2022 Microgrid R&D Program Peer Review Meeting

Beyond DERMS: Demonstrating Advanced Grid Services for Utility and ISO/RTO through Behind-the-Meter DERs

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Beyond DERMS: Objectives

To create and demonstrate a holistic platform that enables utilities to evaluate and manage the impact of

- future DER deployments,
- load growth,
- electrification initiatives, and
- distribution network changes

using the same tools that are used for real-time operations and across time scales (historical and future planning).

Background and Project Evolution

Concept (FY16-17)

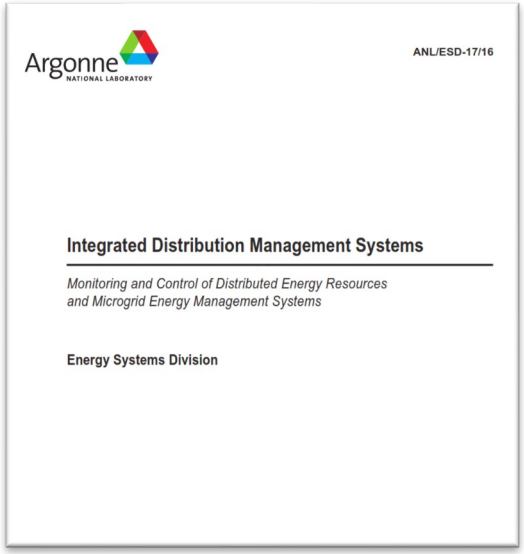
Structuring DMS, Microgrids, and DERMS

- Developing **an architecture of integrated** system, **use cases** for new DMS functions, **gaps analysis in integration** of DMS, OMS, µEMS and DERMS, and communication interface requirements for integration

Demonstration (FY18-20)

Interaction of Micro-EMS and DMS via Field Verification at PECO Smart Energy Campus

- Secure interface for microgrid and ADMS integration
- Simulation, Modeling and Integration Testing
- Configuration of over 1000 I/O points between microgrid and ADMS
- Validation of use cases
  - Microgrid Islanding and Reconnection by ADMS
  - Visibility and Monitoring of Microgrid by ADMS
  - Capacity Management Using Microgrid by ADMS
  - Utility Voltage Support Using Microgrid by ADMS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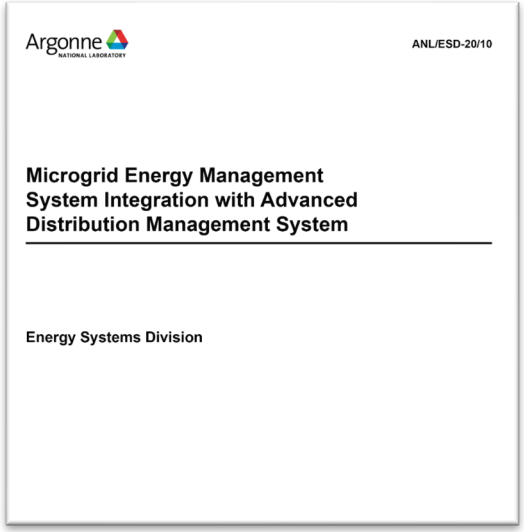
ANL/ESD-17/16

Integrated Distribution Management Systems

Monitoring and Control of Distributed Energy Resources and Microgrid Energy Management Systems

Energy Systems Division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ANL/ESD-20/10

Microgrid Energy Management System Integration with Advanced Distribution Management System

Energy Systems Division

The Need for Beyond DERMS

- DER integrated with ADMS/DERMS in microgrids alone do not resolve all resolve grid issues such as load relief, voltage, and constraint management.

- A new holistic and easy-to-use platform is needed that
  - goes beyond microgrids and can integrate aggregated DERs, microgrids, VPPs and utility ADMS
  - can provide market services to ISOs and distribution network services to operators in an integrated fashion
  - demonstrate the results at scale (thousands of devices or above 1 MW).

This project is a step forward to providing a tool for distribution system operators to demonstrate the use and value of a platform that offers visibility and management of aggregated DERs that is Beyond DERMS.

DERMS in Different Contexts

Beyond DERMS for the market, TSOs/DSOs, aggregation, and grid services

Full-featured utility DERMS

Utility manages interactions with bulk grid

Distribution Utility DERMS

Coordinate DERs for grid services (peak reduction, load shaping, constraint management)

DERs+ µgrids+ Aggregat ors

Virtual Power Plant/Aggregator

Bulk power purchases

Balancing services sold to wholesale market

Distribution Utility DERMS

Aggregator DERMS

Utility provides settings/signals for voltage, frequency, constraint management

DERs+ µgrids+ Aggregat ors

Device-level Cost Optimization

Bulk power purchases

Distribution Utility

Dynamic or TOU pricing signals

Aggregator DERMS

Dynamic pricing signals

DERs+ µgrids+ Aggrega ors

Proposed DERMS solution can work in any of the modes shown.

Beyond DERMS: Timeliness

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FERC OPENS WHOLESALE MARKETS TO DISTRIBUTED RESOURCES: LANDMARK ACTION BREAKS DOWN BARRIERS TO EMERGING TECHNOLOGIES, BOOSTS COMPETITION

NEWS RELEASES

FERC Opens Wholesale Markets to Distributed Resources: Landmark Action Breaks Down Barriers to Emerging Technologies, Boosts Competition

September 17, 2020

News Release: September 17, 2020
Docket No. RM18-9-000
Item No. E-1

Documents & Docket Numbers

FERC 2222

- If one can aggregate >100kW of DERs, meet telemetry requirements, and the utility allows the participation of DER, the aggregator can sell ancillary services to ISO.
- Thus, aggregation through DERMS is the way forward and Beyond DERMS platform can play a significant role.

Beyond DERMS: Project Progression

Argonne partnered with Packetized Energy in a multi-year build of the Beyond DERMS platform in three phases:

- ***Phase 1-FY20*** *built Beyond DERMS platform to integrate planning functions & deliver power grid services*
- ***Phase 2-FY21*** *added DER capabilities by integrating weather, load, DER forecasting, economic analysis (report: https://www.osti.gov/biblio/1825329*
- ***Phase 3-FY22*** *demonstrated advanced use cases and black-sky-day operations (report: https://www.osti.gov/biblio/1862821)*

Phase 1 (complete)
Conceptualization
- Systems (AMI, SCADA, DER, etc.) integration with utility
- Integration testing with 300 devices
- Simulation-based demonstrations

Phase 2 (complete)
Platform Development
- Demonstrate flexibility from batteries, EVs and heat pumps
- Integrate weather, load and DER forecasting
- Integrate economic analysis tools that facilitate with project planning

Phase 3 (complete)
Demonstration
- Demonstrate advanced flexibility use cases
- Black-sky operations
- Final report

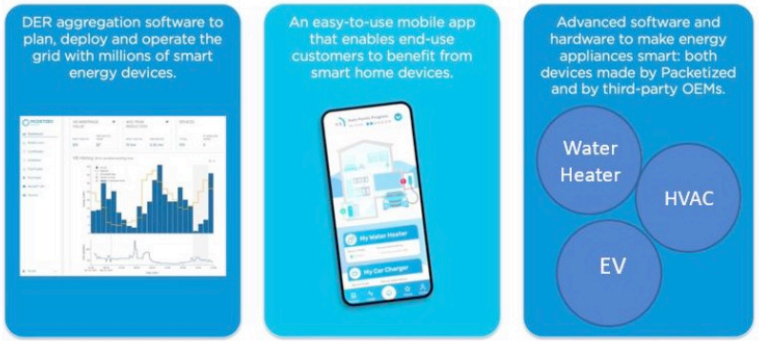
Phase 1 and Phase 2 Accomplishments

- **Platform Development:** Successfully developed Beyond DERMS platform to enable grid services via dynamic resources assessment of BTM devices
- **DER Integration:** Successfully integrated >300 DERs (smart water heaters, EV chargers) with 2 utility partners **(Vermont Electric and Burlington Electric)**
- **AMI Integration:** Successfully integrated over 30,000 AMI endpoints into a next-generation platform for distribution network analysis and planning
- **Use Cases Demonstration:** Demonstrated flexibility from batteries, EVs, and heat pumps.
  - Peak load management
  - Load shaping for energy price (LMP) arbitrage
  - Distribution network management (in simulation)
  - Ancillary services (in simulation)
- **Weather, DER/Load Forecasting Integration:** Integrated weather, load, and DER forecasting models into the platform
- **Value Proposition:** Integrated economic analysis tools that validated project planning facilitated through Beyond DERMS platform

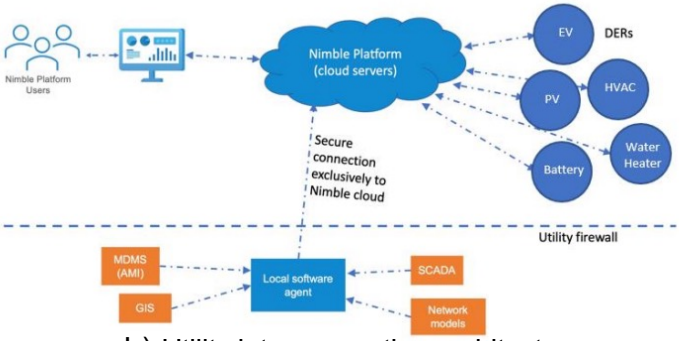
Phase 1 Highlight: Beyond DERMS Platform

Beyond DERMS platform connects grid operators, DER owners and their devices with **three key functions:**

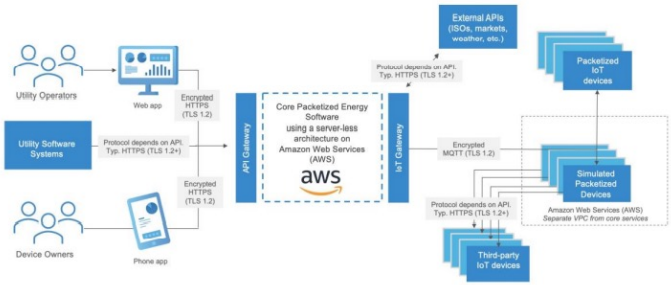
- **Beyond DERMS dashboard:** helps electricity grid operators visualize and manage how DERs operate to provide grid services
- **Beyond DERMS mobile app:** allows DER owners (home/business owners) to connect their DERs & manage how those devices interact with the grid.
- **Beyond DERMS backend Internet of Things (IoT) platform:** allows devices to interact with the platform in real time to coordinate the behavior of millions of devices and uses Packetized Energy Management (PEM) as foundation for IoT system.



a) Beyond DERMS platform



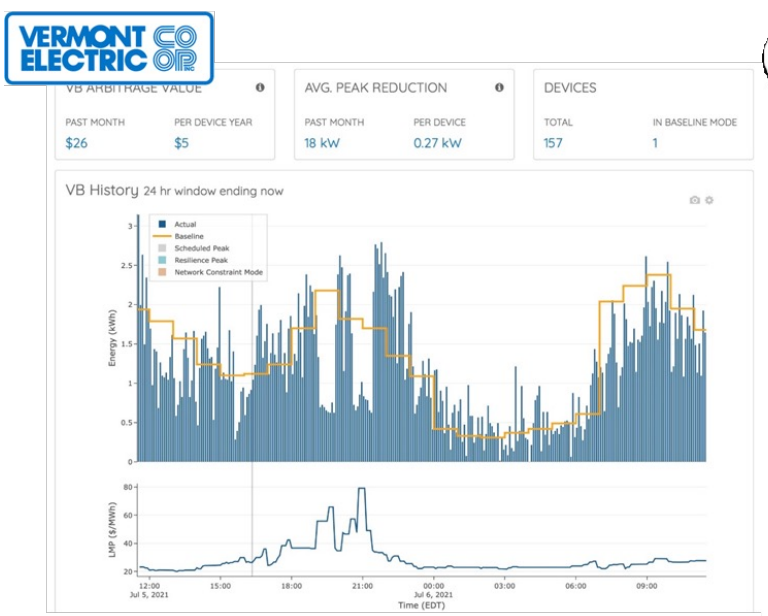
b) Utility interconnection architecture

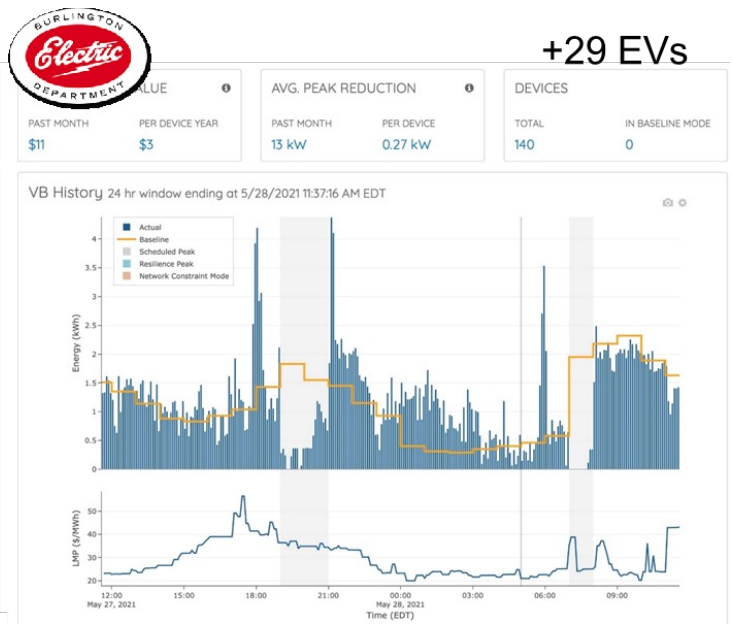


c) Cloud and IoT architecture

Phase 1 Highlight: Device Integration

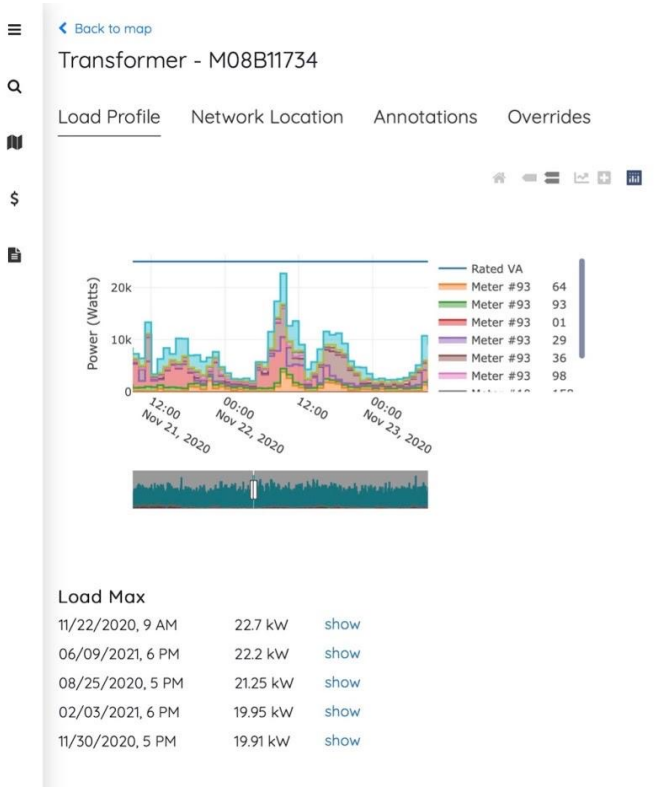
- Electric hot water heaters using the Mello smart thermostat for water heaters (~300 units).
- Level 2 EVSEs, primarily using the Turbo DX from Webasto (~40 units).
- Mini-split heat pumps (~5 units).
- BTM batteries and PV inverters (~10 units).
- Rooftop PV systems.
- Heat, ventilation, and air conditioning (HVAC) systems (particularly with heat pumps

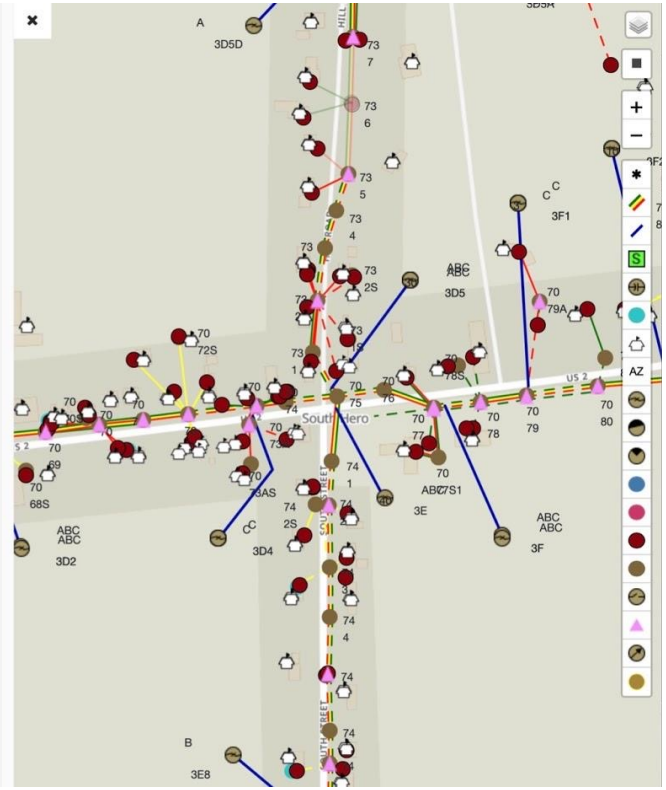




Phase 1 Highlight: Aggregation

Successfully integrated over 30,000 AMI end points into a next-generation platform for distribution network analysis and planning





Screenshot from the platform, showing the ability to aggregate AMI data to reveal time series loading on a particular asset (e.g., service transformer)

Phase 2 Highlight: Peak Prediction

Advanced forecasting algorithms allow us to accurately estimate the probability of peak events, based on uncertainty quantification, in order to more precisely schedule grid services from DERs

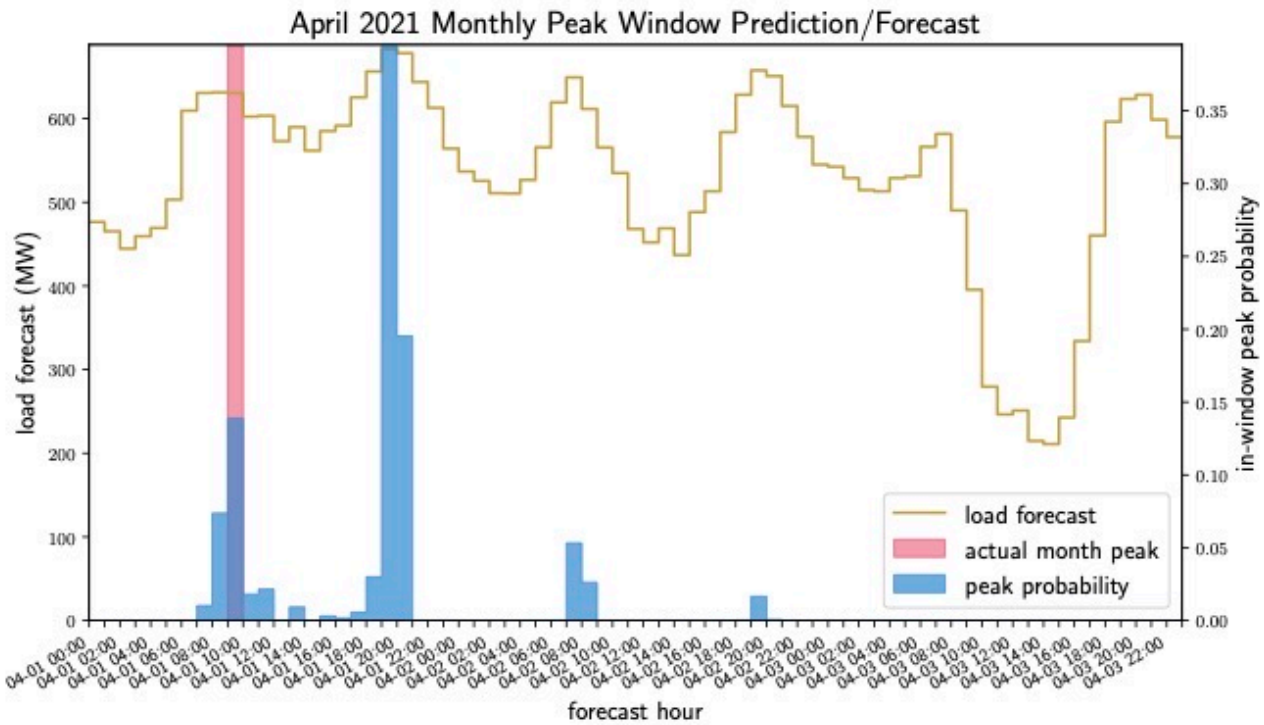
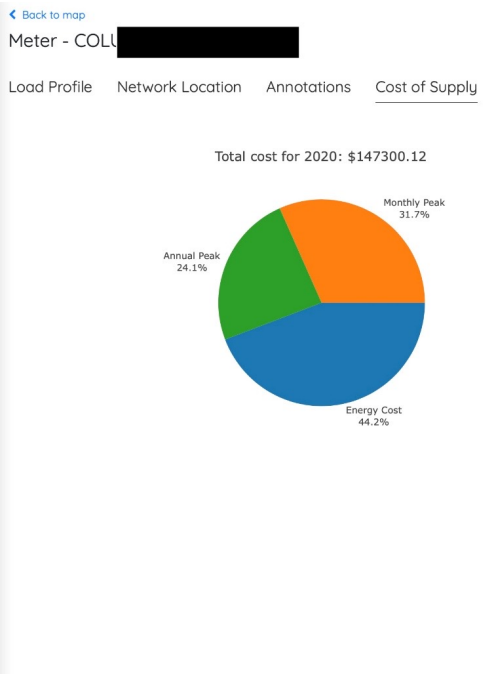
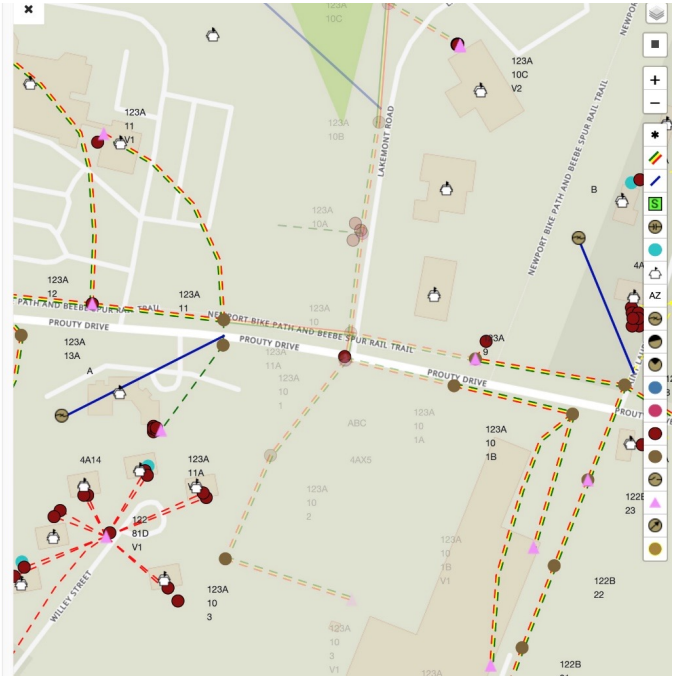


Figure showing the forecasted load level for our target region (yellow) and the probability of each hour being the peak of the month, which is needed to schedule DERs to flatten load profiles and reduce capacity costs.

Phase 2 Highlight: Cost of Supply Tool

A newly developed cost of supply tool uses AMI and market data to measure the cost of purchasing power and capacity to meet historical loads, enabling strategic planning for DER projects.





Phase 3-Tasks and Use Cases

- Demonstrate the automated provision of **ancillary services** to the ISO/RTO i.e., frequency regulation
- Demonstrate the ability to **automatically switch between operating modes** based on grid and market conditions
- Demonstrate **black-sky-day operation** scenario
- Quantify the performance of each grid service in terms of flexible capacity offered per device and for the portfolio as a whole
- Dissemination, information sharing, and final report

Use Case 1: Ancillary Services

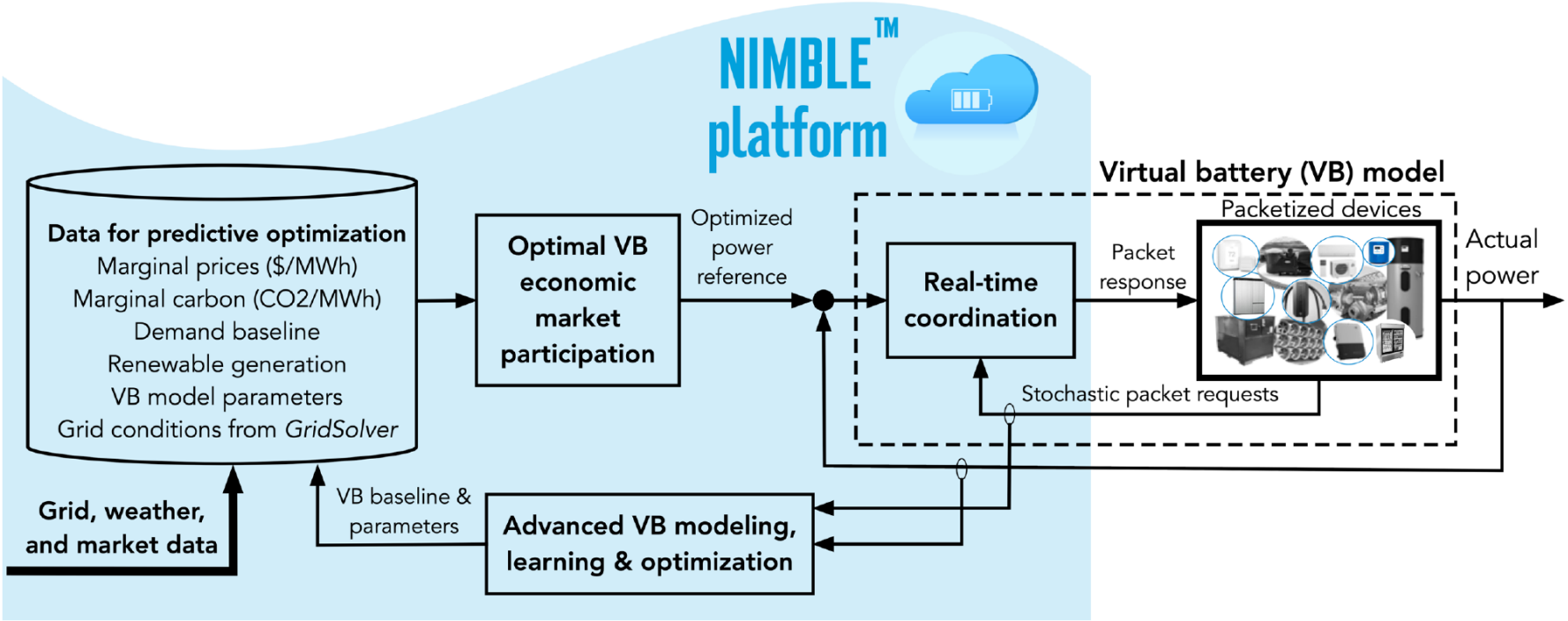
Response to PJM's Reg-D signals

- Used a group of ~200 DERs from Vermont Electric and Burlington Electric Service territories to provide synthetic AGC by tracking a typical PJM "Reg D" signal.
- Adjusted the baseline level of flexibility per device in different scenarios

Scores/Metrics:

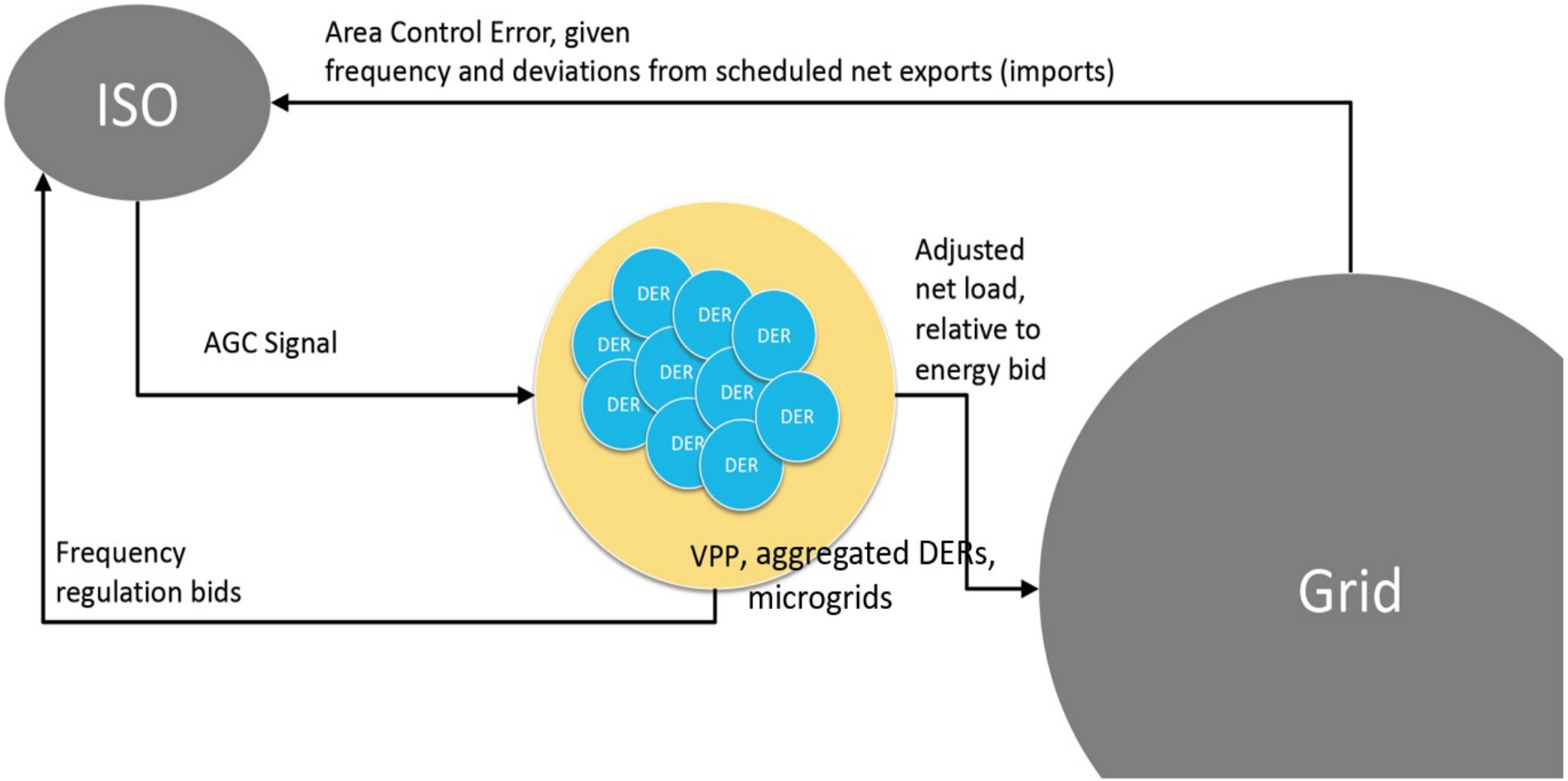
- **Accuracy**: (delayed) Correlation between target and actual
- **Delay**: Time delay between target and actual with the best correlation
- **Precision**: Average error between target and actual

Using Beyond DERMS Platform for Ancillary Services



Packetized Energy's Nimble Platform is the core of Beyond DERMS

DER Aggregation for Frequency Regulation

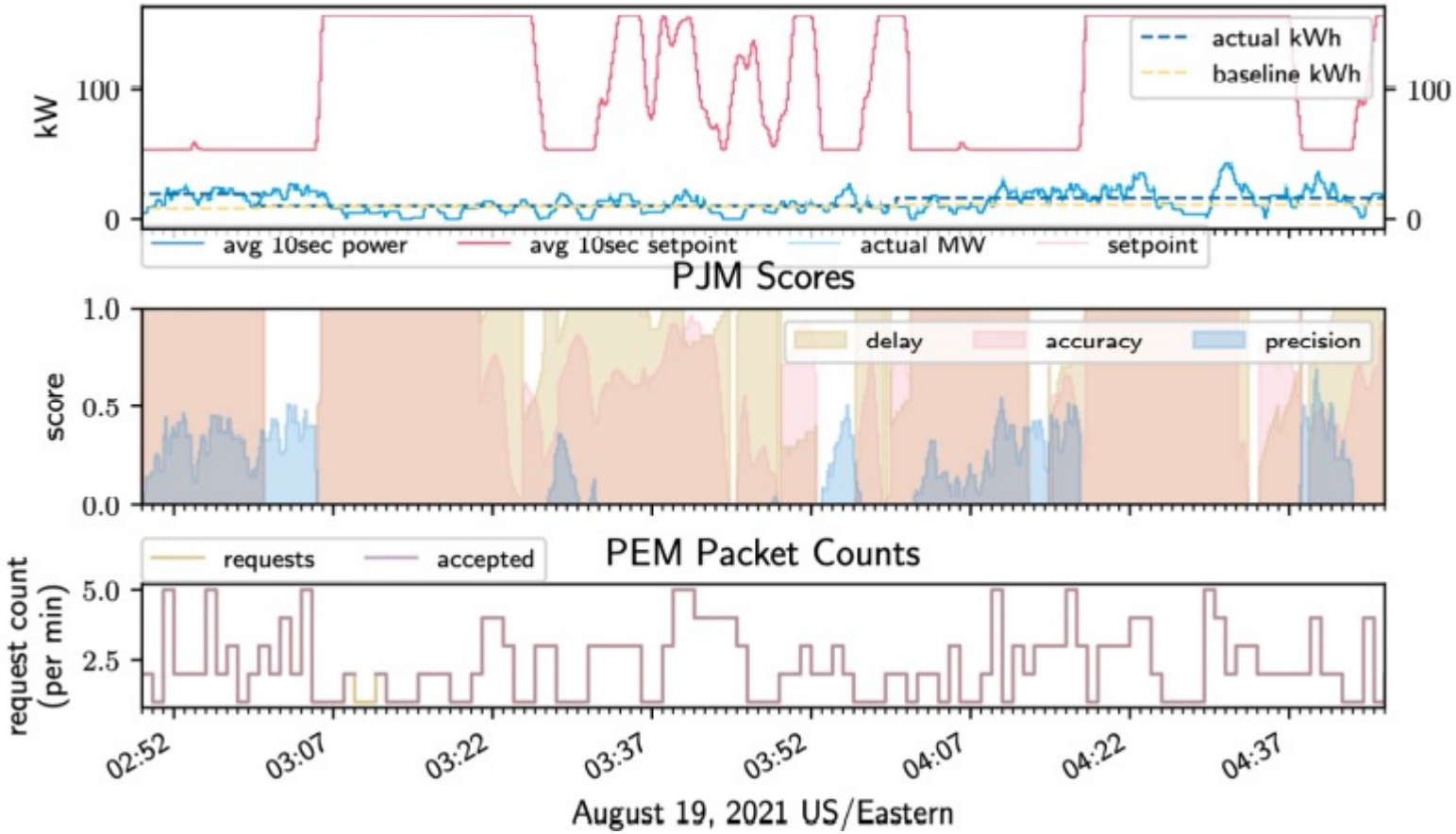


Small Scale Demonstration of Frequency Regulation

- Connected about 250 DERs primarily in Vermont utility territories
- Set Virtual Battery to track in real time with a test PJM Reg D signal.
- PJM performance scores above 90% (better than typical scores from most gas plants)

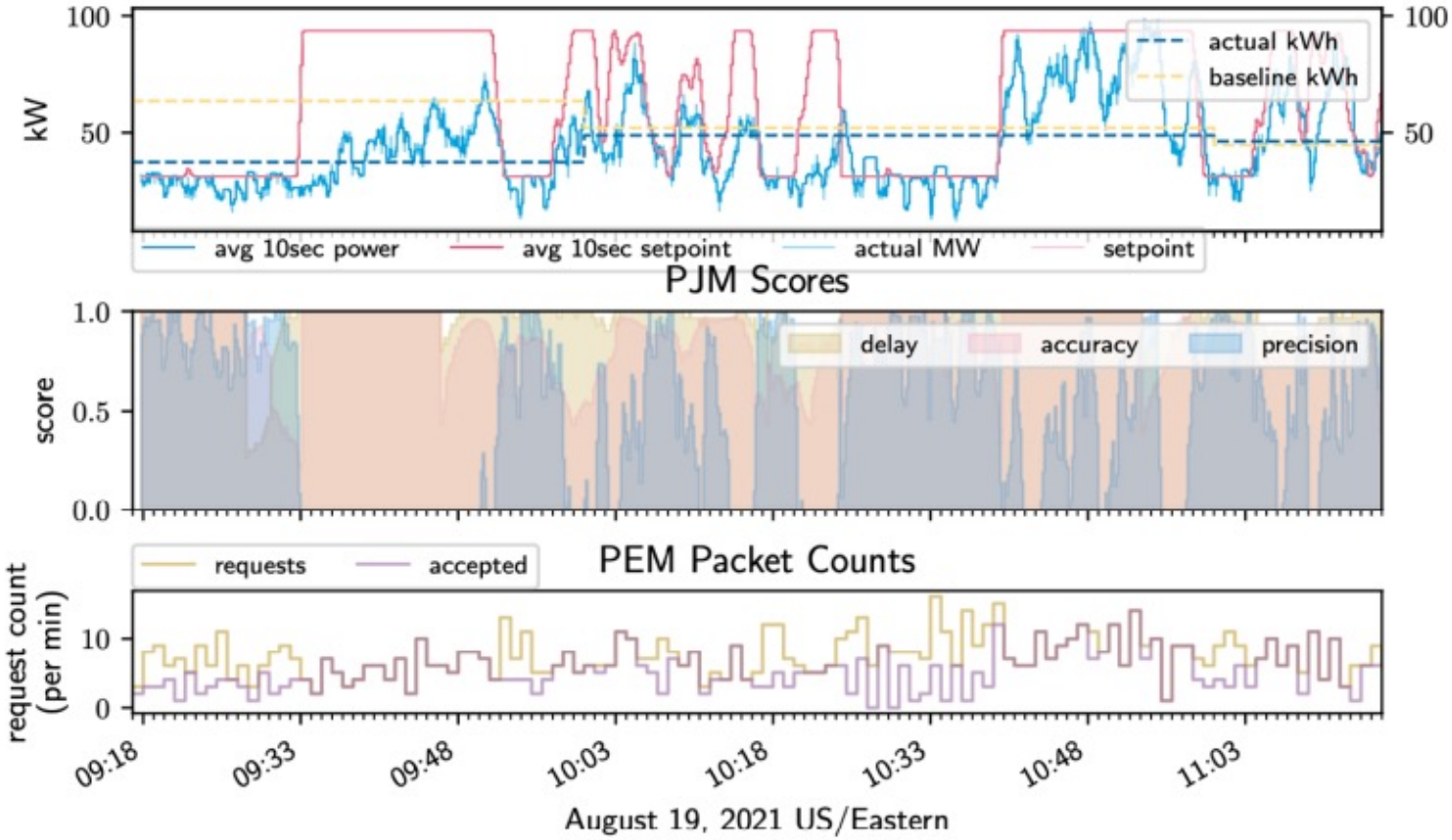
Frequency Regulation Results

Trial 1: AUG 19, 2021, 2:49 AM, 208 Devices: Target power level was set quite high, relative to the actual baseline load



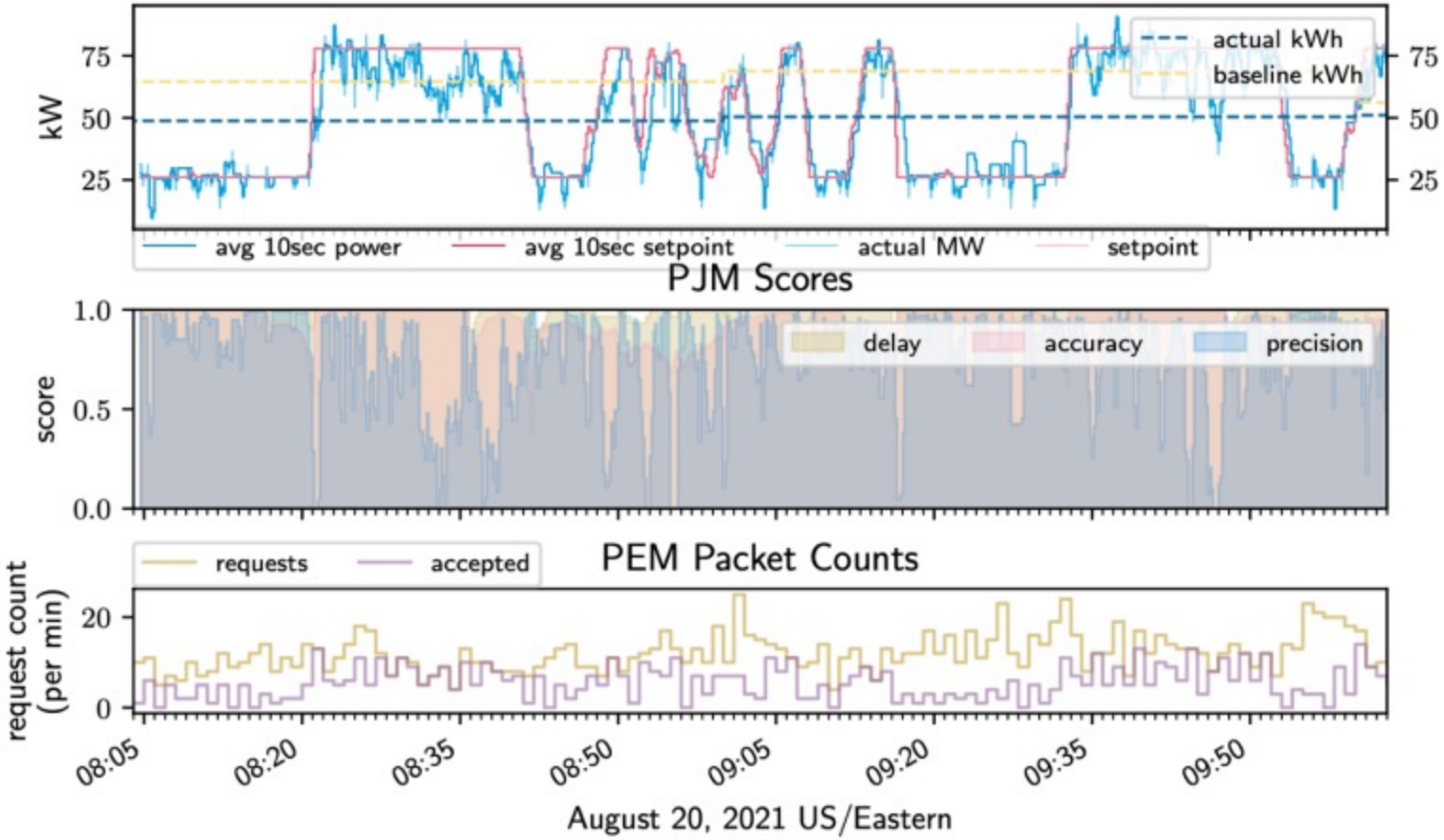
Frequency Regulation Results Cont..

Trial 2: AUG 19, 2021, 9:17 AM, 208 Devices: Scaled-down the relative position of the setpoint, but not far enough to fully allow the load to track with the target signal



Frequency Regulation Results Cont..

Trial 3: AUG 20, 2021, 8:04 AM, 208 Devices: Scaled-down the target setpoint to about 50kW, substantially increasing the overall performance scores.



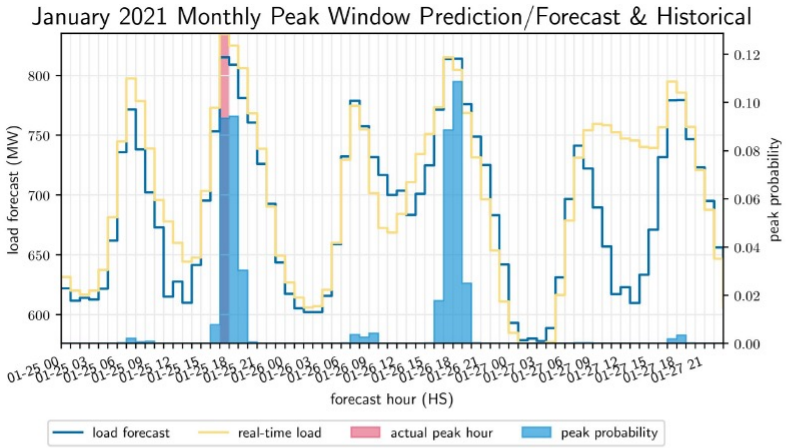
Use Case 2: Automated Mode Switching

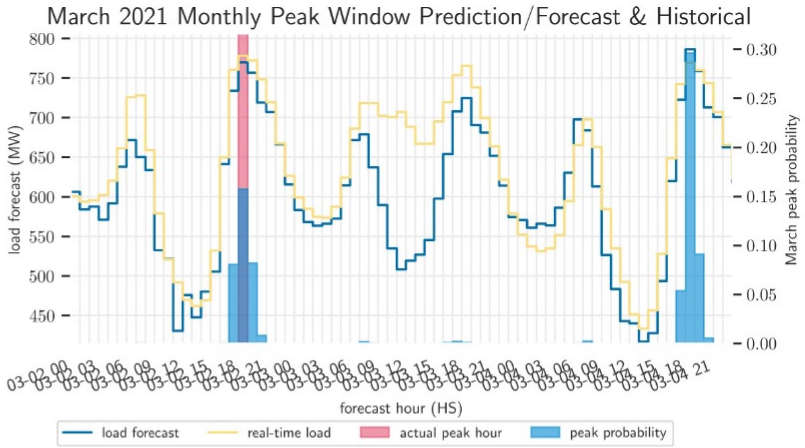
Automatically predicting peak events and then switching between Peak Mitigation and Energy Arbitrage modes

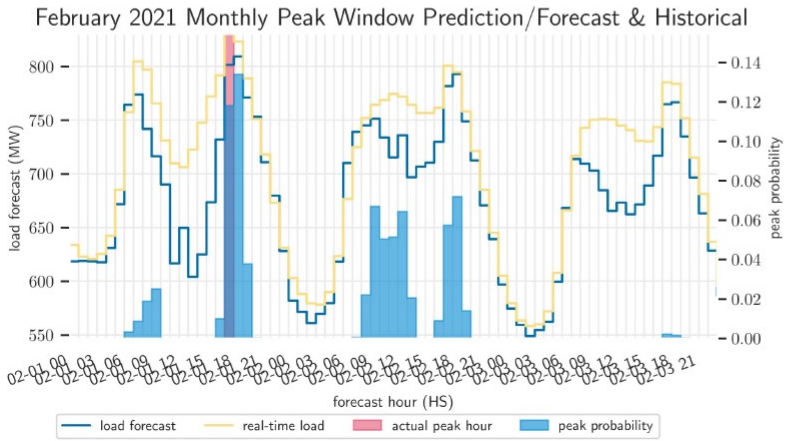
- Motivating scenarios:
  - When conditions are normal, we can use DERs for bulk grid market services, such as frequency regulation or energy arbitrage while maintaining tight control on customer QoS constraints.
  - When grid constraints emerge, we will want to focus narrowly on managing those constraints and may want to relax QoS limits for a short window of time.
  - Can we automatically predict when “high-cost windows” will occur and switch between operating modes?
- Process for Automated Mode Switching

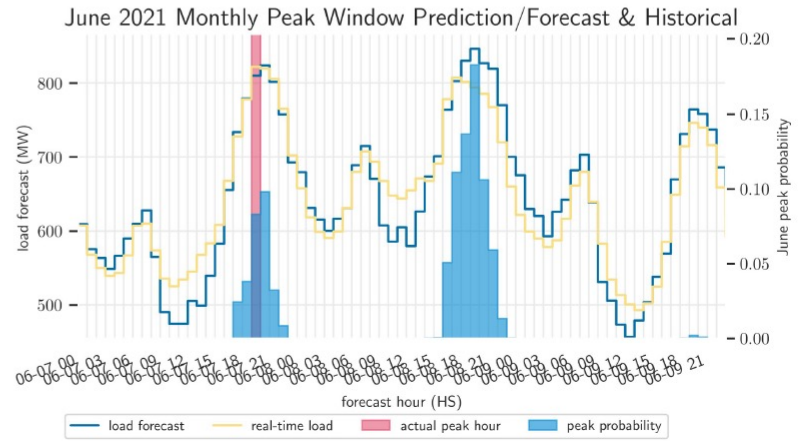
1. Forecast circuit-level and regional net load over a ~72-hour horizon.
2. Compute the probability of binding network constraints or expensive peak load events.
3. If the probability is low:
   - Continue to perform economic grid services within customer QoS limits (ancillary services or load shaping for energy arbitrage).
4. If the probability is high:
   - Execute peak load management.
     - a. Pre-position.
     - b. Notify customers.
     - c. Minimize load with (somewhat) relaxed QoS limits.
     - d. Recovery.

Results: Actual Peak Events Compared to Model: Validation of Accuracy









Once the peak is detected, the platform automatically switches the mode from grid service mode to constraint management mode

Use Case 3: Planning Platform Demonstration Showing Results of Black-Sky-Day Operation.

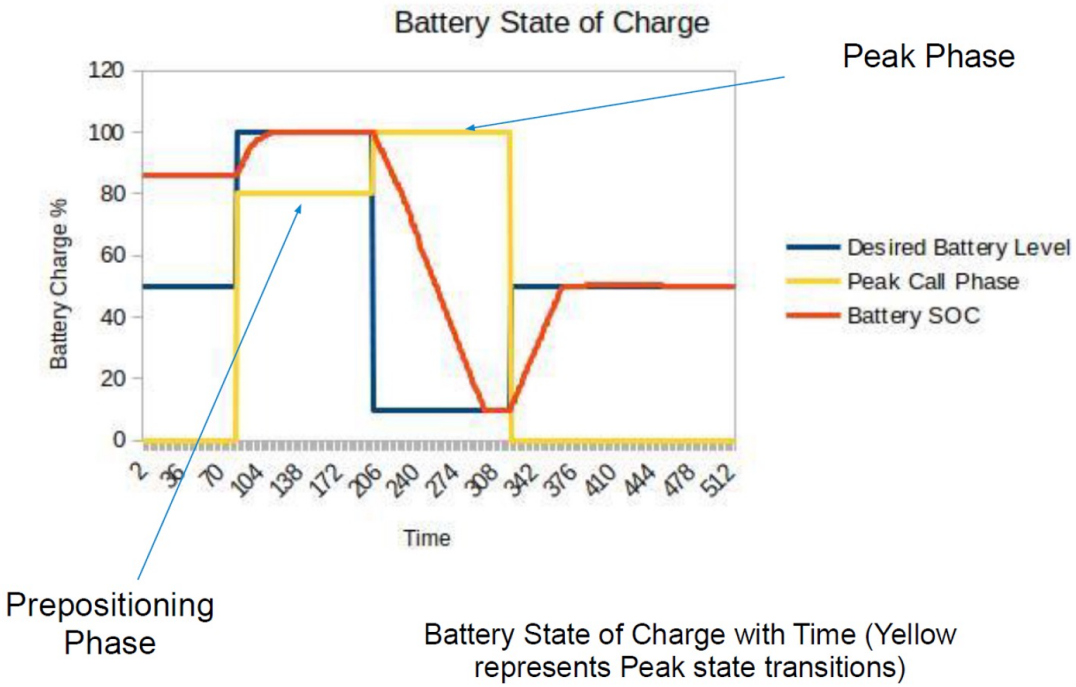
- Beyond DERMS platform was used to manage energy backup systems, such as batteries, for both “blue sky” (normal grid operations such as peak load management) and “black sky” (backup power) scenarios.

- Our finding is that it is possible to use DERMS to build energy storage programs that provide both energy resilience for customers and grid/market support via aggregators and/or DERMS.

The residential-scale battery system and inverter used for this “Black Sky” demonstration.

Grid Services under Blue Sky Scenario

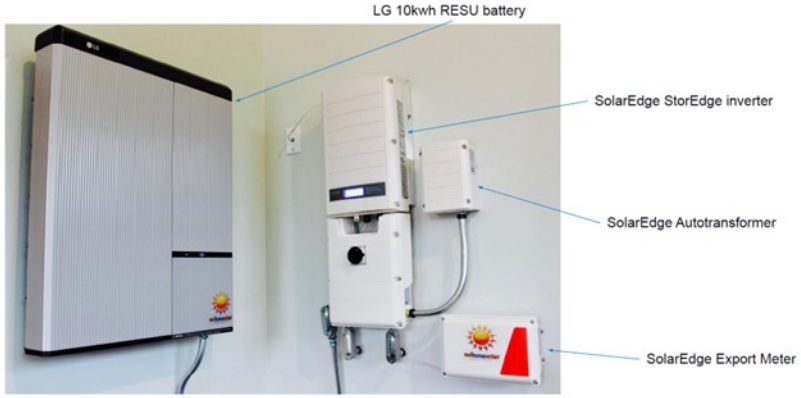
- Peak call via Beyond DERMS platform
  - 4-Hour Event
    - 2 hours of prepositioning (Force battery to 100% capacity)
    - 2 hours of peak (Force battery to 10% capacity)
  - Battery nominal reserve capacity outside of a peak set to 5%



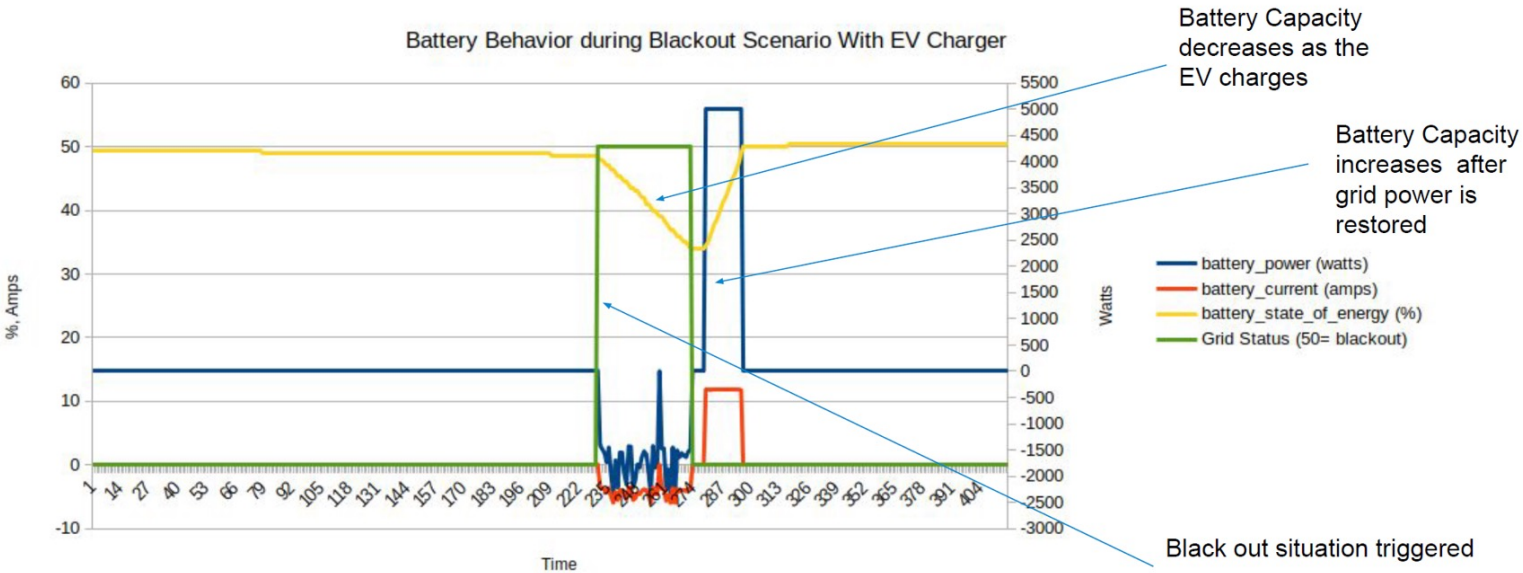
Battery State of Charge with Time (Yellow represents Peak state transitions)

Grid Services under Black Sky Scenario

- SolarEdge StorEdge/LG RESU Battery combination
- Backup Panel on SolarEdge sources a Wallbox EV charger restricted to 6A of Charging current.
- Black Out event-triggered
  - 50-minute duration
  - 1 charging event during starting prior to blackout event and extending into the event.



SolarEdge/LG Battery backup solution



Dissemination and Publications

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ANL/ESD-22/7

Beyond DERMS: Demonstration of Automated Grid Services, Mode Transition, and Resilience

Energy Systems Division

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ANL/ESD-21/17

Beyond DERMS: Platform Development, Flexibility, Prediction, and Value Measurement

Energy Systems Division

DERMS Projects Enabled and Supported by Beyond DERMS Project

California Aggregator

With support from CA Energy Commission, deploying ~7000 smart devices and providing grid services (peak reduction for resource adequacy, energy arbitrage) to CAISO.

Collaborators include GRID Alternatives, Leap, Demand Side Analytics.

Vermont Utility DERMS

Integrating with utility AMI and SCADA systems to use DERs for peak reduction to mitigate capacity costs, provide energy arbitrage, and local distribution network services such as voltage management and feeder constraint management.

New York Hybrid

With support from NYSERDA and a NY utility, demonstrating how DERs can provide grid services to NYISO (e.g., frequency regulation) as an aggregator, while also providing value to distribution utility (e.g., non-wires alternatives) and energy customers.

Conclusions and Next Steps

- The project successfully demonstrated advanced grid services through the aggregation of DERs using the Beyond DERMS platform.
- The project provides a visibility and management tool that can help utilities relieve congestion and while also delivering grid services to markets
- Technology seen as promising and acquired by EnergyHub, resulting in much greater industry impact looking forward
- Next Steps:
  - Implement the architecture and services specified in IEEE 2030.11
  - Focus on constraint management in the distribution network during the dispatch of these services.

Adaptation of Beyond DERMS Technology at Scale

- California Aggregator Project

PACKETIZED ENERGY

Packetized Energy Awarded $2 Million Contract to Make Energy Demand Flexible and Help Solve California Grid Challenges

Company Will Lead Project Funded by California Energy Commission BRIDGE Program

- Through this project, Packetized Energy will be able to provide valuable energy flexibility through the state's grid operator (California ISO), in a way that goes beyond conventional demand response programs.