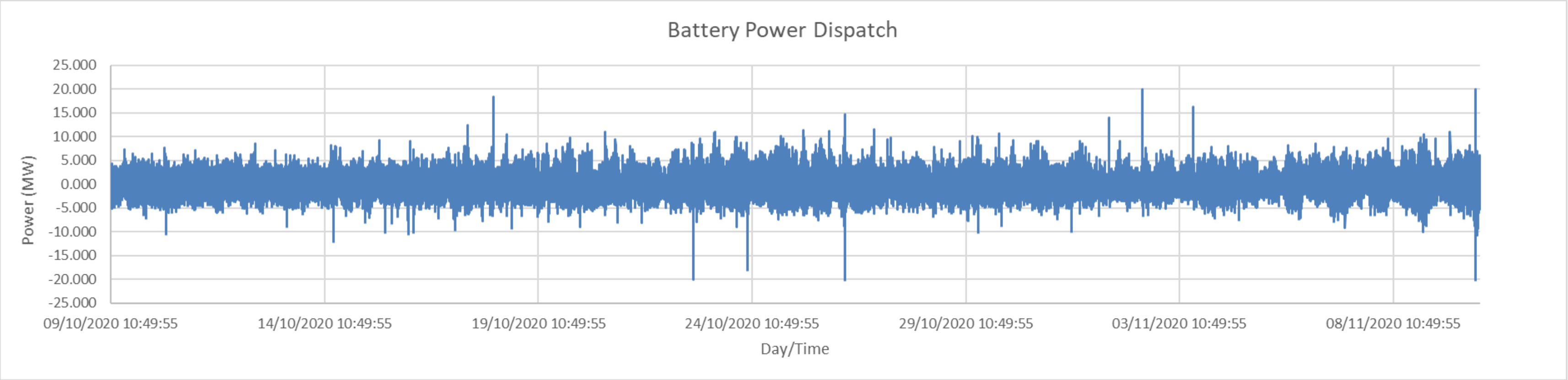
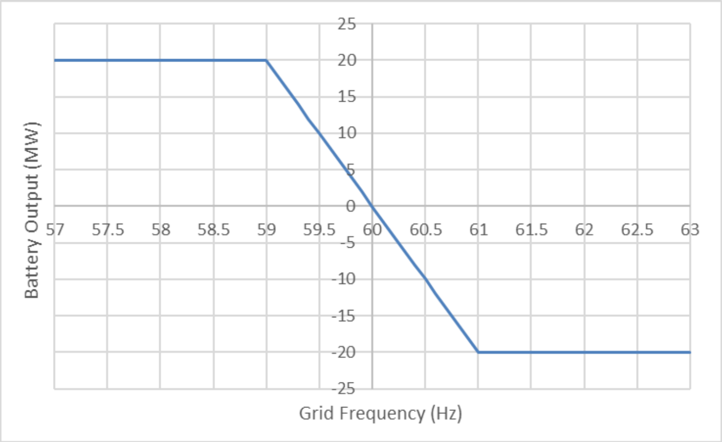
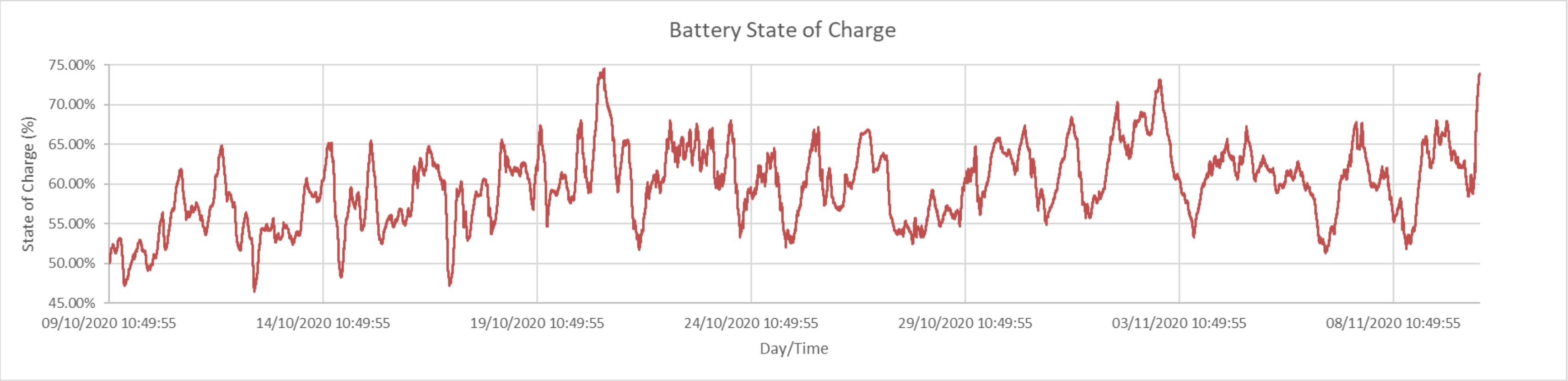
Frequency Control – Very Aggressive

- No deadband
- Full output at 59 & 61Hz
- 527.5 MWh discharged per month







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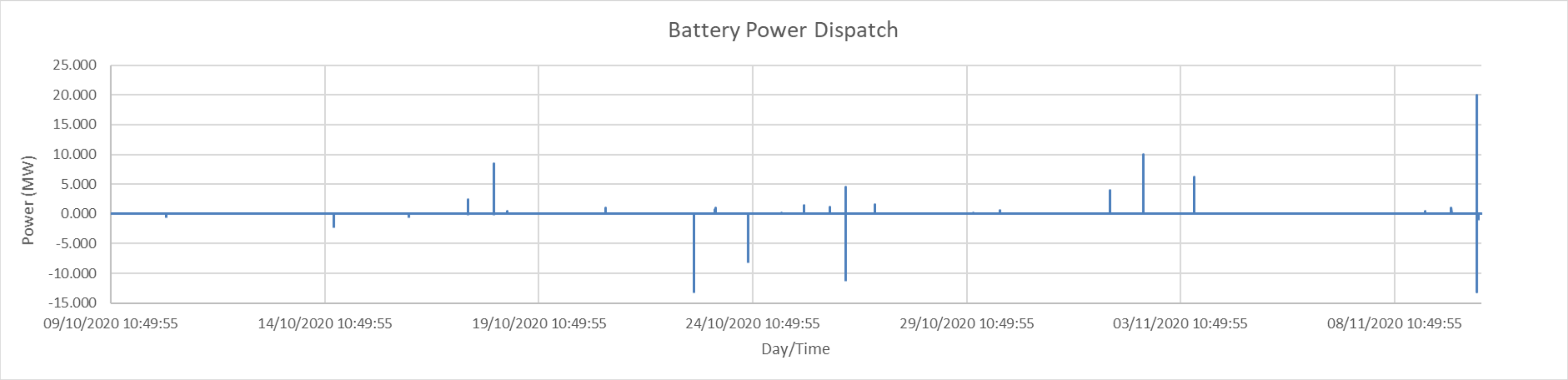
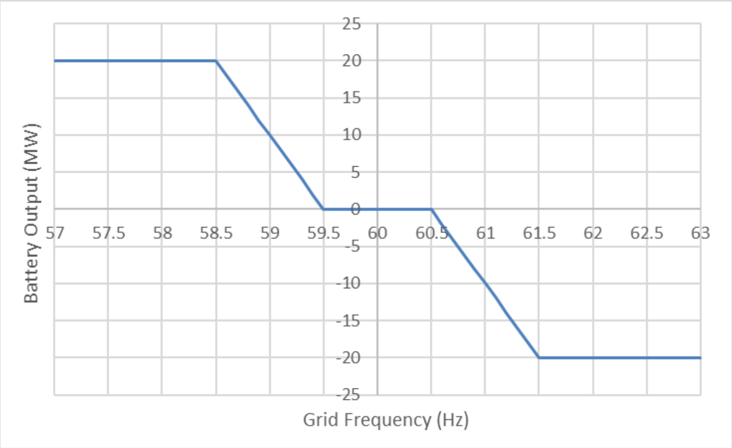
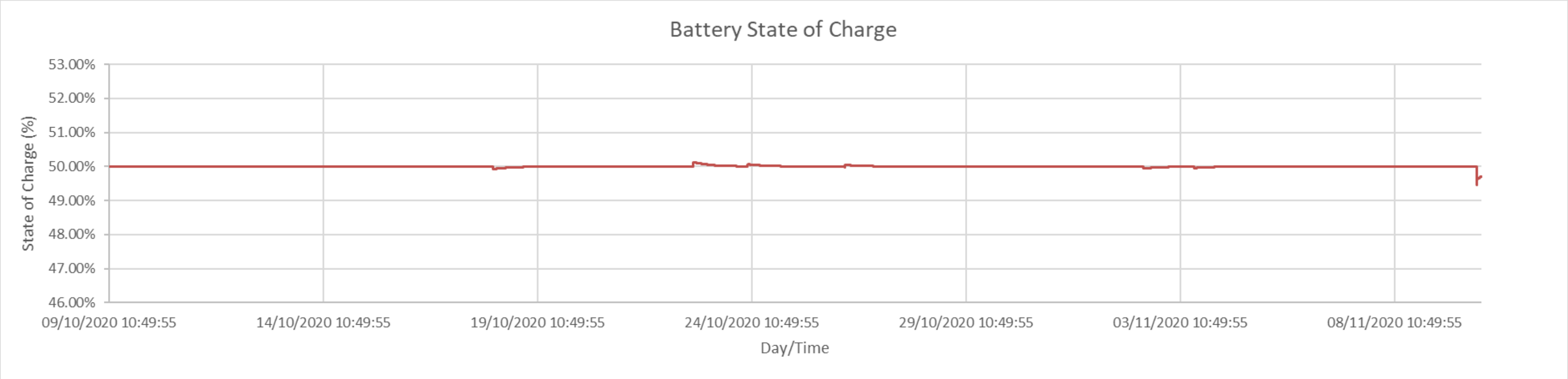
Frequency Control – Conservative

- +- 0.5 Hz deadband
- Full output at 58.5 & 61.5Hz
- 0.4 MWh discharged per month







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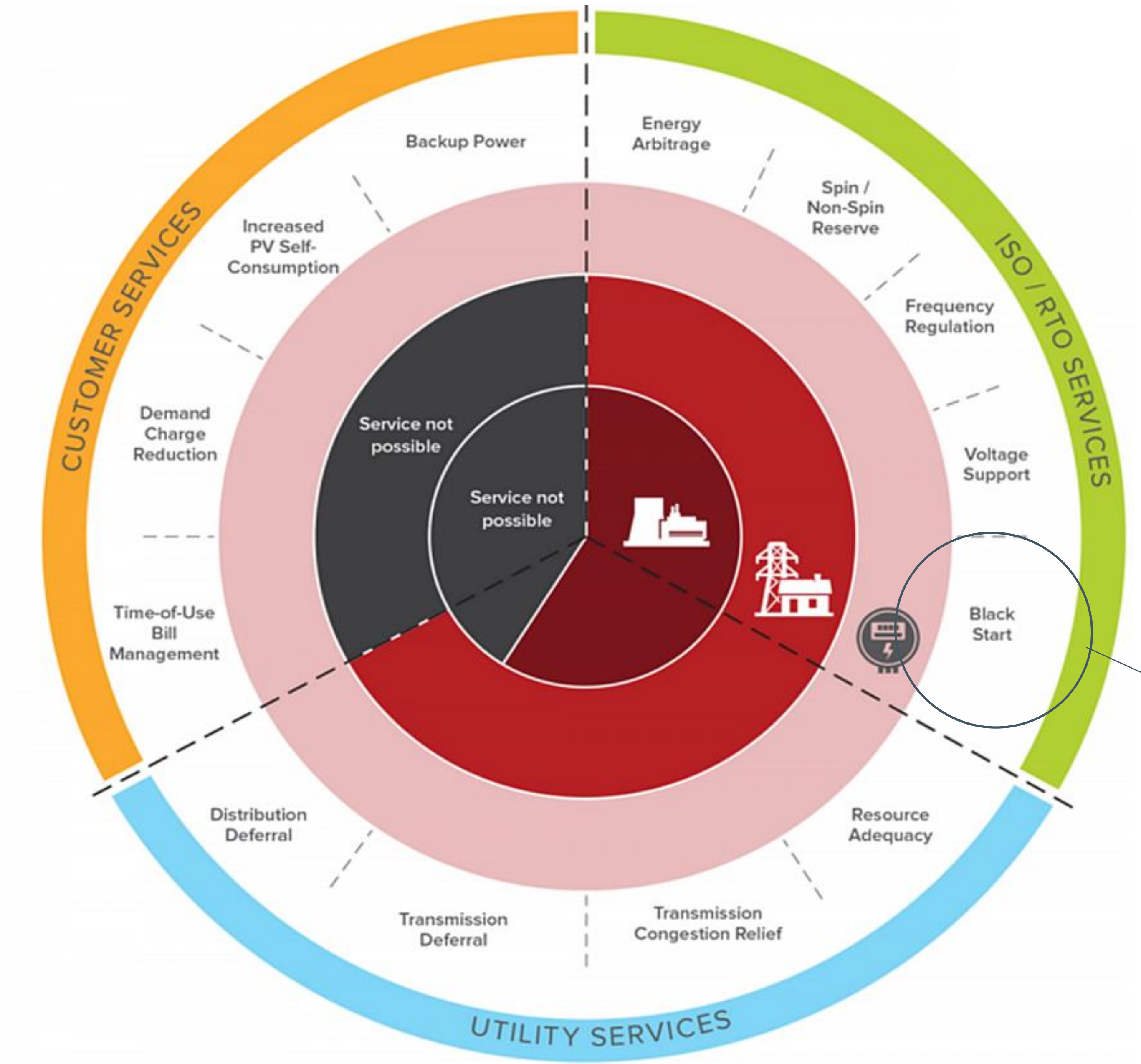
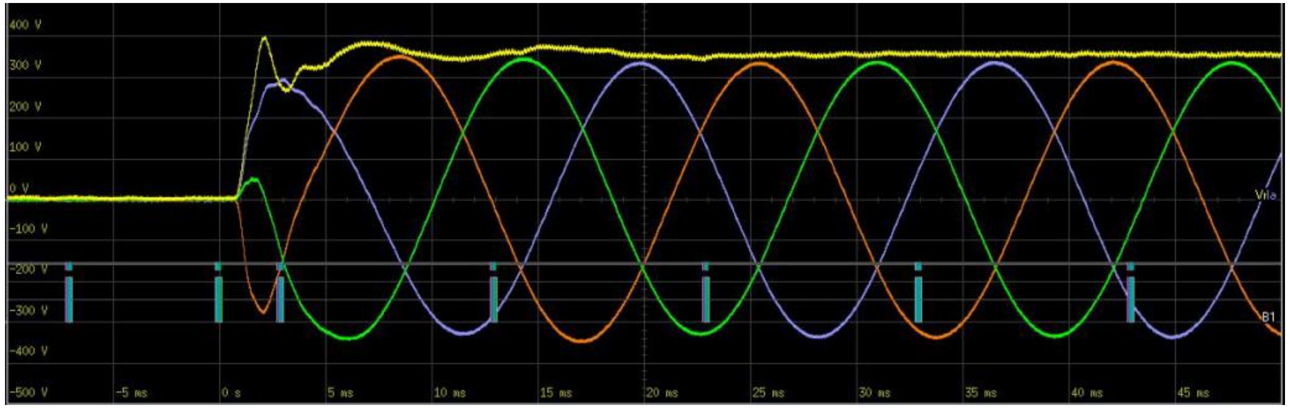


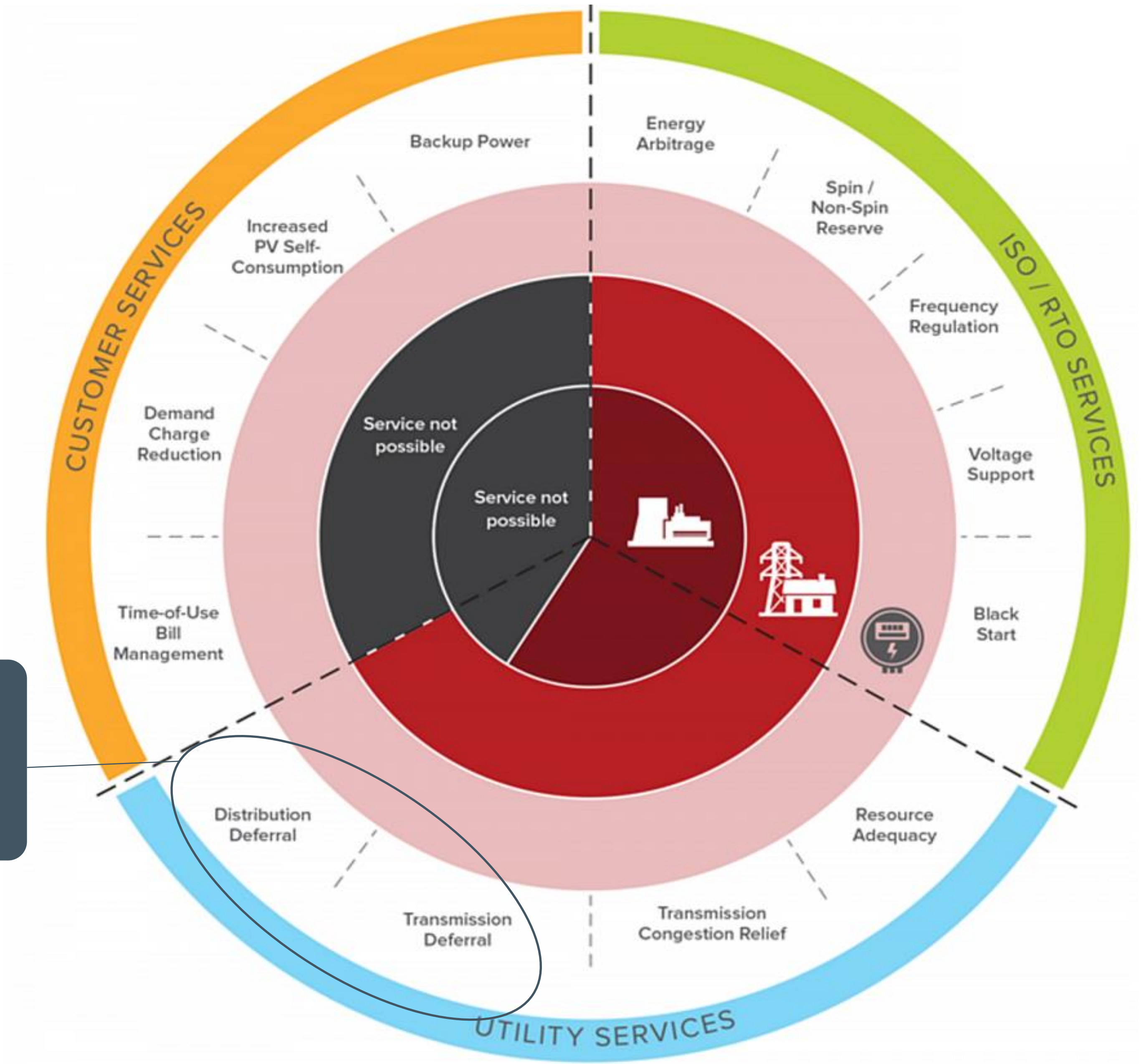
Black Start

- Utilizing "always ready" capability of BESS
- Requires extensive modelling

Black Start & Grid Forming

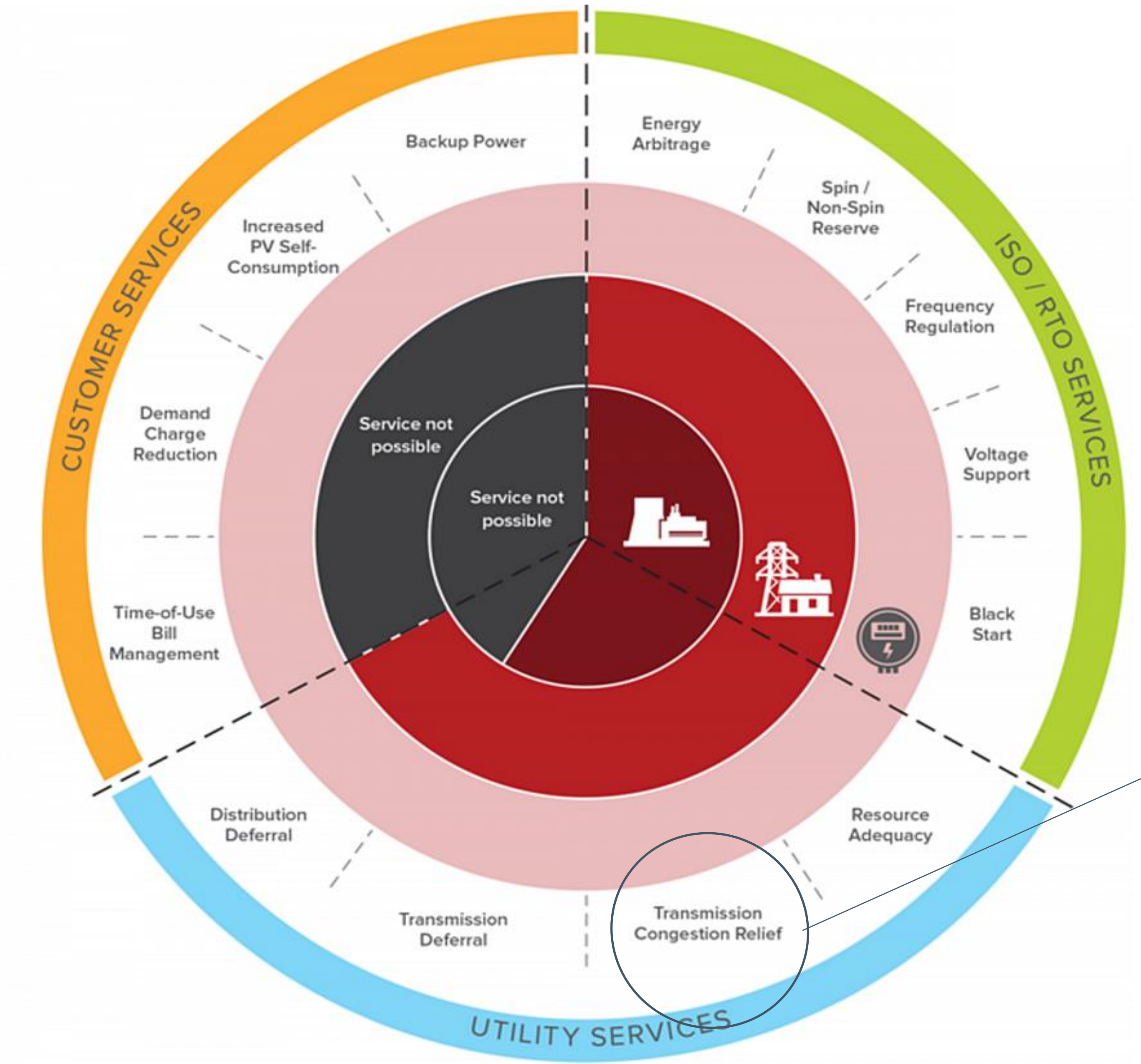
- Feature on advanced BESS inverters
- Requires consideration in UPS or battery redundant feed
  - Major difference between PV and BESS inverters
- Inverter can "form grid"
  - Predominantly used in generator-off scenarios
  - Uses internal 60 Hz reference
- Added consideration for cranking path and energization of upstream transformers





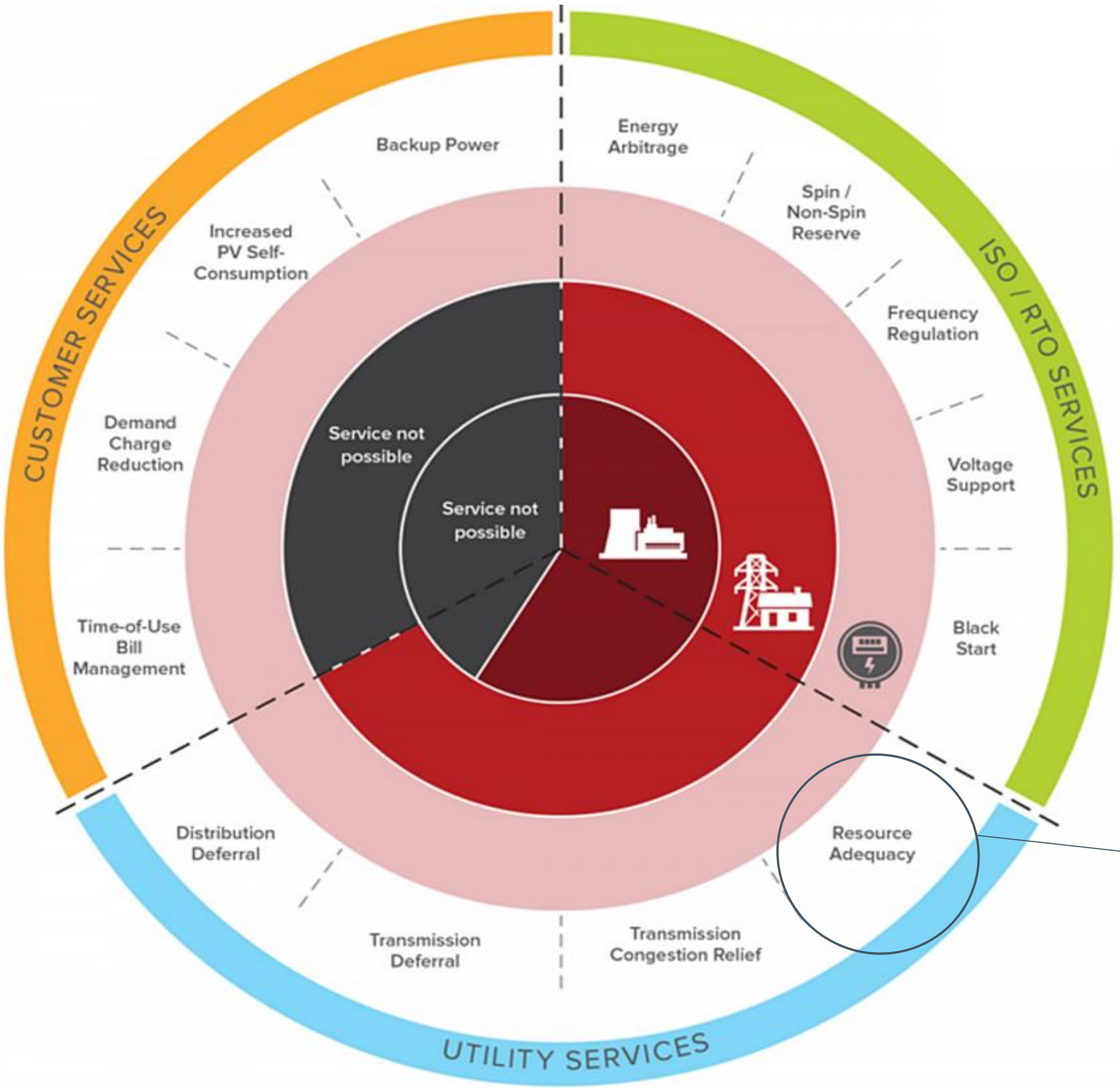
Cost Deferral

- “BESS vs. major capital upgrade”



Congestion Relief

- Prevent overloading on lines



Resource Adequacy

- Aligning dispatch with other generators
- Encompasses spinning reserve

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Renewables + BESS

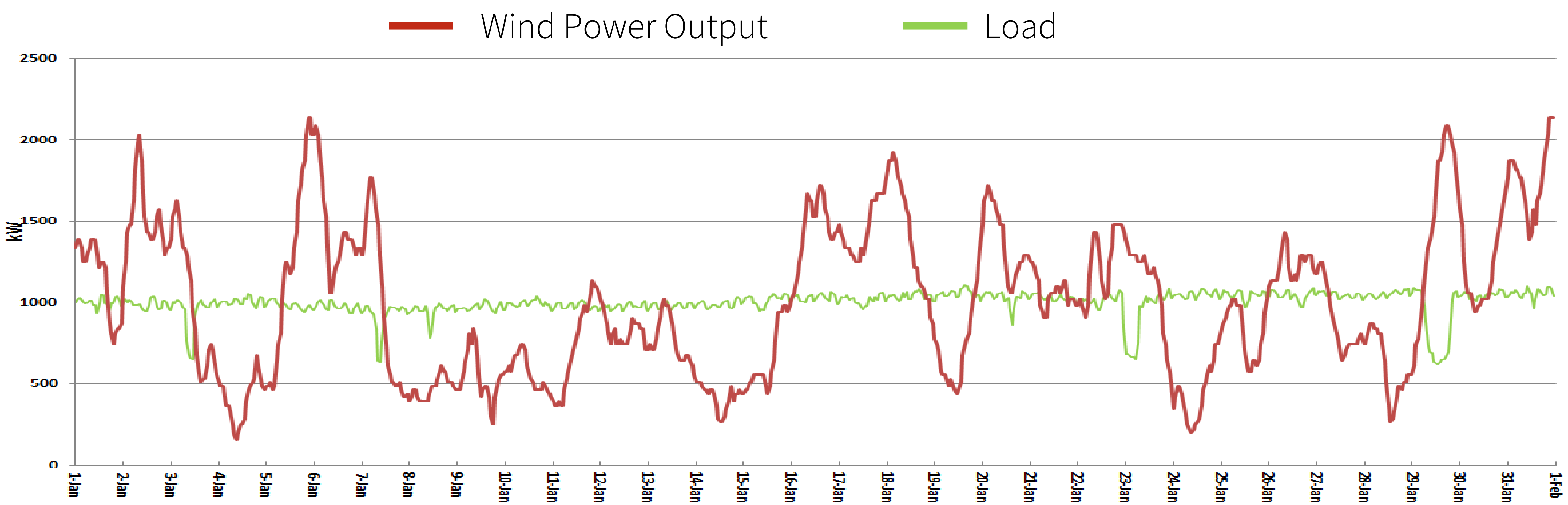
Solar PV

- Lower capacity factor
- Variable

Wind

- High intermittency / variability
- Generation in off-peak periods (overnight)
- Potential of resource inadequacy, and spinning reserve requirements

Wind Power Intermittency



Wind output varies 75-100% depending on wind speed variability; clear resource inadequacy in this case; likely problem with spinning reserves

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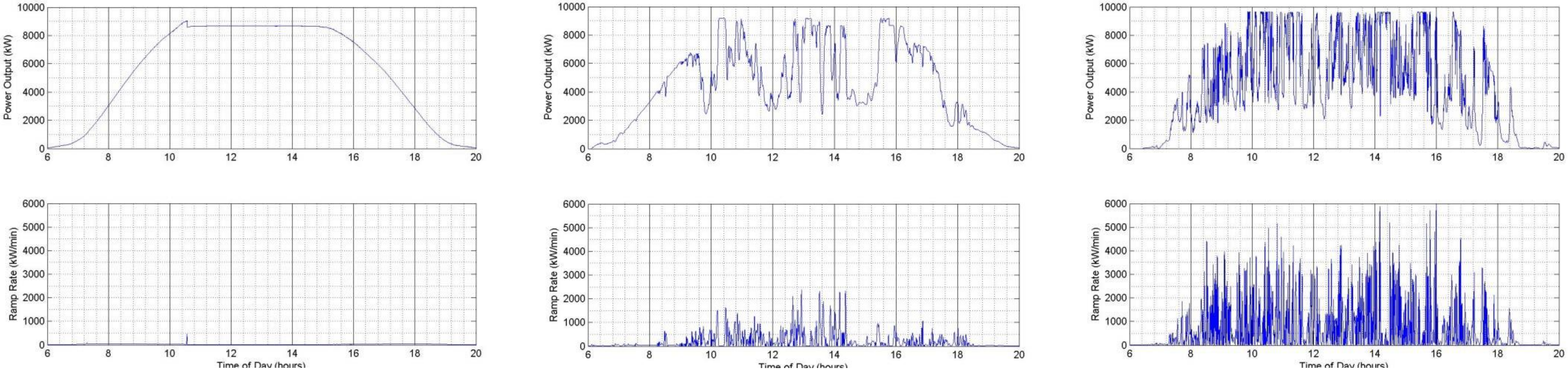
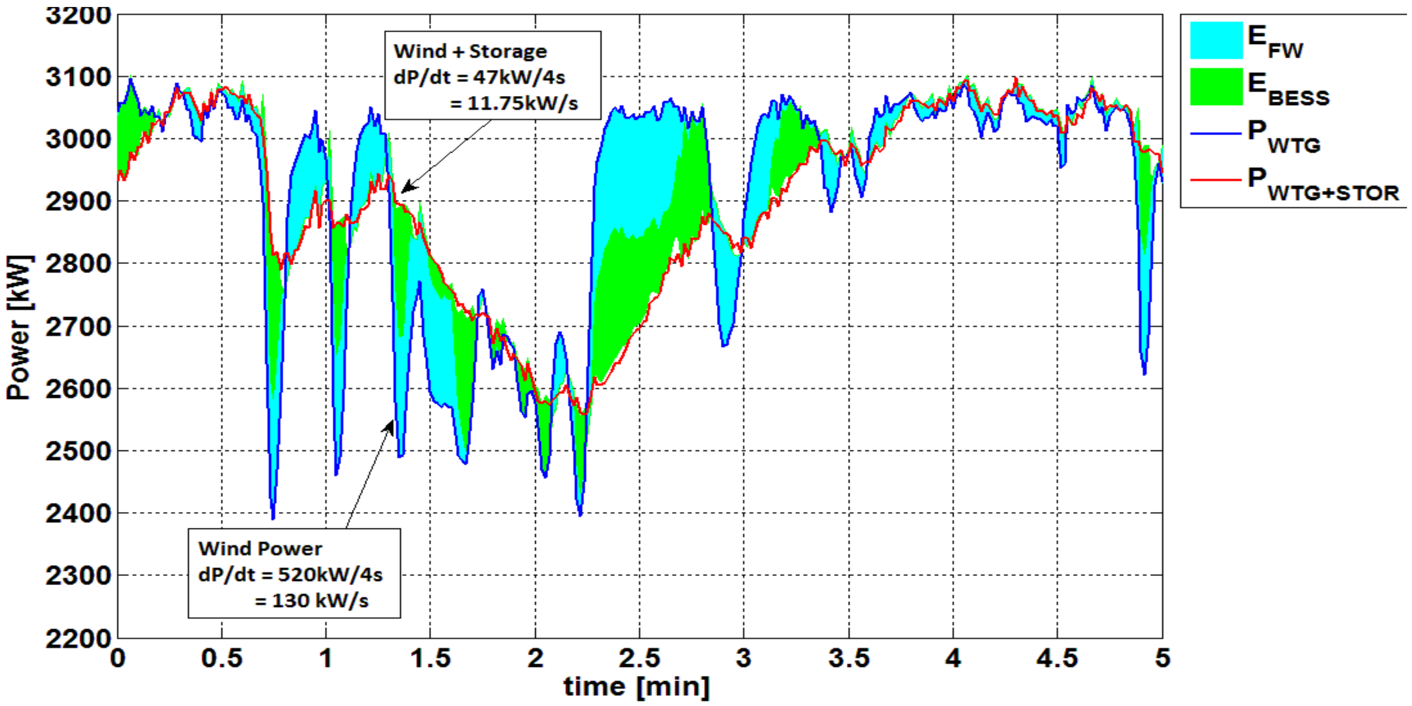
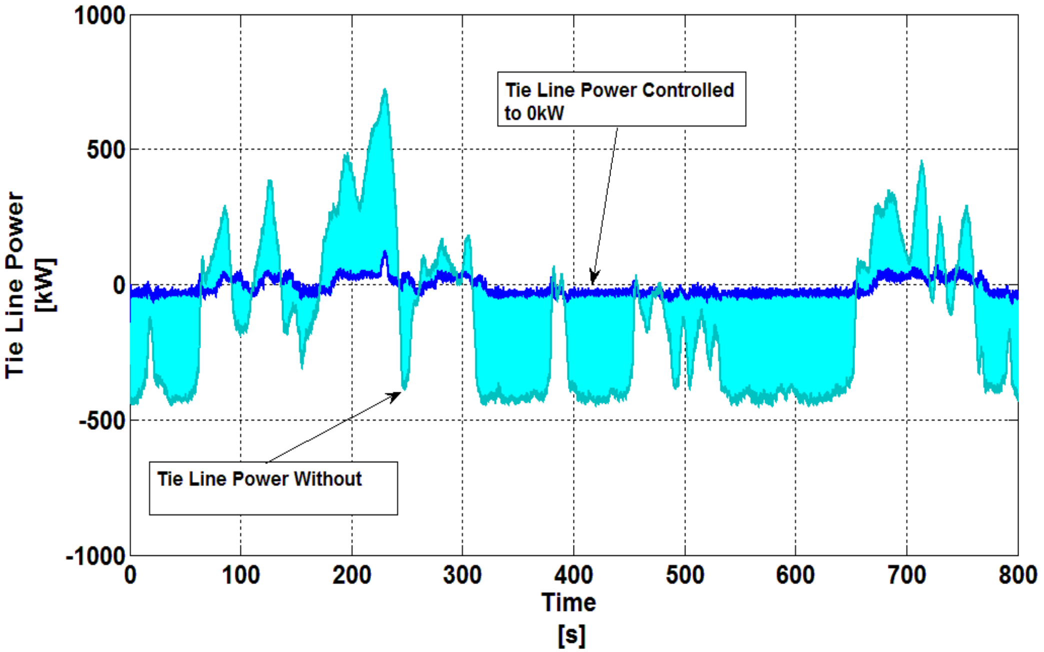
Solar Power Variability



Cloud cover can drop PV power output by 80%, hence need for 80% of spinning reserves (with respect to instantaneous power)

Smoothing of Renewable Power





Key Standards and Certifications

Electrical Safety & Compatibility

Underwriter's Laboratories (UL)

- UL 9540 –Energy Storage System and Equipment
- UL9540A –Test Method for Evaluating Thermal Runaway Fire Propagation
- UL 1973 –Batteries in Stationary Applications
- UL 1642 - Lithium-Ion Batteries
- UL 1741 – Inverters & Converters
  - Includes IEEE – 1547 Interconnection of DER

Fire Safety

NFPA

- NFPA 855
  - Applicable in USA, generally followed in Canada
  - Focuses on spacing, fire suppression and fire prevention
- NFPA 68 – Explosion Protection with Deflagration
- NFPA 69 – Explosion Prevention Systems (ventilation)

Communications

MESA/SunSpec

- Modular Energy Storage Architecture (MESA) Standard Alliance
- SunSpec Alliance
- Set of Best Practices for Communications for ESS
  - Not mandatory
- Standardize integration, and reduce integration risk and challenges
- SunSpec: communication between ESS, PCS, & Meters

Transportation & Storage

UN/DOT

- Transportation Requirements for Li-Ion (considered Dangerous Goods)
- UN 38.3 and US DOT 49 CFR 173.185

Local Codes

Other Standards

- Local Electrical Code, Building Code
- IEEE Standards
- Electrical Safety Association
- ISO Standards
- ANSI Standards
- IEC Standards & Safety Test Protocols
- NEMA Requirements for Containers

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BESS Environmental

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Typical Themes in Community Engagement

- Environmental concerns
- Visual concerns
- Fire
- Construction noise & traffic
- BESS Regulations
- BESS recycling
- Equipment origin

NIMBYism is leading challenge

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The more interesting questions…

Are batteries radioactive?

What happens if a tornado rips through the project?

Will they give me headaches?

Will they spontaneously explode?

What if they are shot at? Can you make them bulletproof?

What happens if batteries are ingested?

Environmental Assessment for BESS

EA Screening

- Based on jurisdiction
- Typically defined screening process
  - Except for long transmission connection

Noise

- For large BESS noise assessment is critical
  - Need to model noise to determine if in compliance with local bylaws
  - Mitigation measures may need to be implemented

Drainage/wetlands

- Can be extensive depending on wetlands/watercourse status
- Includes Desktop and Field Assessments

Species at Risk (SAR)

- Includes Desktop and Field assessments
- Need to consider migration, nesting/mating, etc.
- Results may impact construction schedule

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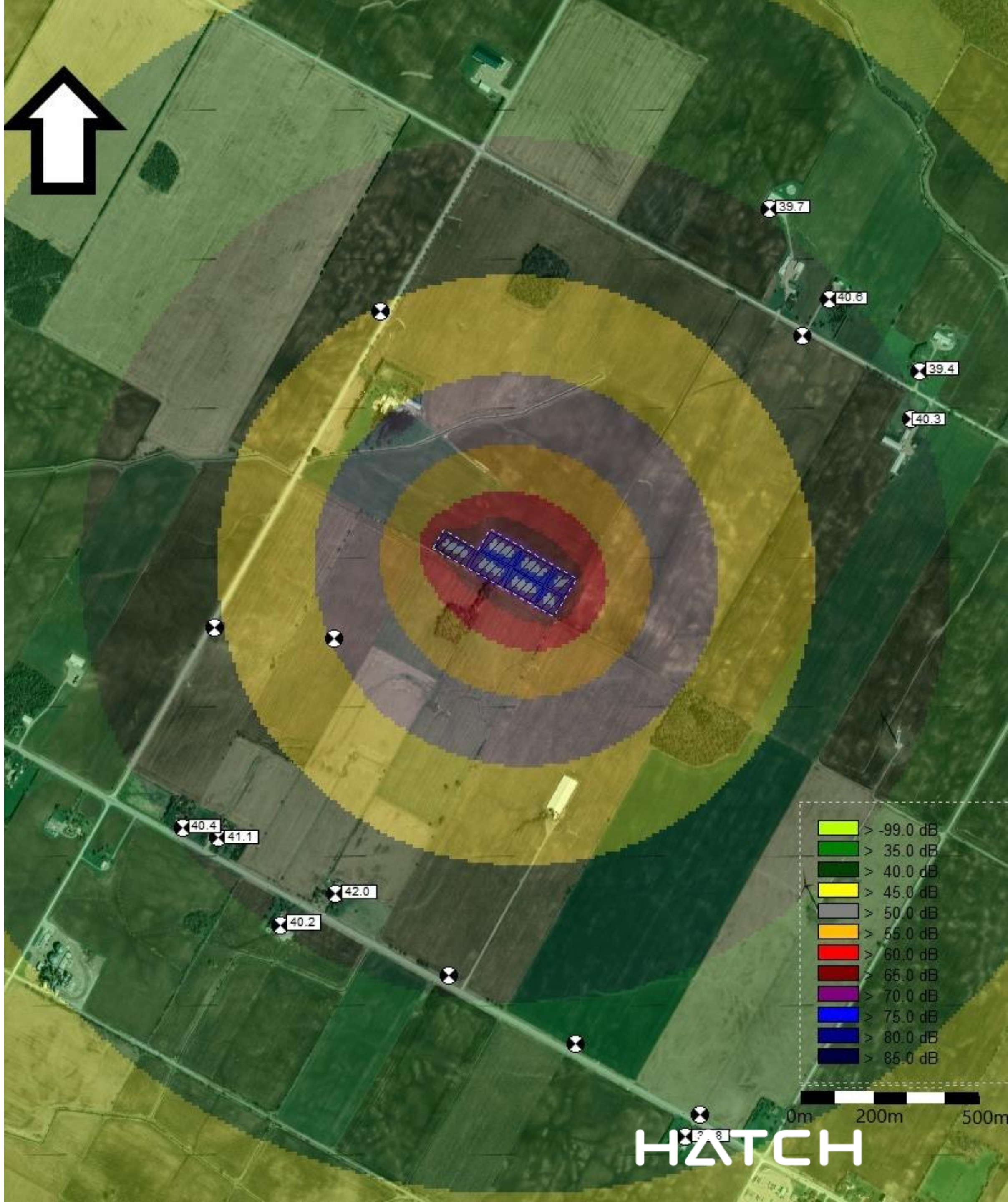
Noise Studies

- Inverters, BESS HVAC and Transformers all emit noise
  - Inverter noise can be tonal
- Rural & large BESS can be a concern
  - Modeling to assess
  - Identify receptors on nearby properties
- Studies produce contours to show noise levels
- Study various mitigations
  - Noise Wall
  - Berms
  - Enclosing loud equipment



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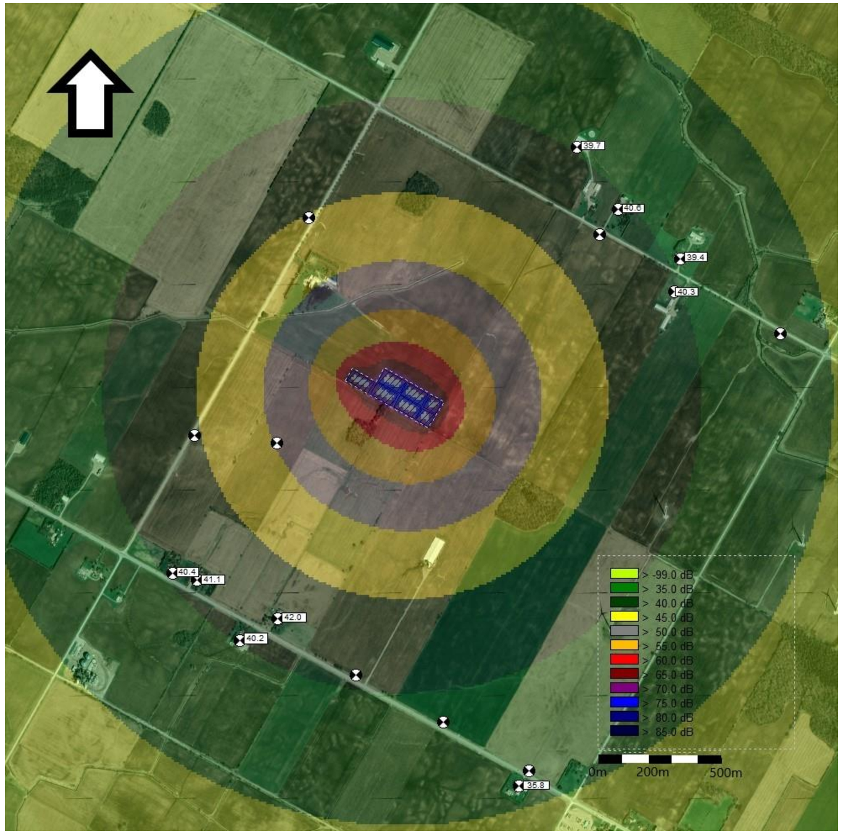
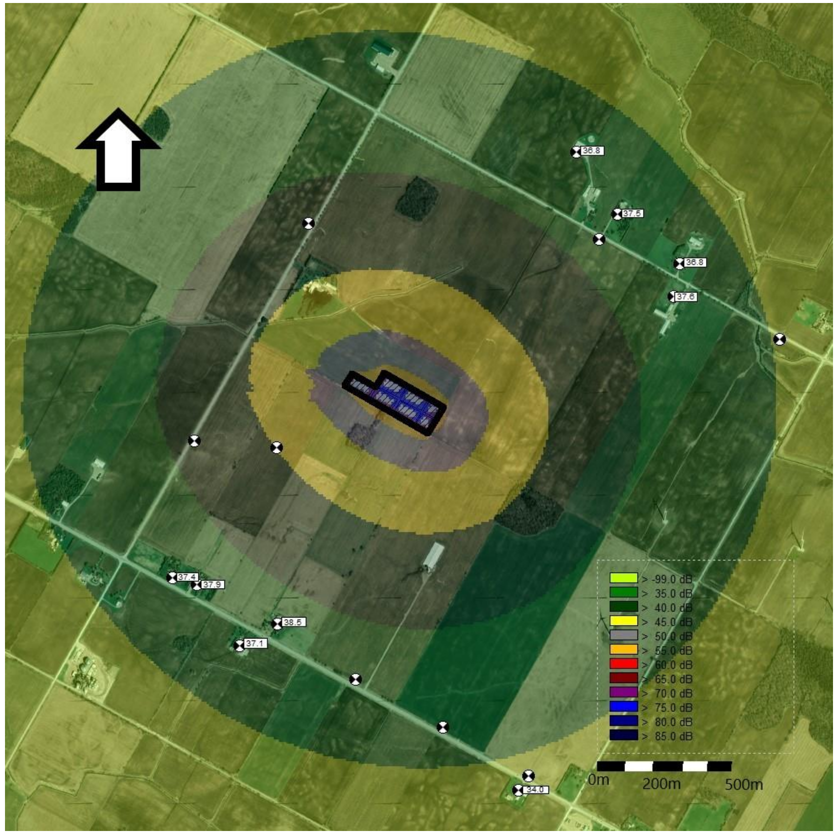
Example Noise Contour with and without Mitigation

No Mitigation



With Mitigation



Fire Assessments and Studies

- Requirements are evolving
- Some studies required
  - Hazard Mitigation Analysis
  - Fire Risk Assessment
  - Plume Studies
  - Community Impact Assessment
  - Materials Handling Plan
    - Installation & Decommissioning

Other Studies and Assessments

Site Assessments

- Topography
- Geotechnical
- Survey

Salt Spray

- Container Coating Requirements

Seismic

- Site conditions
- Assessment of equipment and foundations

Transportation and Logistics

- Large Projects
- Remote Sites

BESS Operations & Maintenance

Day-to-Day Activities

BESS sites do not typically have full time operating staff on site

- Remotely operated

Operators focus on dispatch of BESS

- Commands & operating plan
- May be automated depending on controller

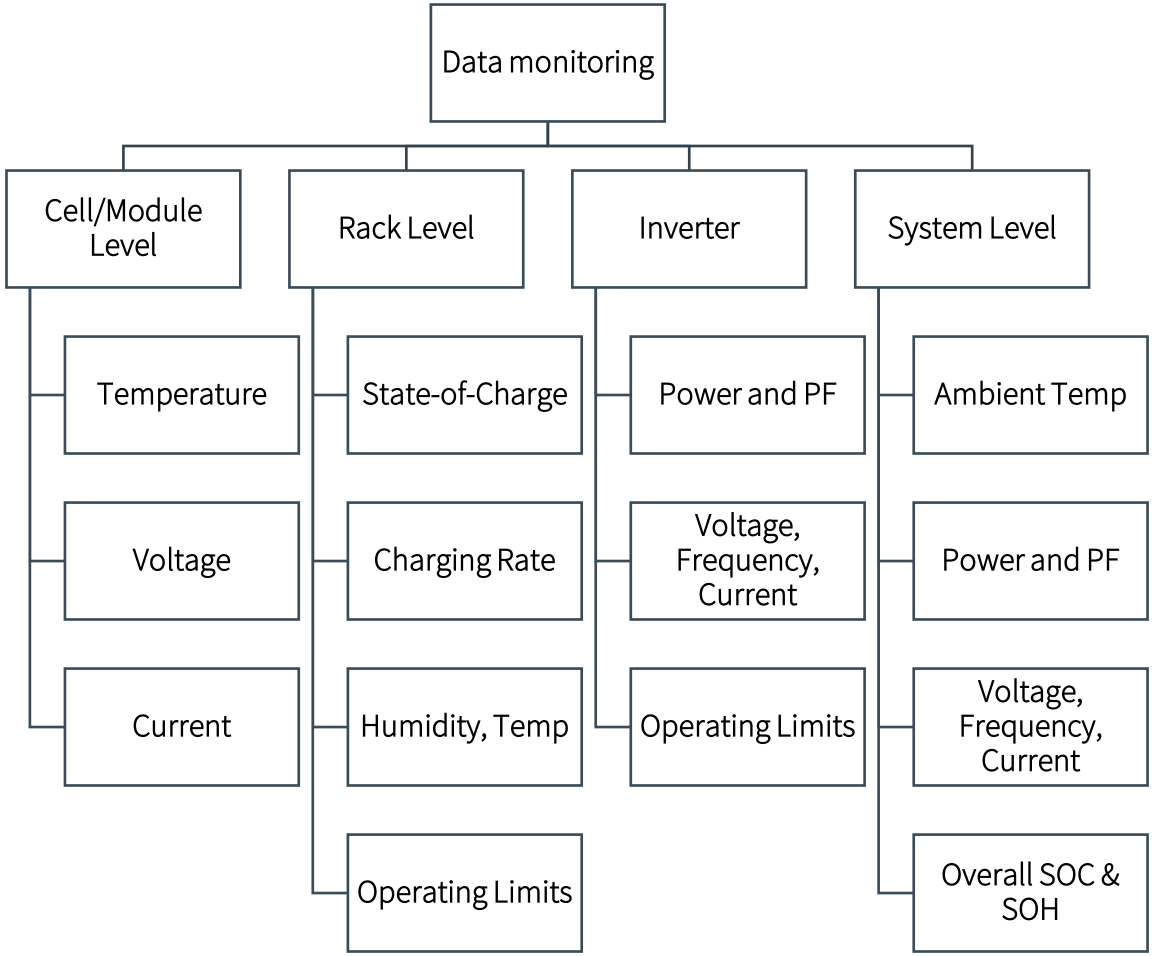
Data monitoring

- Monitoring performance
- Monitoring datalogging and archiving

Responding to alarms

- Work with Supplier to respond and triage alarms as they arise

BESS Monitoring & Data Collection



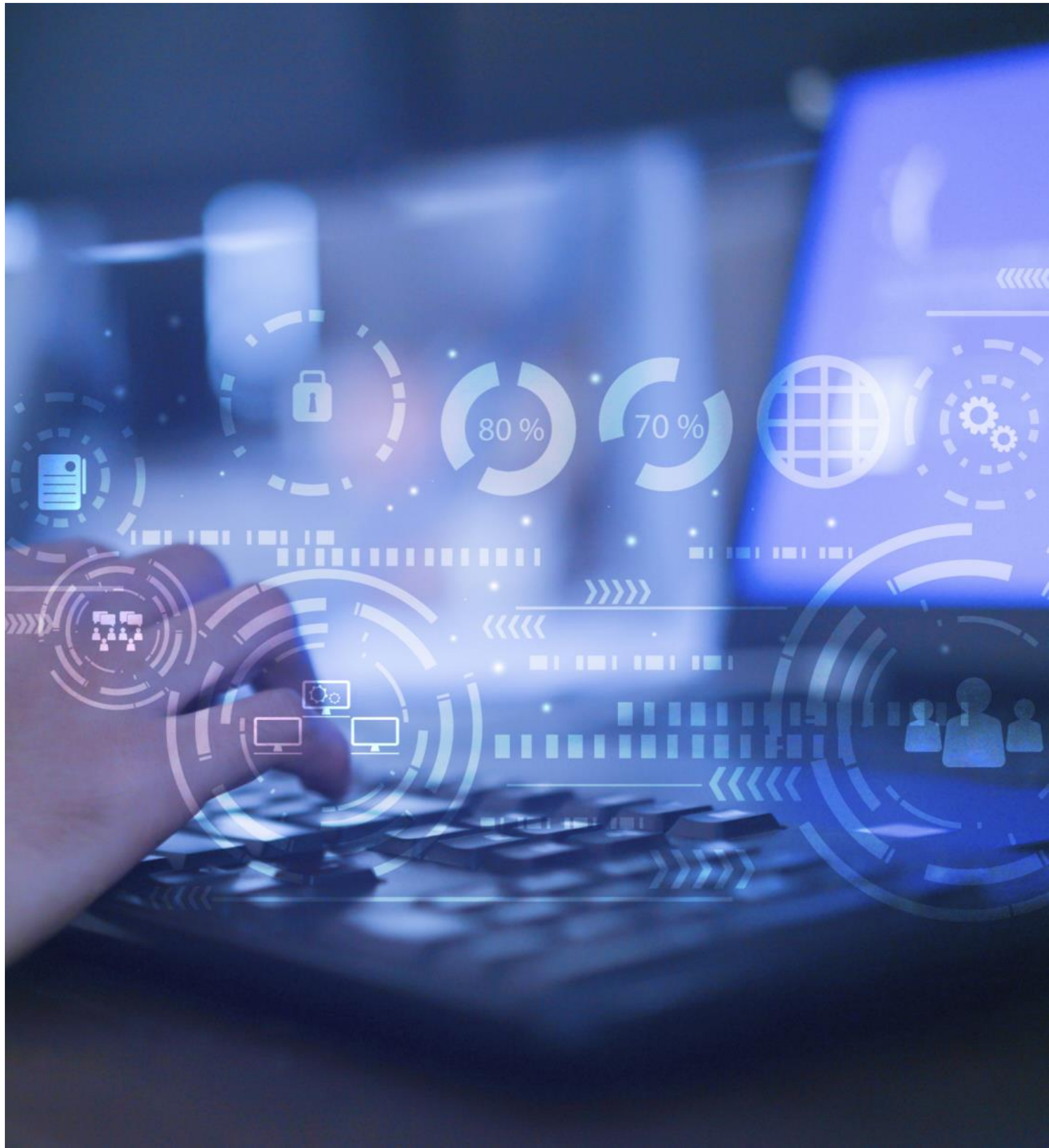
BESS Data logging requirements are strict for warranty purposes.
High resolution data (1-5 sec) for 60-120 days
Lower resolution data archiving (10-30 min)

Remote Monitoring

- Suppliers monitor BESS 24/7 remotely
  - Many monitoring points
  - Some Suppliers offer data analytics and monitoring of performance
  - Some Suppliers offer coordination services across multiple assets
- Integrate into Utility monitoring from operations center

Software Integration Considerations

- Software access by Owner
- Stability of internet connection
- Software as a service fees
- Expandability
- Cyber security
- Access to and number of settings



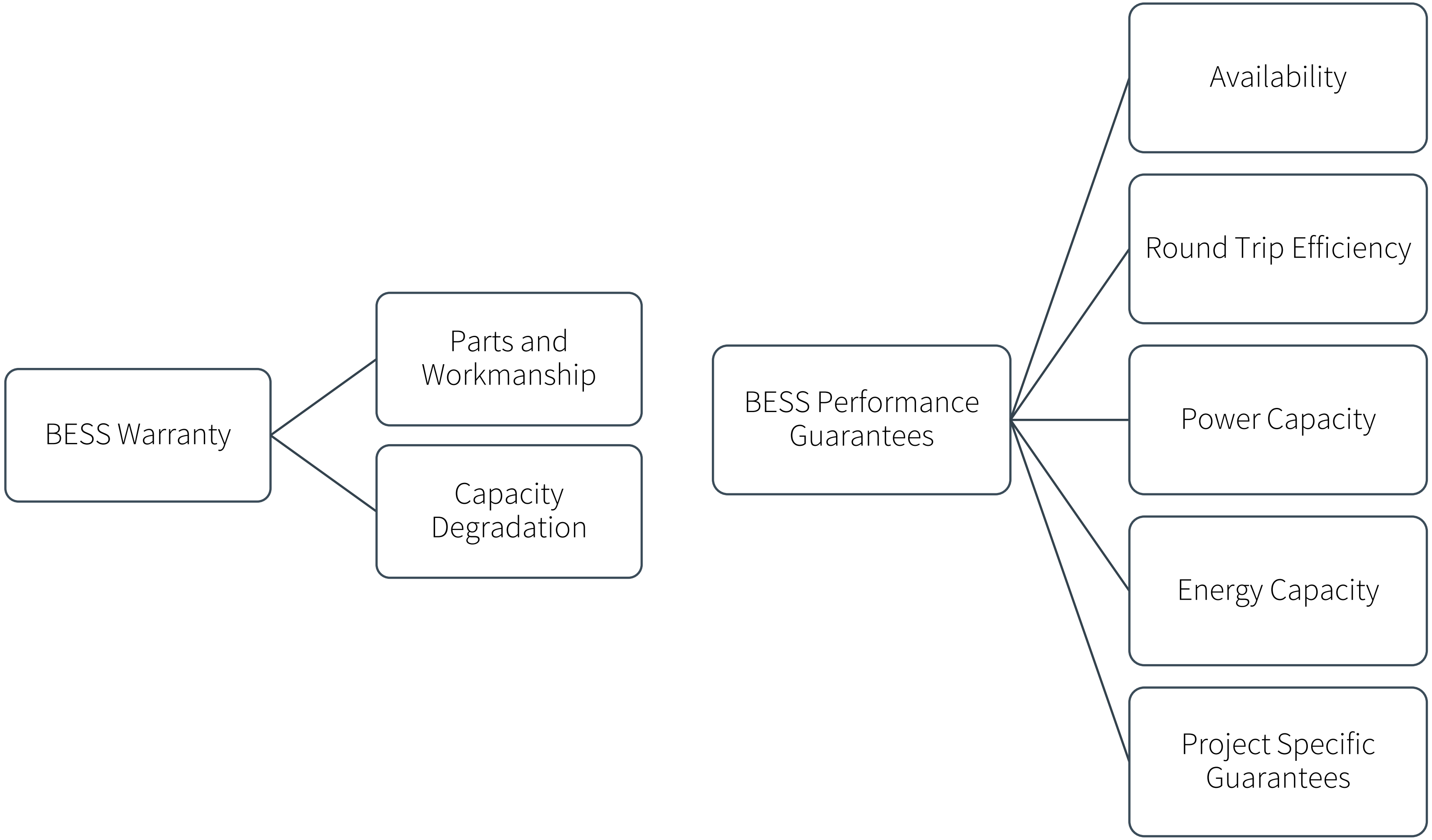
Supplier Engagement & Services

- Cover annual preventative maintenance
- Corrective maintenance may or may not be included
- Remote monitoring and troubleshooting
- Performance assessment
- Asset Management

Long Term Service Agreements

- Covers Preventative Maintenance, Monitoring
    - Occasionally Corrective Maintenance
- Outlines the maintenance requirements for the BESS
- May be coupled with warranty and performance guarantees
- Ranging between $5-10 USD/kWh-yr, excluding augmentation

Performance Guarantees



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BESS Fire Safety and Planning

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Safety & Fire Mitigation

Three Pillars to BESS Fire Safety

Prevent

- Technology Selection
- Top Tier Suppliers
- Safety in Design
- Safety Certification
- Installation Codes
- Testing for Performance

Monitor

- Battery Management System (BMS) to monitor temperature, voltage, and more
- Most Suppliers have 24/7 remote monitoring
- Maintenance program to ensure adequate BESS health

Respond

- Fire response training and coordination
- Work with local first responders to ensure safe and effective response in case of an emergency

Preventing a Fire & Thermal Runaway

BESS are designed with Safety Features at all Levels to Mitigate Thermal Runaway.
There are Rigorous Testing and Certification is Required for All Products

Equipment Design

- LFP Chemistry
- Cell Design
- Propagation Prevention
- Rack level electrical protection
- Fire Suppression System
- Ventilation System
- Appropriate clearances to prevent propagation

Testing & Certification

- Battery Cells, Modules & Racks and Battery Management System
  - UL1973 & UL1642
  - Safety features and design
- Testing completed at cell, module and unit level
  - UL9540A tests behavior in thermal runaway event
- Battery System
  - UL9540 Container & System level safety
  - NFPA 855 Container Design and Site Design Safety

Monitoring

BESS Suppliers typically offer remote monitoring and troubleshooting support

System Monitoring

- Battery Management System
- Cell & Module Level Monitoring
  - Temperature sensors and protection
  - Overcharge/Over-discharge (voltage) sensors and protection
  - Overcurrent sensors and protection
- Container disconnect in event of alarm
- Container smoke, heat & temperature detection
- Any alarms should be sent to Owner and Battery Supplier
- Critical alarms should be sent to First Responders

Emergency Response Planning

Emergency Response Planning is critical for BESS
Need to work with Operators, Local Community and First Responders to develop an approach

Automatic Response

- System Alarms
  - Sent to Monitoring Facility & Fire Department
- System is shutdown automatically
- Ventilation is activated to vent any gases built up

First Responders

- Advanced Training for First Responders
- Assess Situation & Coordinate Response
- Fire Suppression

Contain

- Prevent spread to other containers
- Clearances
- Spray with water or aerosol as needed
- Continue to monitor & respond as needed

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Fire Suppression Systems

Inert Gas/ Clean Agent

- Automatically released
- Aim to remove oxygen from container
- Ventilation is turned off, gases can build up
- Effective to suppress open flames
- Does not offer long term cooling to stop thermal runaway

Aerosol

- Automatically released
- Ventilation is turned off, gases can build up
- Effective to suppress open flames
- Does not offer long term cooling to stop thermal runaway
- Aerosol can be corrosive and damaging to equipment

Dry Pipe & Water Injection

- Can be automatic or manual
- Either flood container or modules
- Provide sustained cooling to bring temperature of cells down
- Ventilation can be left on to vent flammable gases
- Results in damage to flooded container

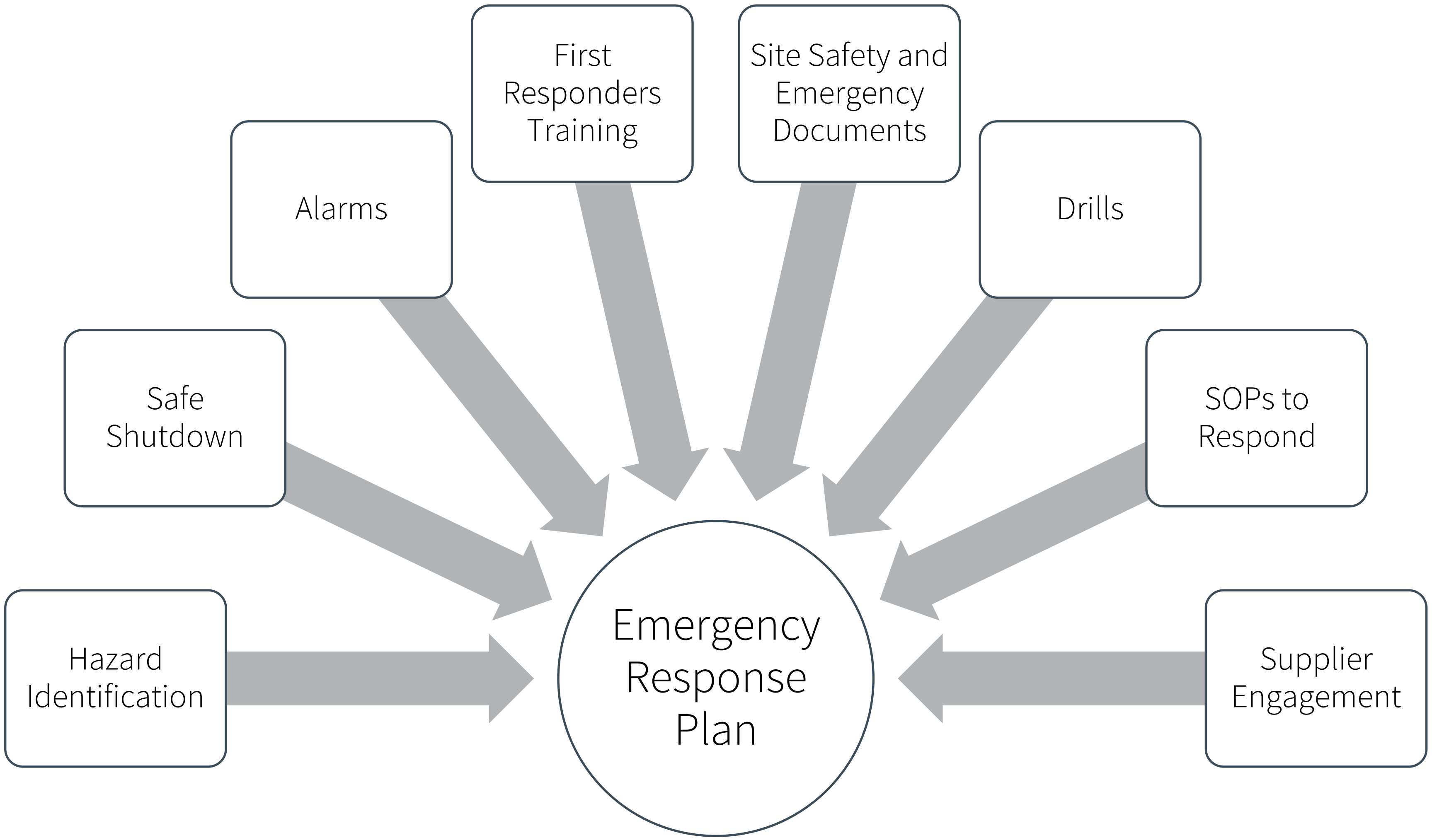
Let it Burn

- Controlled thermal runaway of enclosure
- Designed to reduce risk propagation (module, rack, enclosure)
- Need containment strategy – spray nearby infrastructure
- Ventilation can be left on to vent flammable gases
- Need defined emergency response plan

Deflagration Management

Flammable gasses (H_2 and CO, Hydrocarbons) are released during thermal runaway	Deflagration Panels	Panels designed to automatically blast off when gas pressure increases
		Deflect panels away from equipment and people
		Governed by NFPA 68
	Active Ventilation	Ventilation that is active when H_2/CO gas detected (typically 25% of LFL)
		Vents system until gases are extracted
		Governed by NFPA 69

Emergency Response Planning



Thank you

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please visit www.hatch.com