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PUC PROJECT NO. 51603

PUC PROJECT NO. 52373

REVIEW OF DISTRIBUTED	**§**	**BEFORE THE PUBLIC**
ENERGY RESOURCES	**§**	**UTILITY COMMISSION**
	§	**OF TEXAS**

COMMENTS FROM TESLA, INC.

Tesla, Inc. (Tesla) appreciates the opportunity to provide comments to this important project at the Public Utility Commission. Tesla has a material interest in all aspects of energy reliability and the resilience of a flexible, dynamic grid in ERCOT, Texas. Tesla, Inc. affiliate Tesla Energy Ventures, LLC holds a license for retail business in Texas. Tesla also owns and operates Power Generation Company assets participating in the ERCOT wholesale market. Tesla also is a vendor and Original Equipment Manufacturer (OEM) of devices and software which facilitate the transition of residential, commercial, and industrial customers to sustainable, renewable-energy powered solutions that allow those customers to self-consume stored solar energy and provide grid services from excess, high-value capacity from controllable devices, particularly battery energy storage systems (BESS) on the distributed grid and behind-the-meter (BTM). Tesla also owns and operates a major industrial load in the Lower Colorado River Valley transmission system area and is the owner and operator of a commercial scale rooftop solar installation on its industrial facility. Tesla will also be the first party to utilize ERCOT NPRR1100 at that load site.

In the past two and a half years since Tesla's entry into the ERCOT market as a Corporate Member of ERCOT, Tesla staff and partners have brought exceptionalism and innovation to every aspect of the company's efforts for advancing a sustainable, reliable, dynamic, and competitive grid, and supporting changes to the ERCOT market rules that will deliver on these goals. Tesla staff have devoted hundreds of hours, individually and through coalitions of innovation-minded companies and incumbent stakeholders in the ERCOT market from ALL market segments, to the improvement of the state's market design for the benefit of increasing innovation and competition in ERCOT. This proceeding for the consideration of advancing Distributed Energy Resources (DERs) is no different. Tesla takes seriously the challenge before the state of Texas to help the complete electric system survive the next emergency, support the market design of ERCOT, and save lives.

Without a model for small commercial and residential DERS to be dispatched in SCED, ERCOT does not have command and control of when and how these energy-limited resources actually provide those ancillary services. For this reason, Tesla is focused on providing information in this proceeding primarily on the need for ERCOT to quickly develop a framework or utilize an existing market framework to enable market participation in ERCOT Secured Constrained Economic Dispatch (SCED) by aggregated residential and small commercial BTM DERS capable of providing the same, or better, quality of grid services as conventional power plants and front-of-the meter storage. It is unfortunate that Tesla has heard numerous contentions since (and during) the Texas legislative session following Winter Storm Uri, that DERs providing these grid services is not a priority for ERCOT because of sundry reasons such as: (i) there is already some residential demand response participating in ERCOT (which is NOT export of grid services and does NOT enable residential aggregations to receive dispatch signals

from SCED to providing ancillary services on ERCOT's command), (ii) retailers already offer such demand response products (the paltry record of BTM participation in ERCOT products from residential systems is already well established in PUCT Docket No. 52373), and (iii) the MWs that DERS which export can provide to the grid, are not substantial enough to be a priority for ERCOT implementation. Some of these arguments were heard by the public as recently as at the Tesla-hosted Virtual Power Plant workshop on May 31, 2022, even though it was clearly laid out by workshop presenters from multiple companies that there is massive opportunity that the ERCOT market can start accounting for immediately. A recording of that workshop may be obtained from third-party websites that provide a full recording of the session. These arguments also miss the goal: ERCOT needs all resources which it can "command and control," and this is at the direction of the Commission and the Texas Legislature.

Finally, it is critical to note that enabling this grid participation for aggregated small commercial and residential DERs (individually, 5kw to 100 kw by site) is a new value stream for an energy and ancillary services program and a new price signal to investors and innovators (load serving entities, retailers, and residential and small commercial customers). To make the demand-side of the grid smarter and flexible, there needs to be recognizable value to chase in the market – that is the essential principle of the ERCOT design. While ERCOT struggles to find the supply-side "cover" needed to manage sudden and frequent demand contingencies on the system, the demand-side is adding instantaneously responsive resources. *If* the ERCOT market helps, this growth will multiply, and the next grid emergency may very well solve itself in advance, right down at the residential customer level. That growth in DER adoption will, in turn, also give more homes and small businesses the tools they need to be emergency facilities that can support their neighbors and their communities.

Importantly, aggregated DERs can provide reliability service from energy-limited, high capacity value systems to respond to daily, non-emergency peaks throughout the year and reserve capacity to support extended outages (changing behavior in seconds). Another often-heard argument is that if DER systems are purchased for self-use and outage management, then it is not clear how those resources can provide daily grid reliability or support the grid in an emergency. Examples are obvious. Taking the example of solar-paired residential batteries: the majority of the time when the grid is not invoking an EEA, but is managing daily constraints and system imbalance, these DERS under ERCOT's command and control will use the excess capacity from residential batteries to do whatever ERCOT wants them to do in a program DER customers sign up for. While a home load may use about 0.75 kW – 1.3 kW, a single residential battery is ~5kW. With two residential batteries for those that elect whole-home backup, there is nearly 8 kW available to instantaneously deploy in response to dispatch up/dispatch down instructions from ERCOT. Customers choose to enroll their systems in these programs because it is a value for their investment presented by the load-serving entity managing their energy bill, a meaningful opportunity to help the grid, and a fit with the sustainability and resiliency objectives these customers have already committed to when they invested in solar and storage. In the time when ERCOT needs to invoke an EEA, customers can preserve a higher level of their stored capacity instead of sending it back to the grid, but ERCOT would *know* when that was happening, because ERCOT could direct that those customers to relieve the grid quickly, simply by raising prices and signaling to load-serving entities that those customers should move to a self-consumption mode. If customers automatically respond to a price signal reflecting the emergency condition, no phone calls need to be made by a utility to tell specific customers to "conserve" and there is no misinformation about what is happening on the distributed system in

real-time. The takeaway is clear: aggregated DERS add value and resiliency to help the Texas grid. ERCOT's market is set up already to allow Qualified Scheduling Entities (QSEs) to undertake full responsibility for how resources are made available and whether they will be available in response to an event on the system – this structure will enable customers to be a powerful aggregated solution and provide seamless services to the grid under a variety of conditions. And the power of this solution will be even more significant when ERCOT completes implementation of real-time co-optimization, allowing QSEs to make five-minute decisions for all of the ancillary service products these DER aggregations would be capable of providing.

It is important to note that the proliferation of distributed, controllable, export-capable devices under 1 MW is accelerating anyway and will do so without clarification of the policy around how these devices can be used for grid service. We should not ignore the growing unrealized price-responsive capacity that ERCOT could quickly dispatch to provide grid-saving ancillary services by controlling their behavior in SCED. Tesla hopes that the work accomplished to date in our virtual power plant demo and other policy efforts will prepare the market for this inevitable growth.

Since Winter Storm Uri, in recognition of the commonsense realities that are at stake, Tesla has been developing and providing evidence to ERCOT directly to demonstrate the fact that the technology is already deployed and to help kickstart a model for grid services in SCED from aggregated small DERs. Separately, Tesla has enlisted the support of like-minded companies that believe in the power of these resources to benefit the grid and the public, to formally propose a revision to the Other Binding Document, Requirements for Aggregate Load Resource Participation, that would allow for sites within a Net Load to provide injection (export)

at the individual site meter, reduce the Net Load while the aggregation always stays a Load to ERCOT, clarify that such aggregations can send telemetry to ERCOT for the load reduction and the aggregated response of injecting/exporting sites within that Load, and clarify that both small commercial and residential customers can co-participate in these aggregations. Recognizing that ERCOT has been fundamentally limited in providing a program that directly dispatches residential DERS in the nodal market for several years, Tesla has worked to develop this short-term solution that will allow aggregated DERS to have a meaningful trial run (individual aggregations limited to a single Load Zone, smaller sizes per aggregation, limitations on growth of each aggregation) while more difficult issues are resolved in a long-term solution which could accept thousands of MWs on the system.

In addition to the narrative shared below on Tesla's work to accelerate DER participation in the ERCOT market, **Tesla requests that the Commission direct ERCOT to prioritize the following actions:**

1. Allow Aggregate Load Resources to provide injection capacity from individual sites in a framework that can be implemented no later than December 2022, which is the objective of OBDRR041;

2. Continue leadership over distributed energy resource aggregation participation in the market, including facilitating working sessions with distribution planning entities and other market participants who can help solve short term issues identified in ERCOT's Draft Issue Summary for OBDRR-41 shared at the May 31, 2022 Workshop. This includes:

a. Establishing transparent criteria for acceptance, including the absolute minimum requirements that market stakeholders and distribution system planners need to satisfy in order to accept ALR/DER aggregations that inject on their systems;

b. Encouraging written filings of all objections and proposed revisions to OBDRR041, to ensure transparency and public recognition of challenges, concerns, and objections to enabling this solution;

c. Encouraging discourse among stakeholders and certainty for market by putting an "end date" on discussions of revisions and approaches for enabling the solution and committing ERCOT resources to enabling that "end date";

3. Study potential distribution grid savings and distribution grid growth over a 2-year period so that when ERCOT can provide a nodal dispatch model for exporting DERs, distribution utilities are prepared and well-informed for the changes required on their systems to handle larger quantities of exports;

4. Kick off load zone remapping and/or prioritize "aggregation zones" to accommodate nodal-zonal congestion concerns before aggregations grow on the ERCOT system;

5. Complete real-time co-optimization;

6. Plan for an automated means to add and remove customers from an aggregation;

7. Allow residential customers to receive 4CP through their Load Serving Entity/Retail Energy Provider;

8. Shorten duration for nonspin and ECRS, or allow QSEs to manage that risk;

9. Simplify interconnection process - have guaranteed timelines for areas of distributed grid that have been identified as high capacity for more DERs;

10. Identify how DERs can help with firm load shed planning – including, but not limited to, convening a forum of distribution system utilities (at an existing or new ERCOT working group) to discuss limitations, barriers, and solutions with the market.

Tesla appreciates the opportunity to comment in these proceedings.

Informational Narrative

Tesla's Virtual Power Plant Demonstration in ERCOT

Tesla's goal was to provide ERCOT with proof-of-concept data showing that behind-the-meter residential storage devices, in aggregate, are technically capable of following ERCOT SCED Base Point instructions and providing various Ancillary Services to support the electric grid. These tests are similar to tests Tesla would have undertaken if attempting to register an

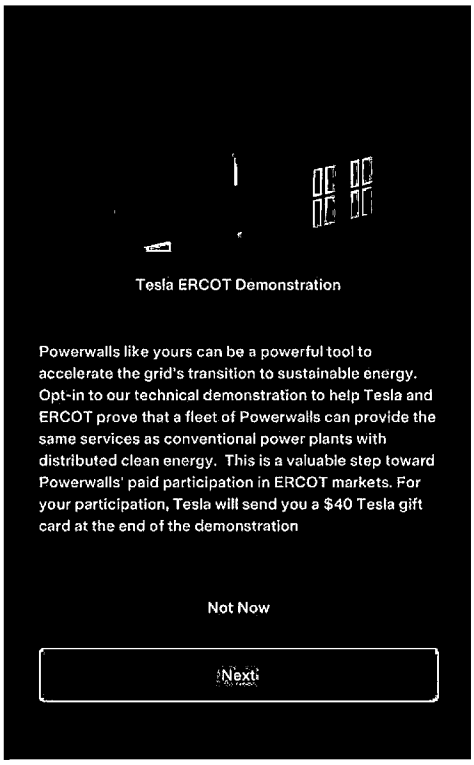
Aggregated Load Resource (which can provide non-spin as Load under current rules), but also demonstrated customers' ability to provide non-spin and other ancillary services from an aggregation of charging and discharging devices.

1. The outlines of Tesla's initiative to unlock DER capacity through the Requirements for Aggregate Load Resource Participation were discussed in detail at a meeting between Tesla personnel and ERCOT Staff in Austin on Dec. 10, 2021. It was established that for ERCOT and the market to consider this policy solution, technical data would be needed to verify that the technical solution is available and provable.

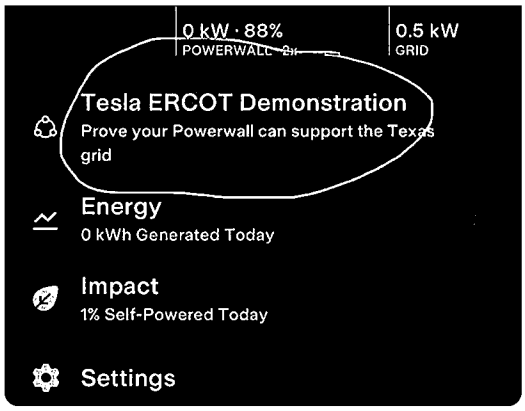
2. Subsequently, Tesla began regular virtual meetings with ERCOT Staff to establish parameters for a proof of concept, similar to the work ERCOT Staff would do to study the potential resource if Tesla had directly attempted to register an Aggregated Load Resource (ALR) under the currently available and implemented market framework. As part of this process, ERCOT Staff agreed to review Tesla-provided data for a series of technical demonstrations using Tesla customer sites that consented to participate in the proof-of-concept of what an actual ALR would look like with the capabilities Tesla demonstrated.

3. ERCOT provided data representing actual dispatch signals, which Tesla engineers in turn used to execute test deployments of the customers that volunteered to participate in the proof-of-concept aggregation, to demonstrate the ability to comply with Market Rules in eventual participation as an ALR.

4. To create an aggregation consistent with a realistic ALR test resource, Tesla reached out to residential customers in competitive choice areas of the ERCOT Region who had acquired Powerwall batteries, usually in combination with rooftop solar panels.[1] The test resource consisted of 61 residential sites with Powerwall batteries on site, with the Powerwalls capable of reducing the on-site residential Load to zero and also injecting energy to the grid. The aggregation also included 75 additional sites consisting of Loads that did not have any devices under control. These sites were present in the aggregation for purposes of ensuring that the resource always remained a net Load during the test period.



In-app message to Tesla Customers



Social media announcement, March 5, 2022

[1] Note that these customers at the time of the technical demonstrations were served by multiple Retail Electric Providers (REPs). Tesla acknowledges that actual ALR participation requires that all sites in an ALR be served by the same Load Serving Entity. Tesla has formed a REP and has a near-term goal of acquiring Powerwall customers in sufficient quantities to meet the ALR requirements.

5. Tesla provided ERCOT with actual meter data from the on-site meters that are routinely installed alongside the TDSP revenue meter when a customer acquires a Powerwall battery and/or rooftop solar panels. These meters are capable of producing data at a far more granular level than the 15-minute TSDP meters; Tesla extracted data with a granularity of 5 seconds and submitted the data to ERCOT for review.

ANCILLARY SERVICES RESULTS

SCED Dispatch and Non-Spin Reserves

Current ERCOT Rules limit ALR participation to Security Constrained Economic Dispatch as Controllable Load Resources, adding that SCED qualification automatically qualifies the Resource to also offer into Non-Spin in the Day Ahead Market and, if cleared, to provide the service in the following Operating Day. Accordingly, Tesla began its technical demonstration by indicating responses to SCED base point instructions, simulating participation in Non-Spin as an Offline Resource. When Non-Spin is deployed by ERCOT, CLRs, including ALRs, carrying a Non-Spin responsibility are required to release Real Time Market Bids to Buy into the SCED clearing engine no later than 25 minutes after the deployment instruction is issued; five minutes later, the Bids to Buy are active in the SCED engine and subject to receiving Base Point instructions. SCED Base Point instructions, usually issued every five minutes, can require the Resource to move incrementally in either direction, representing increases or decreases in generation and Load.

ERCOT provided Tesla with actual historical SCED data representing a period from 3:55am until 5:20am. Tesla executed the SCED test on March 18, 2022. The aggregation responded

to a total of 17 SCED Base Point instructions over the test period, using actual battery discharge (resulting in both offsets to on-site Load and energy injections to the grid), indicating compliance with Controllable Load Resource Energy Deployment Performance (CLREDP)[2] requirements well within the parameters established in ERCOT Market Rules.

Regulation Service

CLRs must be separately qualified to participate in Regulation, which is procured by ERCOT as two Ancillary Services -- Regulation-Up, requiring generation increases or Load reductions, and Regulation-Down, requiring generation decreases or Load increases. Regulation signals are sent every four seconds via ERCOT's Load Frequency Control software to Resources carrying a Reg-Up and/or Reg-Down responsibility.

On 3/23/2022, Tesla's test resource executed Reg-Up and Reg-Down simulations. ERCOT provided Tesla with actual LFC data and actual frequency data representing the period of 00:00 to 03:00. The aggregation responded to second-based LFC signals over that period, using both battery discharge (resulting in both offsets to on-site Load and energy injections to the grid), indicating compliance with Controllable Load Resource Energy Deployment Performance (CLREDP)[3] well within the parameters established in ERCOT Market Rules.

Responsive Reserves

Participation by CLRs, including ALRs, in the principal type of Responsive Reserve Service (RRS) – that is, RRS coupled with Primary Frequency Response -- is similar to that required in Non-Spin. Both services are dispatched by SCED with identical CLREDP metrics as the performance evaluation methodology. The only significant difference is that upon

[2] CLREDP is the primary performance metric for CLR participation in the ERCOT market.
[3] CLREDP is the primary performance metric for CLR participation in the ERCOT market.

deployment of RRS the Resource must have a Bid to Buy active in SCED within five minutes rather than 25 minutes. At the 10-minute mark after RRS deployment, the RTM Bid is active in SCED and subject to Base Point instructions. Tesla's successful completion of its SCED/Non-Spin test provided evidence that the aggregation was also capable of meeting SCED requirements in RRS.

Primary Frequency Response

CLRs providing RRS, Non-Spin and Regulation service are also required to continuously provide Primary Frequency Response (PFR), demonstrating the ability to respond automatically to deviations in frequency outside of an established deadband. As a primary component of its RRS test, Tesla conducted tests providing evidence that its aggregation could qualify for PFR well within the requirements established in the Market Rules.

Fast Frequency Response

Fast Frequency Response (FFR) is a subset of RRS that requires instantaneous performance of a full Resource within 15 cycles (1/4 second) when grid frequency dips to a point no lower than 59.85 Hz. Because the 59.85 Hz level is rarely reached on the actual grid, Tesla conducted FFR testing by setting its Under-Frequency Relays at a point well above 59.85 Hz. While its testing indicated a total response by the aggregation within the prescribed time frame, Tesla acknowledges that this would not constitute a real-world FFR qualification test, primarily because such testing requires the presence of high-speed data recorders capable of measuring response at a rate of 52 samples per second. However, Tesla believes its performance in the FFR test is an indication that the service could be open to aggregated Resources with fast-acting batteries in the future.

Respectfully Submitted,

_____s/_____

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ATTACHMENT: ERCOT TESLA ANCILLARY SERVICE DEMO

47 Slides/Pages

ERCOT & Tesla Ancillary Service Demos

6/15/2022

Submission in Texas PUC Project No. 51603 (Distributed Energy Resources) and Project No. 52373 (Review of Wholesale Market Design)

Key meetings between ERCOT and Tesla about the demo program

Meeting Date	Topic	Page number
3/3/22	Introduction: “Clumping” and two telemetry signal approach	3
3/11/22	Demo results #1: Initial results	14
3/18/22	Demo results #2: Non-spin qualification test	19
3/25/22	Demo results #3: Regulation	26
4/15/22	Demo results #4: RRS - FFR	37
4/9/22	Re-visit clumping and the two telemetry signals approach	41

Summary

- Market needs a solution to ensure that the ALR is always a net Load, and allows injections to the grid to tap the full value of the ALR's embedded export capacity
- Focus on the battery data as the primary metric for determining compliance with SCED/Ancillary Service requirements
  - Meter before/meter after performance evaluation methodology
- Secondary data from the full ALR allows the ISO to detect any behavior that could affect compliance

<u>Any problem has a first principles solution.</u>

Objectives

- Tesla's Market Services Demonstration provides the Public and ERCOT Market with proof-of-concept data showing that behind-the-meter residential storage devices, in aggregate, are technically capable of following ERCOT SCED Base Point instructions and providing various Ancillary Services to support the electric grid.

- Tesla seeks to register the first Aggregated Load Resource (ALR) in ERCOT, and participate in services currently available (Non-spin and SCED Load reduction dispatch) with **full value** of grid services that injecting devices can provide in an ALR.

- Tesla will lead efforts to modify ERCOT's ALR Policy Other Binding Document for better fit with practical operational and registration/qualification issues and to clarify that ERCOT can exchange two telemetry points with an aggregation QSE – one signal to show overall compliance as a Load and another to show only batteries/reactive loads responding to SCED basepoints (discharging/exporting) within the Load

- Propose market rule changes implementing Phase 1 of Texas Public Utility Commission Market Design Blueprint
  - Present Powerwall aggregation Market Services Demo to relevant ERCOT Group (Technical Advisory Committee)
  - Collaborate with ERCOT and Market Stakeholders on presentation of barriers, challenges identified which can be mitigated with rule changes

LONG TERM

Qualify future aggregations (i.e., Aggregated Energy Storage Resource) for all ancillary services (services available that the Resources are technically capable of providing) – for both charging and discharging; move from an ALR-constrained model to a nodal dispatch model for all distributed resources.

Provide Ancillary Service as an ERCOT Aggregated Load Resource (ALR)

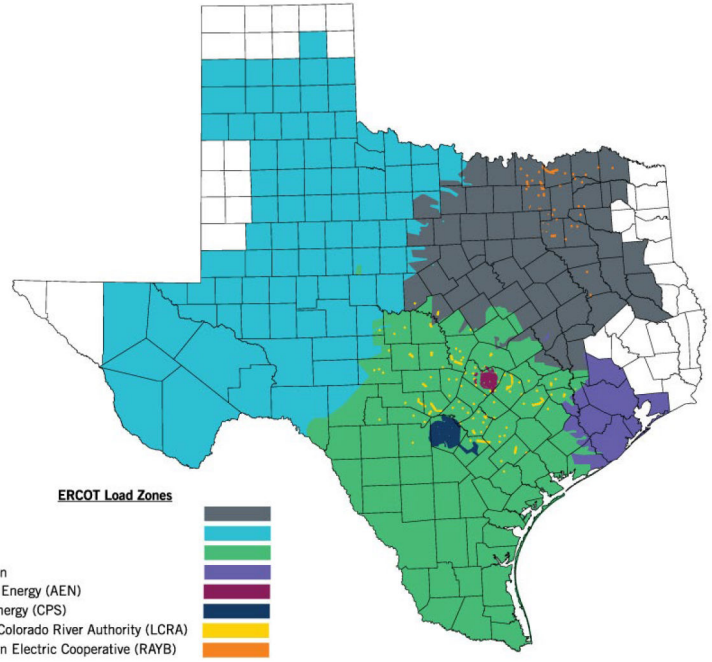
3/3/22

Example scenario

- Provide non-spin with residential batteries in load zone “South”

- Sub-metered devices in ALR:
  - 207 ERCOT Grid-Connected Supercharger stations at 19 sites
  - 400 residential batteries

- Total available controllable load:
  - Reduce ERCOT's Supercharger load by discharging batteries
  - 5kW discharge power per battery
  - 400 * 5kW = 2MW



INFO NOTE:
Tesla has more than 12,000 Superchargers across North America, Europe, and Asia and our network continues to grow daily: more than 99% of the U.S. population is covered by the network.

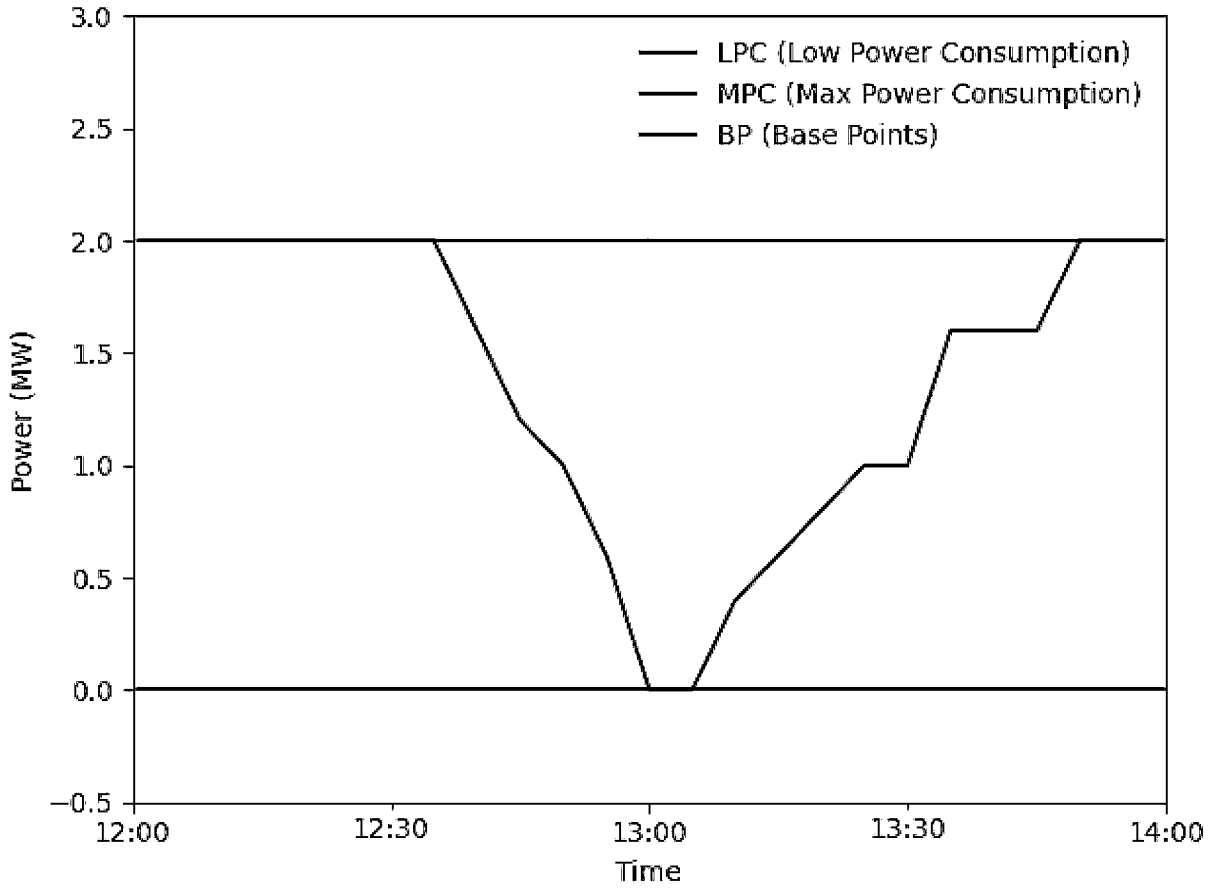
A Supercharger power cabinet supports peak rates of charge from 150kW - 250kW per car depending on the Version of Supercharger (V1,V2,V3)

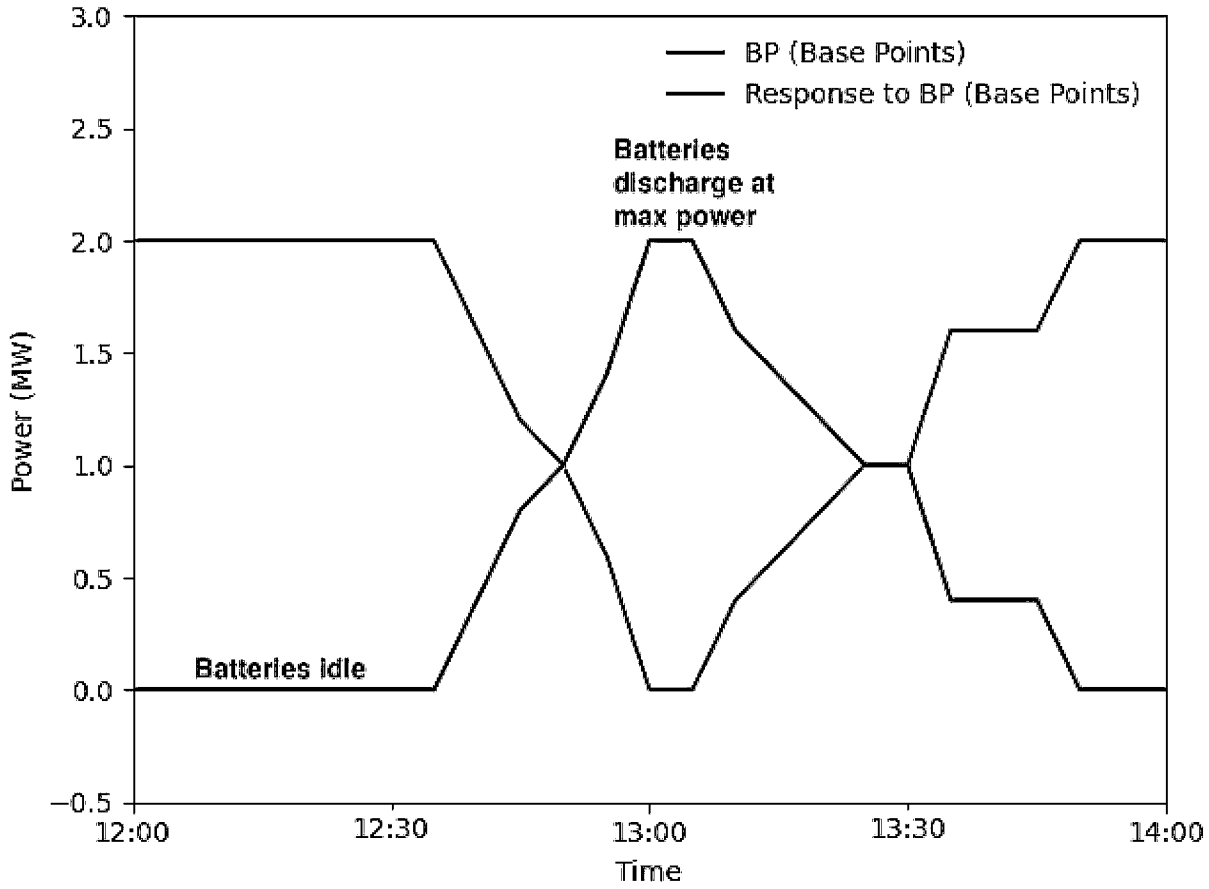
207 Superchargers

400 residential batteries

Response to CLR basepoints

Basepoints based on "Load Resource Qualification, Initial Qualification and Periodic Testing”, ERCOT, Version 2.0, Effective June 1, 2014.





Extra: SCED basepoints

Source: "Load Resource Qualification, Initial Qualification and Periodic Testing", ERCOT, Version 2.0, Effective June 1, 2014.

(basepoints were scaled from 10MW to 2MW in the example on slide 3)

In this example, the CLR has an NSRS responsibility for half of it's load and the balance will be subject to a SCED energy deployment. It follows the Base Point instructions as directed. The LR has a RTM Bid to Buy in the system for 5 MW @ $500 and 5 MW @ $1000. In this example, the 5 MW @ $500 is associated with the SCED only portion of the bid (those MW closest to the MPC) while the 5 MW at $1000 are associated with the Non-Spin portion (those closest to the LPC).

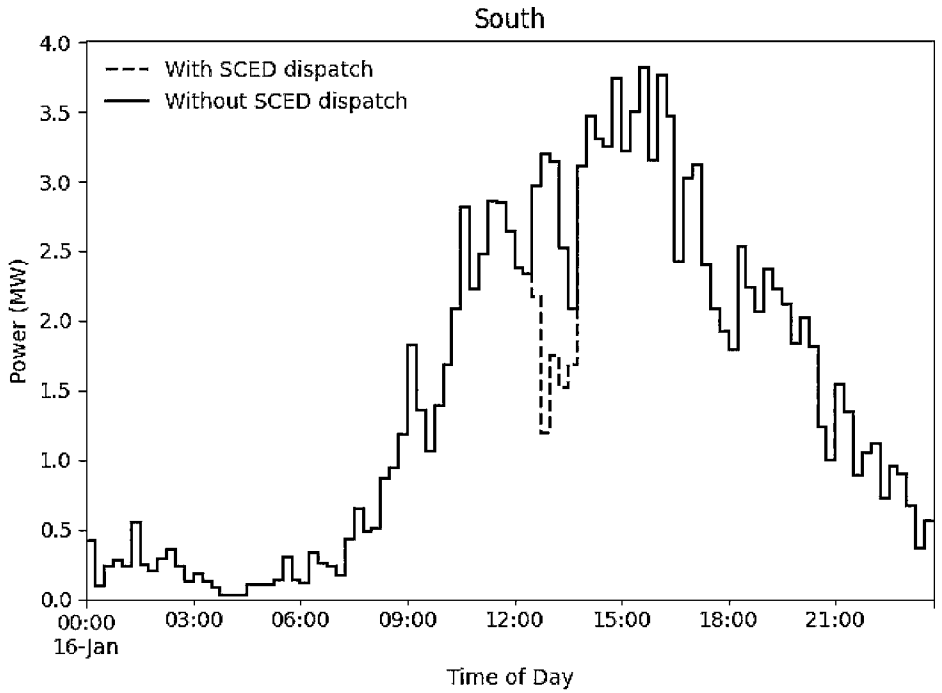
	Time	NSRS Responsibility	NSRS Schedule	NSRS Deployment Flag	BP	NPF	SPC	MPC	LPC	Resource Status	MCPE
0:05	13:00	5	5	OFF	10	10	10	10	0	ONCLR	100.00
	13:05	5	5	OFF	10	10	10	10	0	ONCLR	100.00
	13:10	5	5	OFF	10	10	10	10	0	ONCLR	200.00
	13:15	5	5	ON	10	10	10	10	0	ONCLR	200.00
	13:20	5	5	ON	10	10	10	10	0	ONCLR	200.00
	13:25	5	5	ON	10	10	10	10	0	ONCLR	350.00
	13:30	5	5	ON	10	10	10	10	0	ONCLR	350.00
	13:35	5	0	ON	10	10	10	10	0	ONCLR	350.00
	13:40	5	0	ON	8	8	10	10	0	ONCLR	500.00
	13:45	5	0	ON	6	6	10	10	0	ONCLR	500.00
	13:50	5	0	ON	5	5	10	10	0	ONCLR	500.00
	13:55	5	0	ON	3	3	10	10	0	ONCLR	1000.00
	14:00	5	0	ON	0	0	10	10	0	ONCLR	1000.00
	14:05	5	0	ON	0	0	10	10	0	ONCLR	1000.00
	14:10	5	0	ON	2	2	10	10	0	ONCLR	1000.00
	14:15	5	0	ON	3	3	10	10	0	ONCLR	1000.00
	14:20	5	0	ON	4	4	10	10	0	ONCLR	1000.00
	14:25	5	0	ON	5	5	10	10	0	ONCLR	700.00
	14:30	5	0	ON	5	5	10	10	0	ONCLR	700.00
	14:35	5	0	ON	8	8	10	10	0	ONCLR	500.00
	14:40	5	0	ON	8	8	10	10	0	ONCLR	500.00
	14:45	5	0	ON	8	8	10	10	0	ONCLR	500.00
	14:50	5	5	OFF	10	10	10	10	0	ONCLR	100.00
	14:55	5	5	OFF	10	10	10	10	0	ONCLR	100.00
	15:00	5	5	OFF	10	10	10	10	0	ONCLR	100.00

Market Prices and Bids are shown for illustrative purposes and are not based on real market data. They are not intended to show how a market participant should bid or respond to market activity.

Strongest Technical Solution: Monitor 2 Signals via ICCP

☑ Validation of Load resource (no gen)

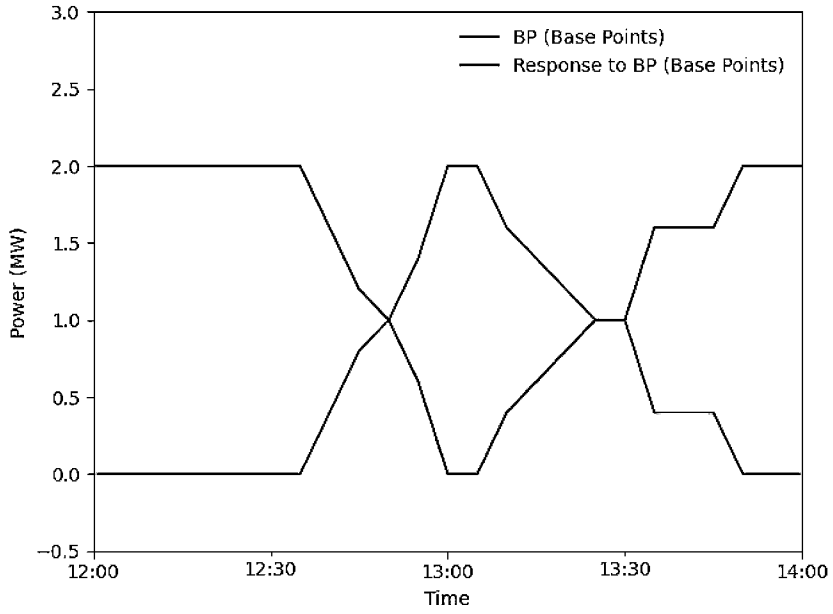
This signal contains all the registered meters/sites/devices.
This signal can be monitored to make sure that **the aggregation is always a load** when the ALR is providing services and ensure compliance.



Aggregate measurements =
Sum of supercharger + battery measurements

☑ Validation of response (from gen)

This signal includes only the devices providing the SCED response and ancillary services. This is used to evaluate performance for qualification and for settlement. This is the best approach because it provides **the clearest signal of the service** being provided. Anything else included in this signal is not reacting to ancillary services dispatch and is therefore noise.



Aggregate measurements =
Sum of battery measurements

ERCOT Demonstration – Collaborative Problem Solving

Key Topic	Best Technical Outcome
RECOGNIZE EXPORTS WITHIN A LOAD	TWO TELEMETRY SIGNALS FOR AN ALR

- The fastest path to Order 2222, battery storage export recognition is to problem-solve the existing Aggregated Load Resources Framework and leverage it for export recognition. Tesla believes this can be accomplished **within one year, faster than in other RTO markets where compliance filings alone are taking a year ++ to implement.**

- Tesla and ERCOT staff met in 2021 to discuss an approach to recognize Exports within an Aggregated Load Resource: called "clumping", the approach is to include within an ALR, reactive loads that can export like Powerwall, but also include large Loads that are non-reactive (like Superchargers) so that the ALR in totality can be viewed as a Load. **ERCOT systems currently cannot recognize and validate Negative Loads (Exports) from distributed energy resources, but this solution will solve that problem and allow for the grid services to be provided.**

- A **two-signal solution is the strong technical solution:**
  - One signal contains all the registered meters/sites/devices. This signal can be monitored to make sure that the aggregate is always a load when the ALR is providing services and ensure compliance.
  - The other signal includes only the devices providing SCED response and ancillary services. This is used to evaluate performance for qualification and for settlement.
  - This is the best approach because it provides **the clearest signal of the service** being provided.
  - Anything else included in this signal is not reacting to ancillary services dispatch and is therefore noise.
  - **This is already allowed under market rules.** Section 5 of the Nodal Protocols for Load Resources defines real time data requirements and states that "Any data mutually agreed to by ERCOT and the QSE to adequately manage system reliability;"

ERCOT Demonstration – Collaborative Problem Solving

Key Topic	Best Technical Outcome
PERFORMANCE MEASUREMENT	METER BEFORE/METER AFTER

Baselining and Meter Before/Meter After are performance evaluation methodologies used to measure demand response. Both are allowed by current market rules for ALRs.

- Baselining is a way of estimating what a Load would have done in the absence of a deployment
- This allows the Load to be credited for demand response based on a scientific estimate of what it would have otherwise consumed
- Baselines are constructed based on historical usage, often with other inputs, especially including weather
- Loads that are most easily able to be baselined are large aggregations of similar Loads (such as households)
- **Baselines are generally not applicable to Loads that are spiky or fluctuating**

Meter Before/Meter After means that the demand response is measured based on the change in load that occurred between the time of dispatch and the required response time (also known as the ramp period)

- It is basically a meter read at the time of dispatch, minus the meter read at the end of the ramp period
- In the case of Load Resources, “meter reads” are the readings from the real-time telemetry
- Telemetry provides the primary data for measurement & verification, always subject to validation using premise-level data
- MB/MA is most often associated with Loads that tend to be very flat and predictable
- **But it is also appropriate as a way to measure demand response from a fast-acting storage device**

ERCOT Demonstration – Collaborative Problem Solving

Key Topic	Best Technical Outcome
PERFORMANCE VERIFICATION	METER BEFORE/METER AFTER

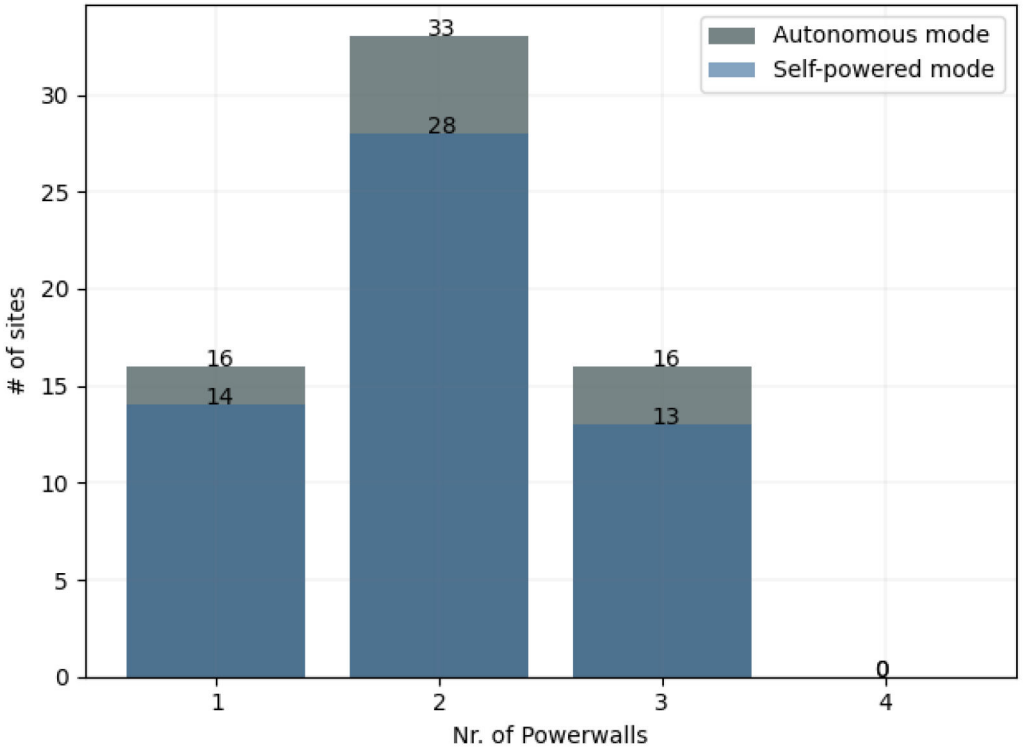
- Telemetry from an ALR at the device level (rather than the premise level) is already allowed by ERCOT market rules
- The ISO (or other dispatcher) can validate the response from the devices by looking at the Loads' behavior at the premise level to ensure that the service is being delivered
- In FERC Order 2222 RTO Proceedings, Device-Level Telemetry has been repeatedly recognized by the RTOs with the most advanced DER integration plans as the preferred approach to validate performance from an aggregation of distributed devices.

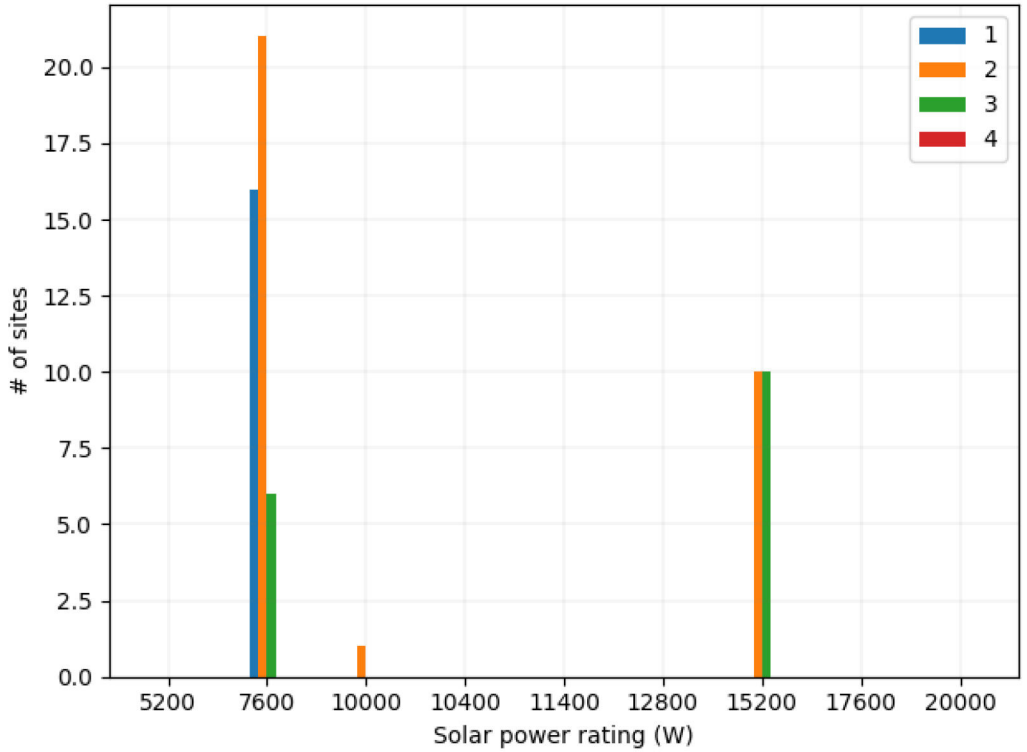
Tesla Demo Setup and first results

3/11/22

Currently enrolled customers

- 200 customers pool
- 64 customer participants
- Texas ERCOT Load zone: North





Autonomous Mode: AKA Time-Based Control/load shifting helps maximize savings through smart charging and discharging of Powerwall, utilized typically for Time-of-use plans where electricity prices may vary depending on the time of day, day itself, or season.

Self-Powered Mode: Powerwall stores solar energy not used during the day to power home at night; Powerwall will charge when excess solar power is produced, stored energy will be used when the home requires more power than the solar can provide. If the home produces enough solar energy to offset all consumption and Powerwall is fully charged, the home will export excess energy to the grid.

Test 1: comparison of battery and premise-level telemetry

Purpose	**Compare battery and premise-level telemetry**
Initial Conditions	Three situations: 1. Evening time (high user load) 2. Morning time (low user load) 3. Day time (solar generating hours)
Test Steps	1. Schedule and execute a 5 min zero power command 2. Schedule and execute a 5 min discharge command 3. Schedule and execute a 5 min zero command
Data Collected	1. Aggregate site net load telemetry data – 5s 2. Aggregate battery power data – 5s
Pass Criteria	1. Aggregate site net load telemetry data is consistent with the battery telemetry data

Results test 1

1.Evening time

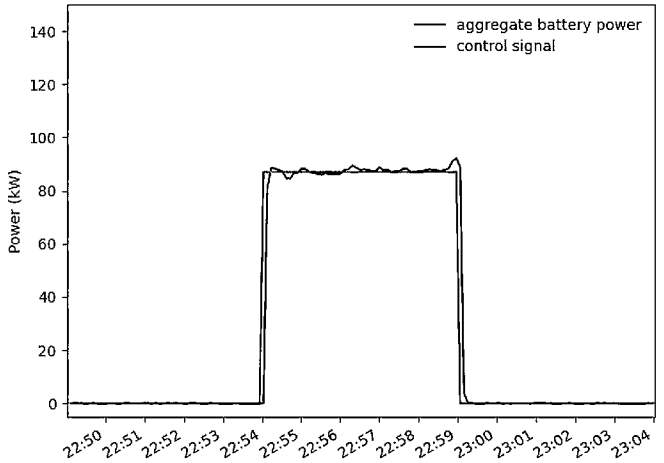
➢ decrease load

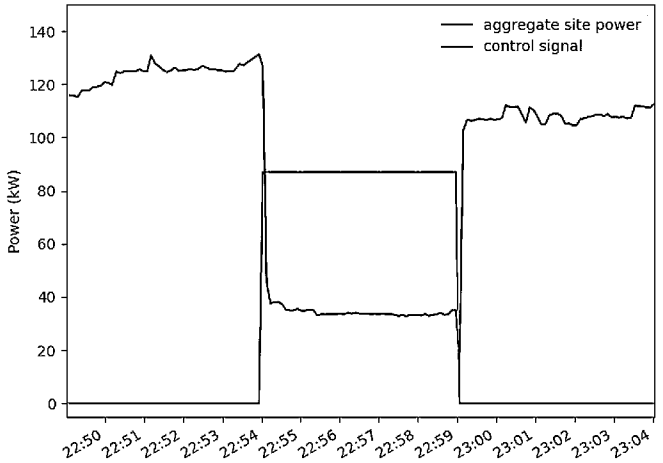
2. Morning time

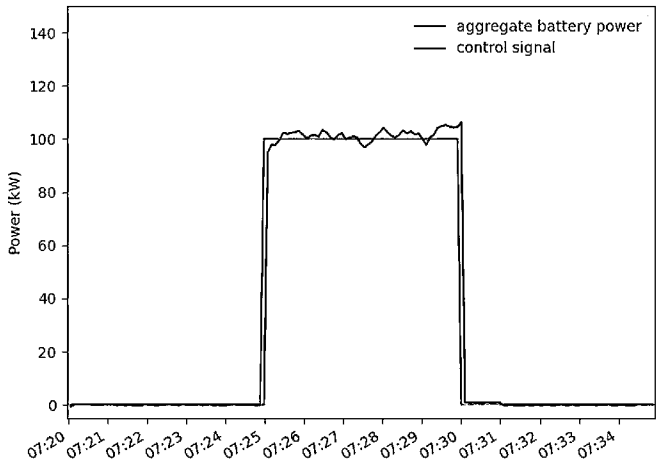
➢ decrease load + export

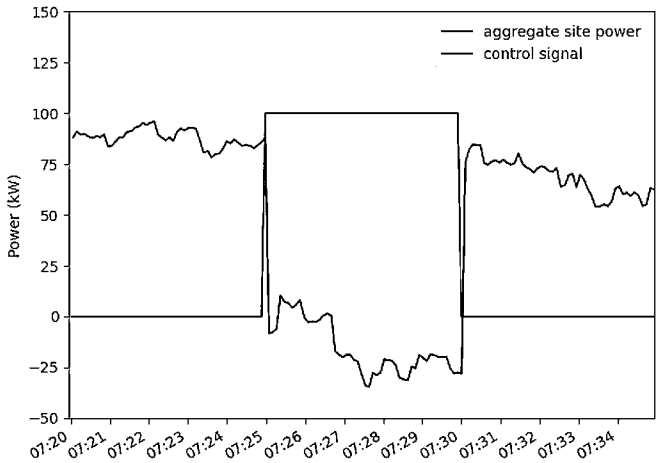
3. Day time

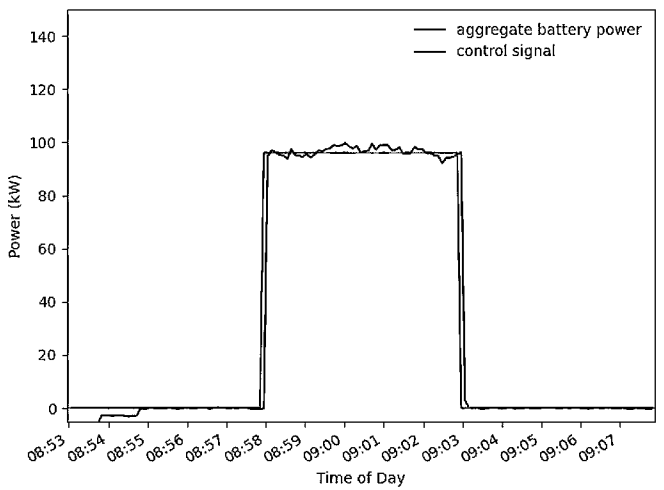
➢ increase export

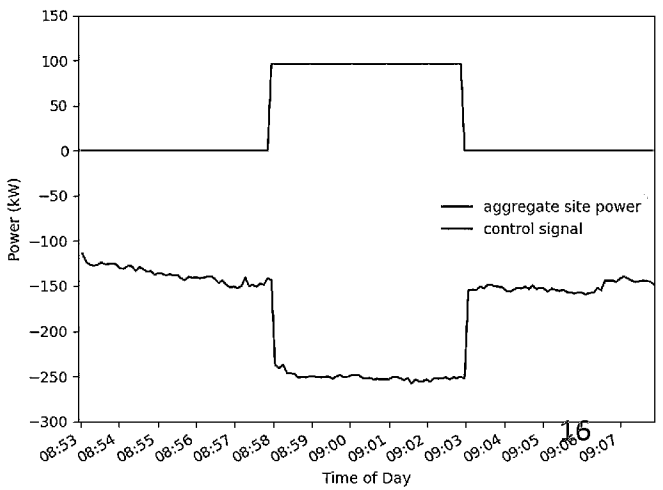












Conclusion –Test 1

- Discharging from the customer's battery using a step function can clearly be identified in the premise-level data
- At different times of day, premise-level data will look differently, depending on the current load:

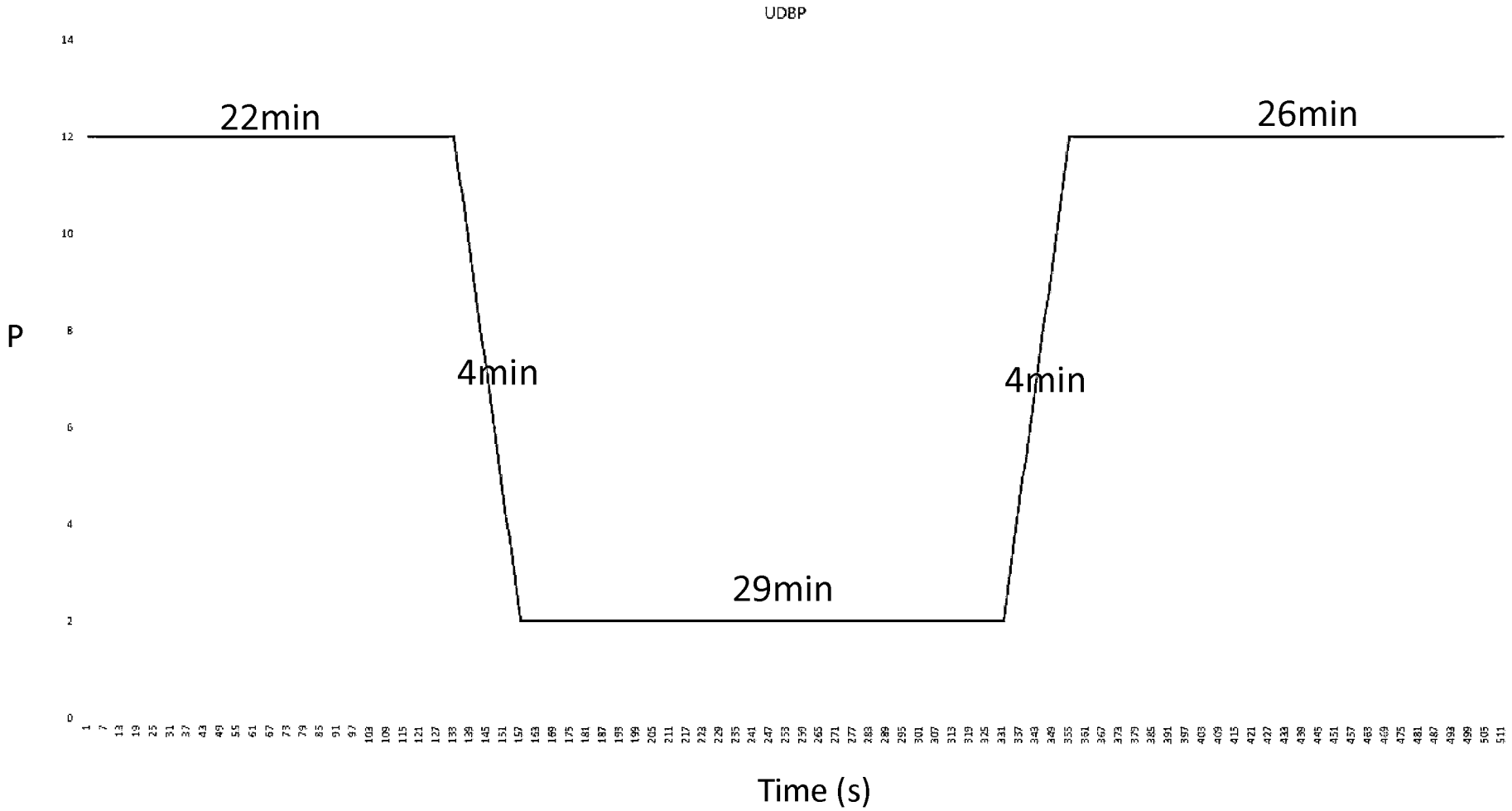
1. evening time: during the evening peak, user load is typically high, and discharging the battery will show up as a decrease of premise-level load

2. morning time: during the night / morning time, user load is typically lower, and discharging the battery will both decrease load, and export energy to the grid

3. day time: during the day time, solar is exporting to the grid, and discharging the battery will increase the export

Qualify ALR/CLR for SCED dispatch

From 3:55 until 5:20



Tesla Demo Results #2
Non-spin Qualification test

3/18/22

Key takeaways

- 65 demo sites in Texas (with 1,2 or 3 PWs installed) were able to follow a series of predefined SCED basepoints[1] by using 5kW controllable discharge power (no charge power, as reducing load as an ALR = discharging Powerwalls) per site.

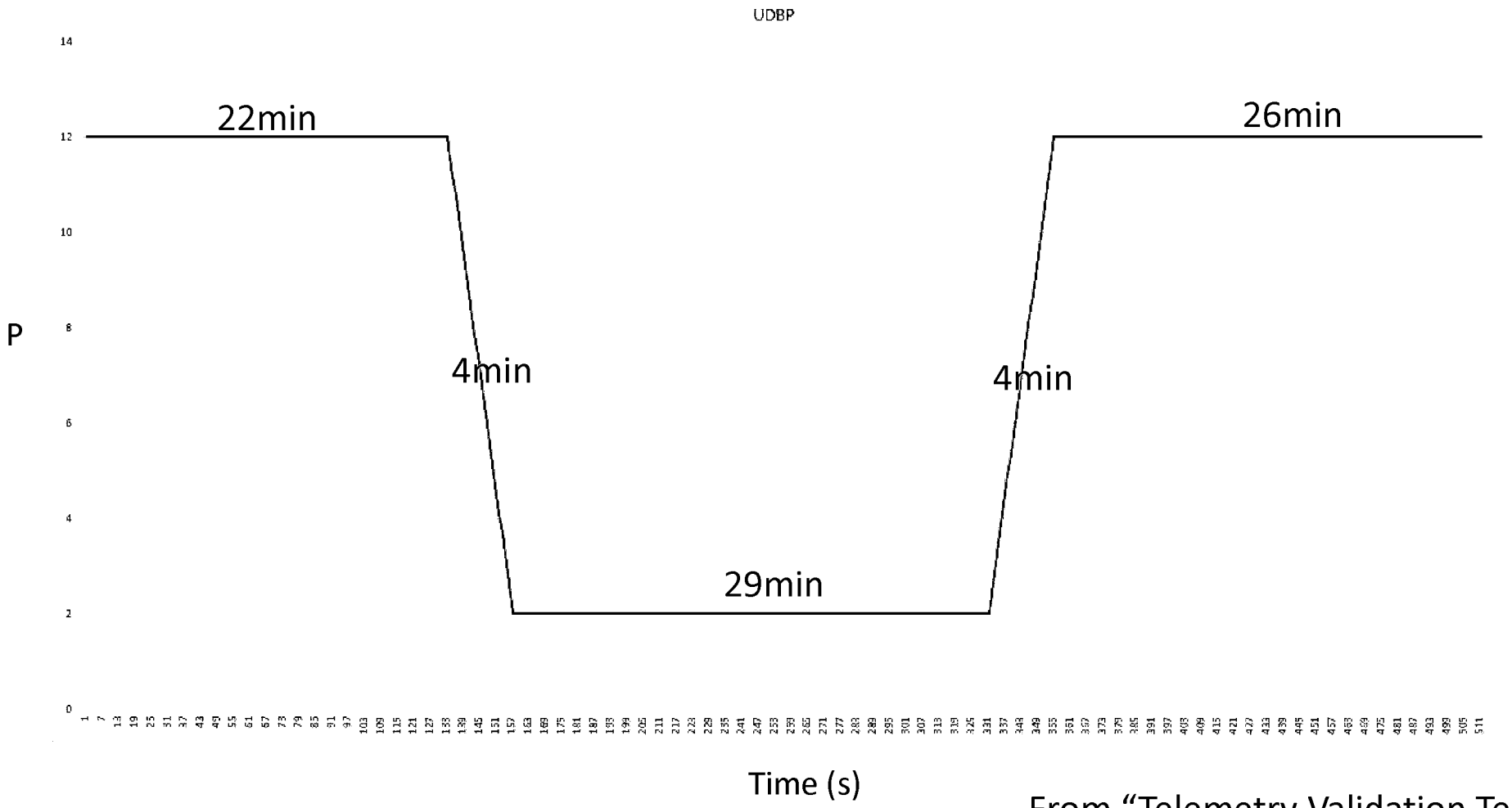
- The recorded response time is sub-5s, as we see a response after a single sample interval of 5s

- The recorded accuracy is within 5kW on a 250kW controllable discharge capacity (= 2%)

[1]obtained from ERCOT, and part of the official qualification test for qualifying ALRs to provide non-spin

Test procedure for qualifying ALR/CLR for SCED dispatch

From 3:55 until 5:20



- 64 customers
- Load zone North
- 5kW per customer

From “Telemetry Validation Template.xls” received from ERCOT on 3/10/22

Test procedure for qualifying ALR/CLR for SCED dispatch

Original basepoints

MPC: 12MW

LPC: 2MW

Scaled basepoints

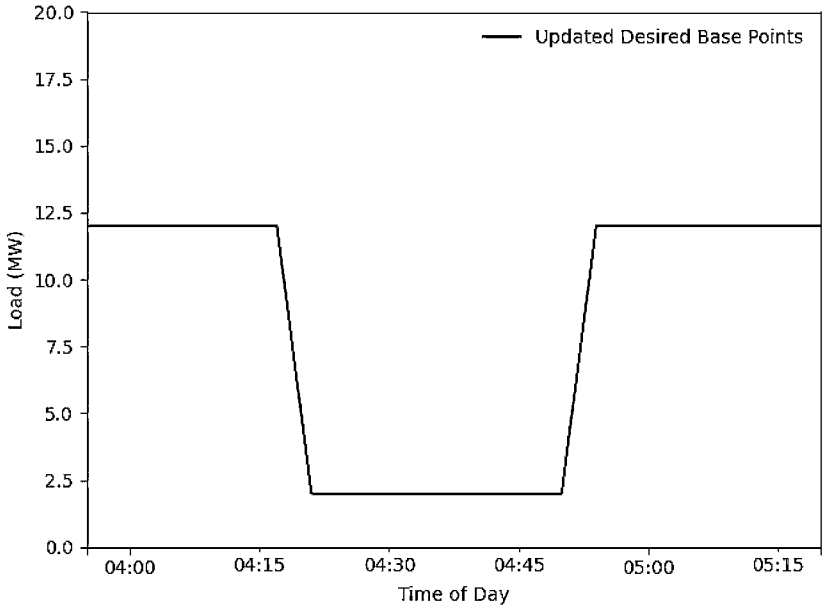
MPC: 0.25MW

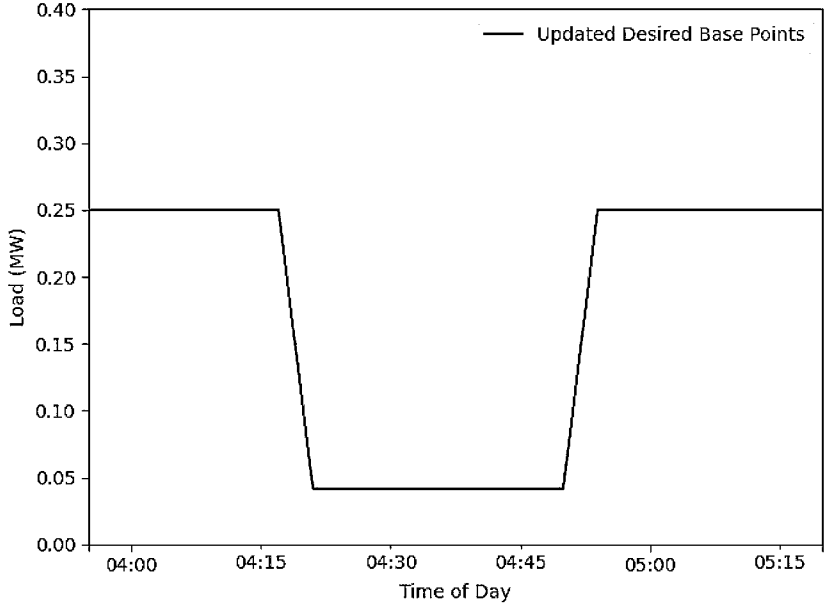
LPC: 0.04MW

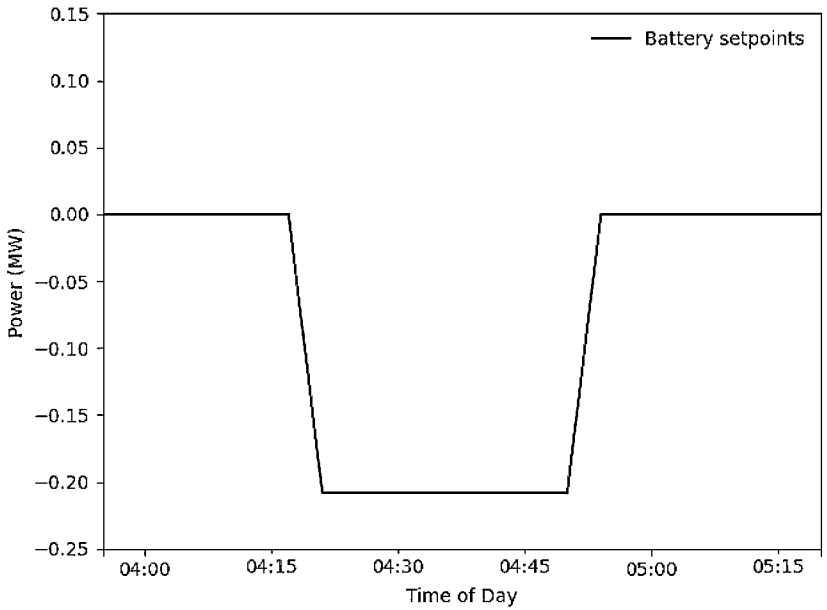
Battery setpoints

Max charge at 0MW

Max discharge at 0.25MW







Recorded test results

3/18/22 From 3:55 until 5:20 CDT

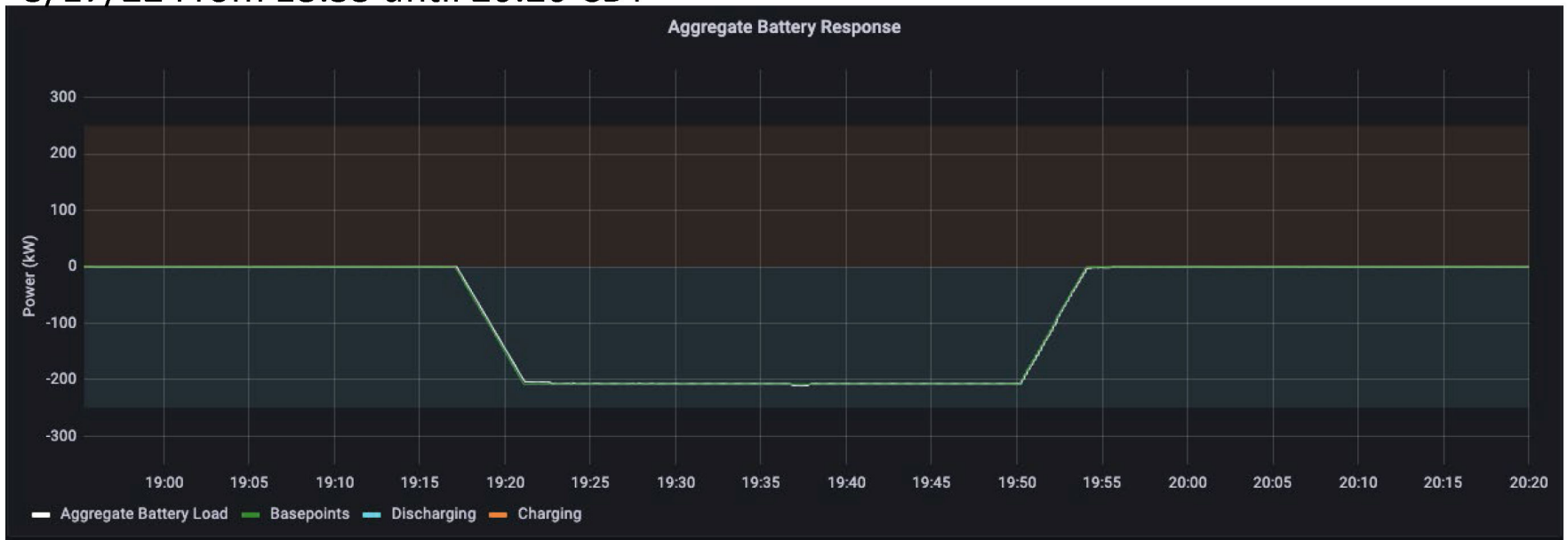
Response time
- Sub 5s

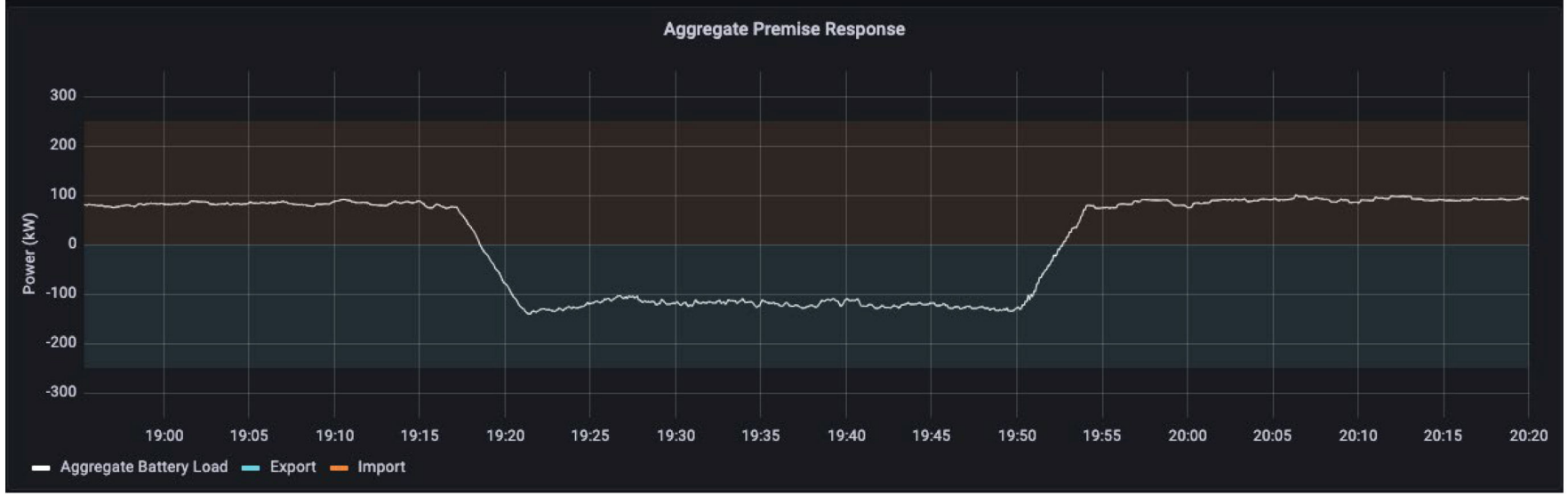
Accuracy
- +/- 5kW

Validation
- Response identifiable in aggregate premise load

Recorded test results

3/17/22 From 18:55 until 20:20 CDT





Response during evening peak

-> Response still identifiable in aggregate premise load

Next steps

Next step: **regulation demo**

- Qualification test profile
- Gambit signal (prerecorded)
- Gambit signal (live)

Tesla Demo Results #3 Regulation

3/25/22

Key takeaways

- The Tesla aggregation of batteries located on 61 sites in Texas was able to **successfully follow a series of dispatch instructions as defined in the qualification tests for regulation-up and regulation-down**, and therefore comply with the required response accuracy (< 3.5%).

- The Tesla aggregation of batteries located on 61 sites in Texas was able to **successfully follow a recorded regulation signal from the front-of-meter Gambit Energy Storage site**. Validation of this response was achieved by calculating the CLREDP, which was less than 6% (well below 15%, the CLREDP metric for an ERCOT Resource with Ancillary Service Responsibility).

- In general, **an aggregation of batteries is particularly well-suited for providing regulation**, because of its fast response time (< 5s) and high accuracy (< 3.5%) which does not change as the aggregation becomes larger.

[1] see "Ancillary Service Qualification: Test Guidelines and Expectations", received from ERCOT on 3/11/22

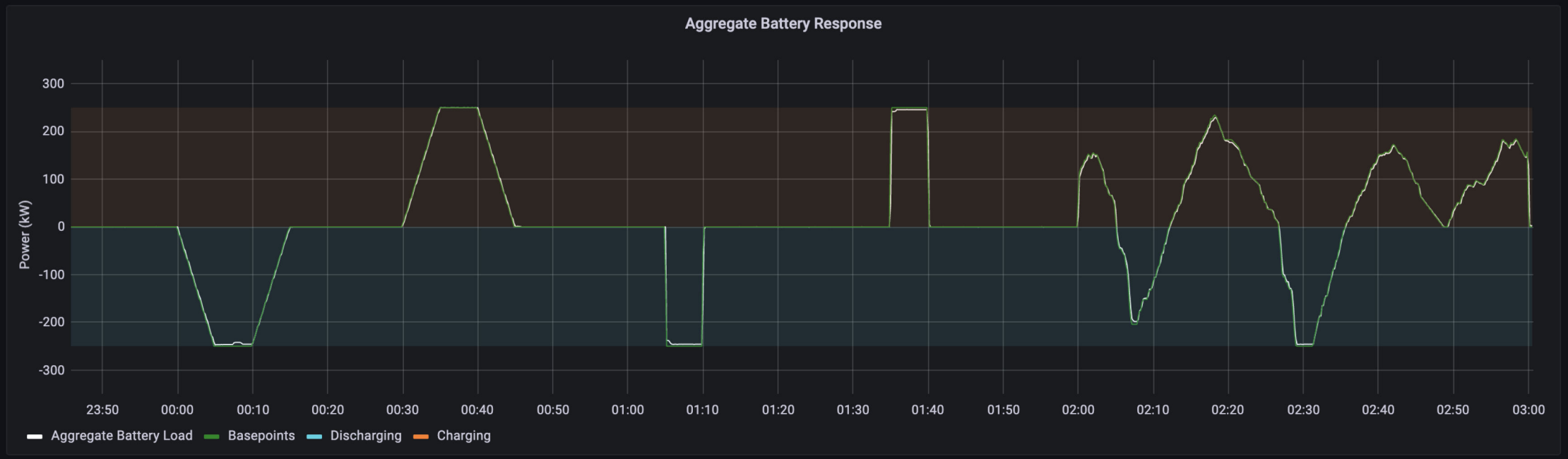
Operations dashboard – monitoring of Demo

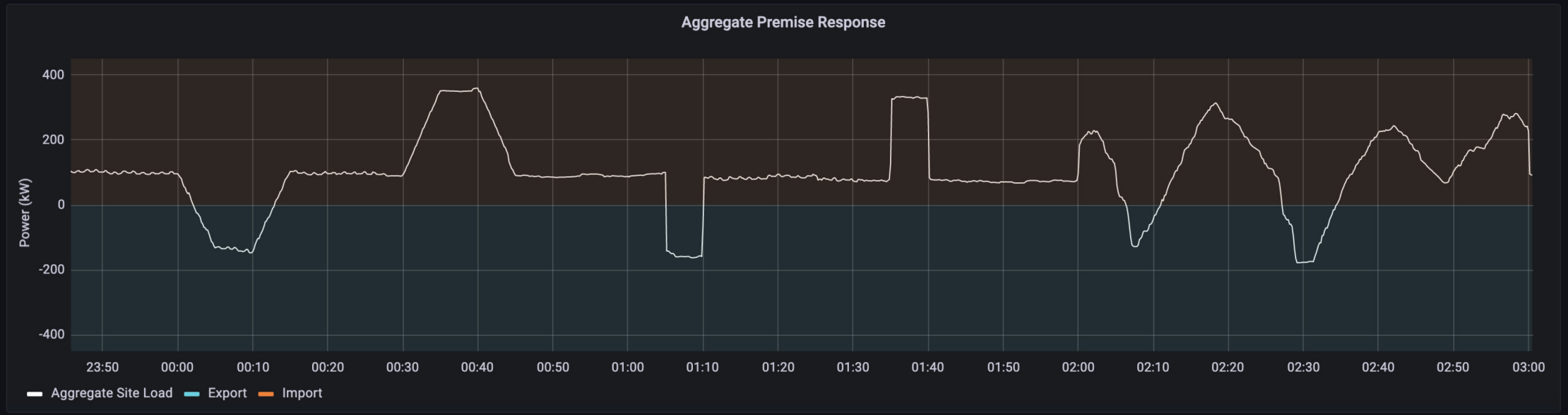
DEMO Results Deck #3

General / Autobidder NE - TEP ERCOT demo

2022-03-22 23:45:46 to 2022-03-23 03:00:39 CDT

Basepoints from File | **Battery Dispatch Enabled** | **ICCP Reporting Disabled**





Time Austin

16 26

Start Time

20 00

Stop Time

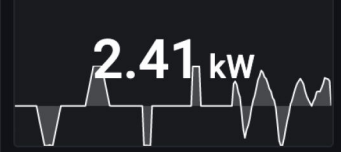
04 00

Basepoint

0 kW

Response

2.41 kW



Operating Capacity

0.25 MW

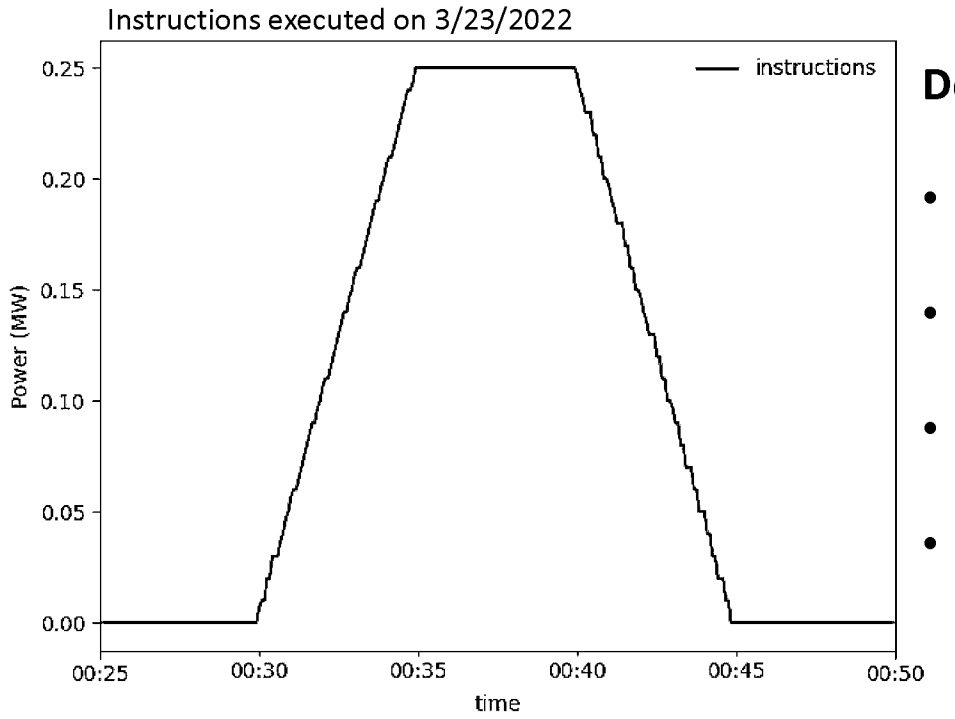
28

Demo regulation-down

REGULATION-DOWN by ESR-Controllable Load Resources (CLRs)

- If testing with RST = ONTEST, Resource must lock Base Point so that Resource only follows Regulation signal
- Start Resource at LPC/LSL
- ERCOT will send Regulation-Down signal to QSE (REGD)
- Resource will begin 5 min ramp to LSL + qualification amount
- Resource will hold at LSL + qualification amount for 5 min
- Resource will then complete test with a 5 min ramp back down to LSL

See ERCOT document "ERCOT Ancillary Service Qualification", Version 2.5 – 09/10/2021

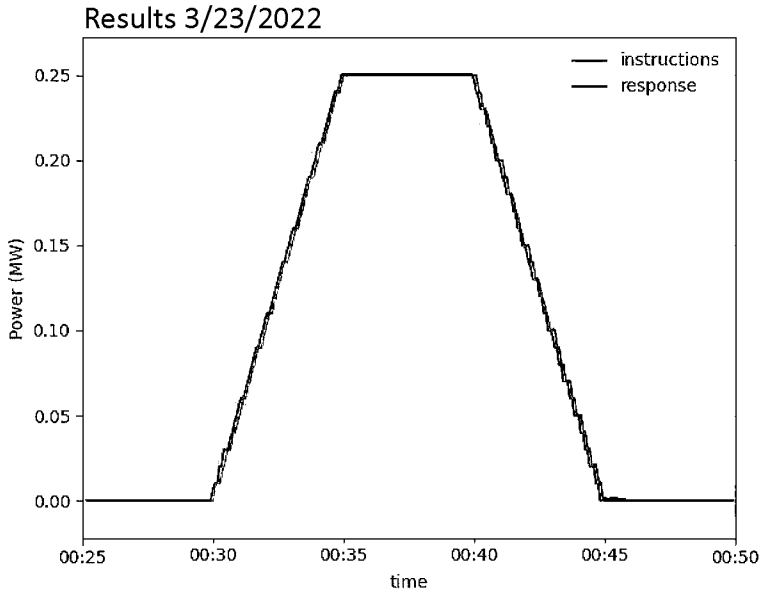


Demo

- Provide REG-DOWN by charging batteries, which <u>increases the load of our ALR</u>
- LSL = 0kW (aggregate sub-meted battery power)
- Qualification amount = 0.25MW
- Instructions with positive sign are 'charging'

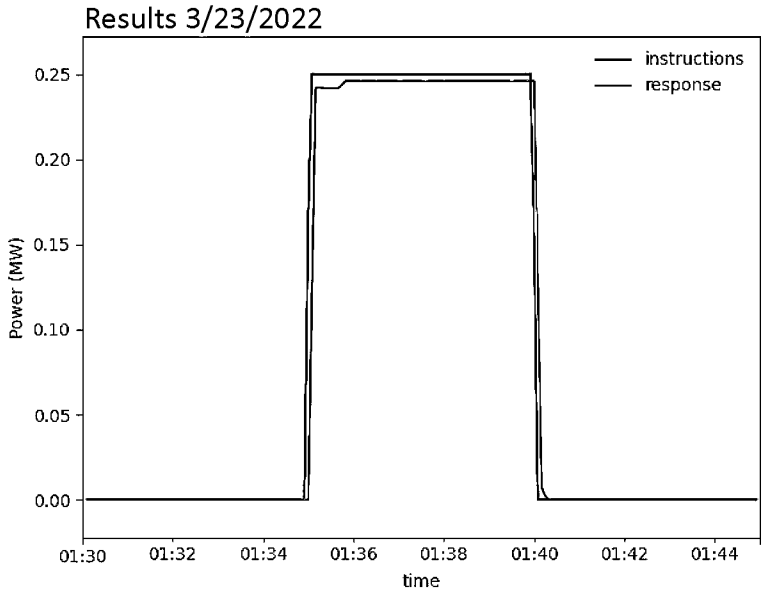
ESR: Energy Storage Resource
CLR: Controllable Load Resource
RST: Resource Status Code
ONTEST: Operations Testing
LPC: Lower Power Consumption (LSL for a load resource)
LSL: Low Sustained Limit

Demo regulation-down



Regulation-down with 5min ramp rates

- Response is within 3.5% of the instructions
- Sub-5s response time



Regulation-down without limited ramp rates

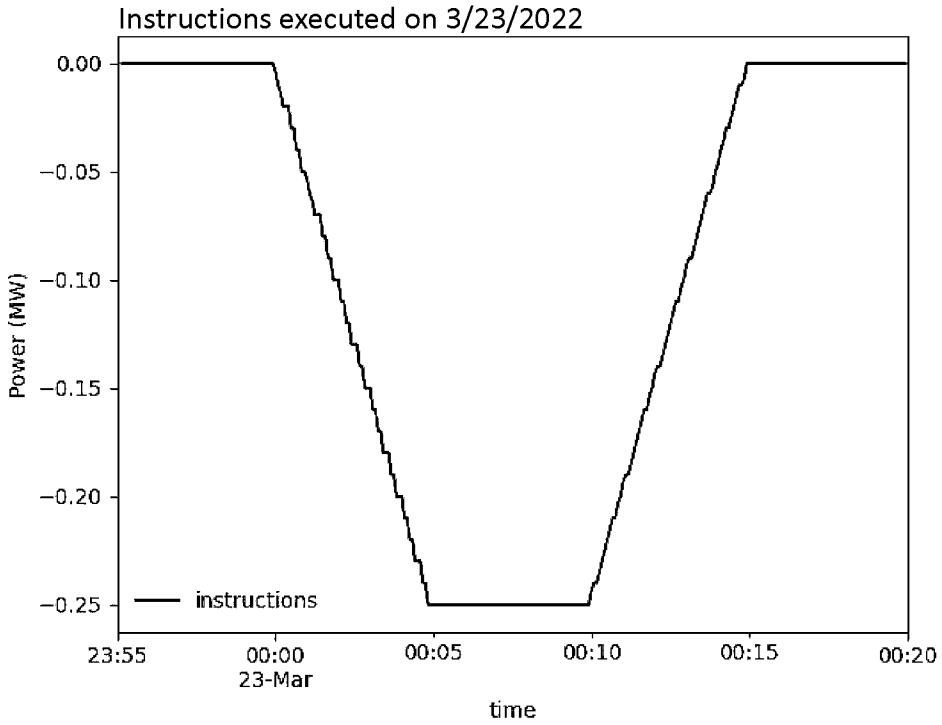
- Response is within 3.5% of the instructions
- Sub-5s response time
- Slight delay to reach full charging power

Demo regulation-up

REGULATION-UP by ESR-Controllable Load Resources (CLRs)

- If testing with RST = ONTEST, Resource must lock Base Point so that Resource only follows Regulation signal
- Start Resource at MPC/HSL (or enough to cover Regulation-Up responsibility)
- ERCOT will send Regulation-Up signal to QSE (REGU)
- Resource will begin 5 min ramp down to cover qualification amount
- Resource will hold at this level for 5 min
- Resource will then complete test with a 5 min ramp back up to start of test level

See ERCOT document "ERCOT Ancillary Service Qualification", Version 2.5 – 09/10/2021

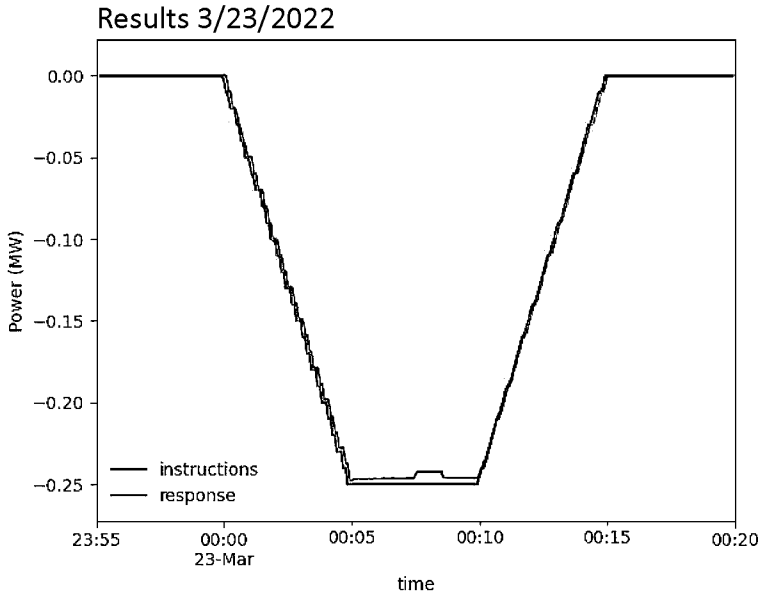


Demo

- Provide REG-UP by discharging batteries, which decreases the load or our ALR
- HSL = 0kW (aggregate sub-meted battery power)
- Qualification amount = 0.25MW
- Instructions with negative sign are 'discharging'

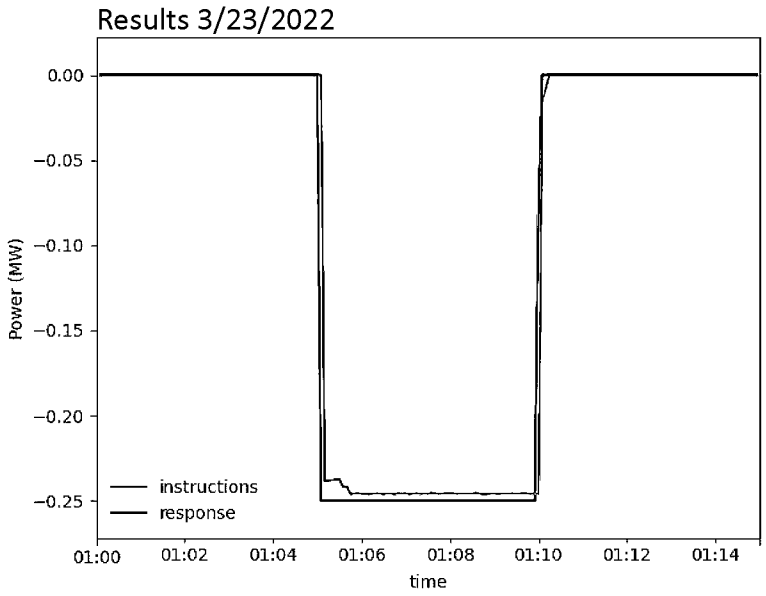
ESR: Energy Storage Resource
CLR: Controllable Load Resource
RST: Resource Status Code
ONTEST: Operations Testing
MPC: Maximum Power Consumption (HSL for a load resource)
HSL: High Sustained Limit

Demo regulation-up



Regulation-up with 5min ramp rates

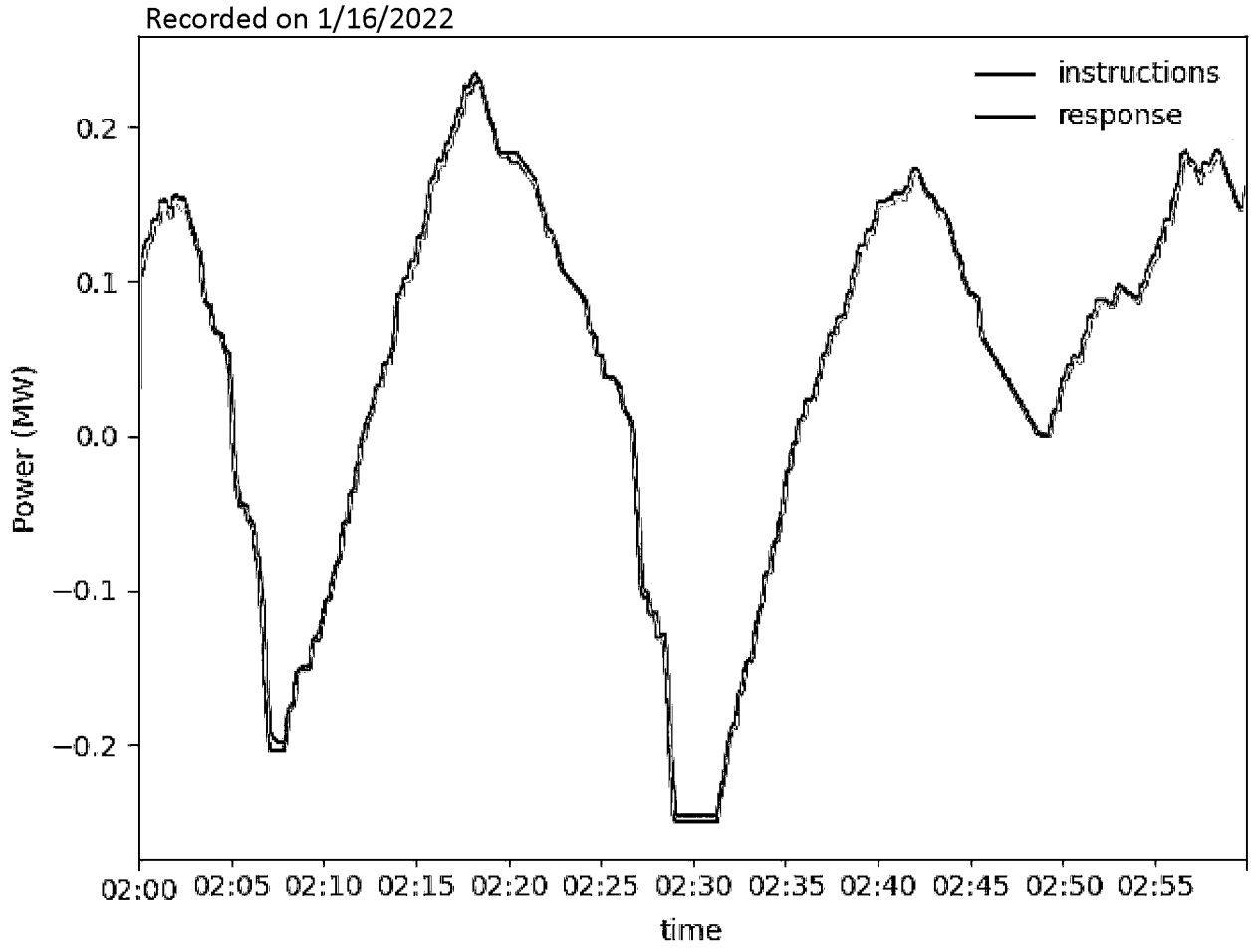
- Response is within 3.5% of the instructions
- Sub-5s response time
- From 00:07:30 to 00:08:30, there is a slight additional offset (= 1.6%)
  - Delayed telemetry
  - Currently, a single PW (= 5kW) is 2% (=5/250) of our response



Regulation-up without limited ramp rates

- Response is within 3.5% of the instructions
- Sub-5s response time
- Slight delay to reach full discharging power

Tesla Megapack recorded regulation signal



Tesla Megapack regulation signal

- Selected an hour in which we were providing both regulation-up (discharging) and regulation-down (charging)
- Scaled from 1MW to 0.25MW

Result

- Response closely follows instructions
- Sub-5s response time

CLREDP (Controllable Load Resource Energy Deployment Performance)

$$CLREDP_{\%} = \left| \frac{(ATPC + AEPFR)}{(ABP - ARI)} - 1.0 \right| \cdot 100$$

$$CLREDP_{MW} = |ATPC - (ABP - AEPFR - ARI)|$$

Where:

$ATPC$: Average Telemetered Power Consumption
$AEPFR$: Average Estimated Primary Frequency Response
ABP : Average Base Point
ARI : Average Regulation Instruction

From 8.1.1.4.1(9) in Nodal Protocols (Dec 1, 2021):
"A Controllable Load Resource must have a CLREDP less than the greater of X% or Y MW for 85% of the five-minute clock intervals in the month during which CLREDP was calculated."

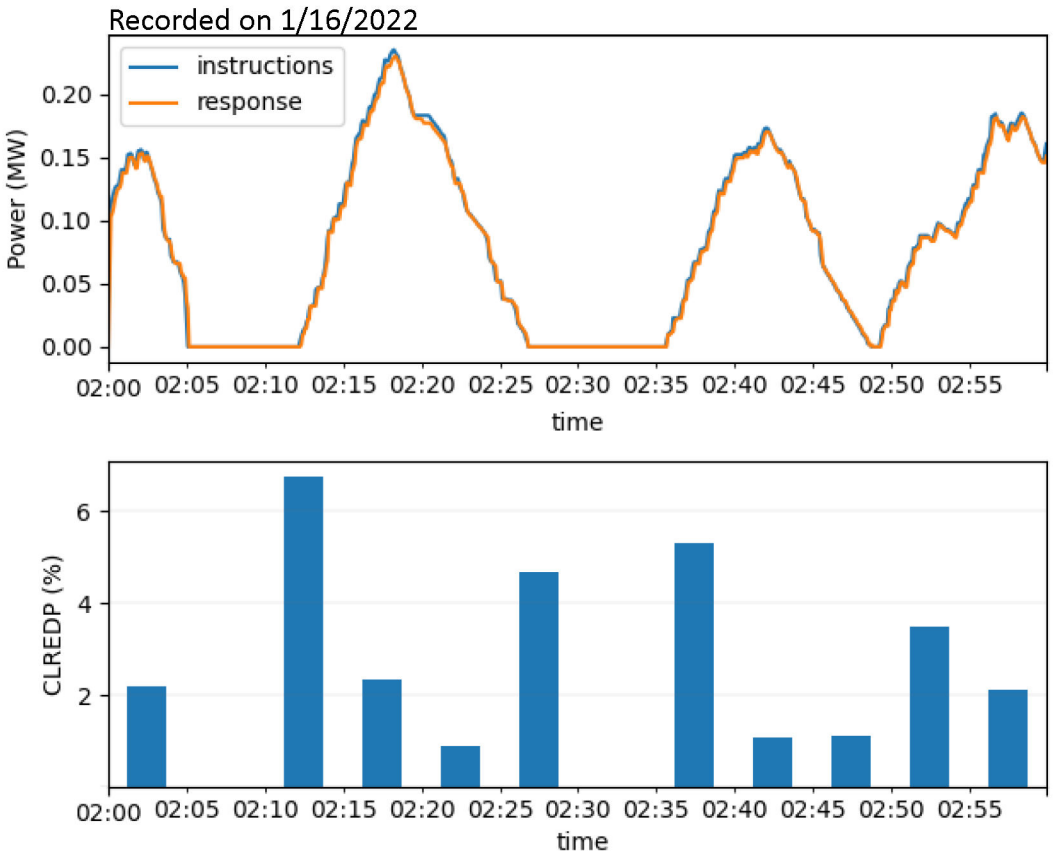
From [1]ERCOT Market Information List:

Resource/Metric	Protocol Reference	X (%)	Y (MW)
CLREDP	**8.1.1.4.1(9)**	25	2
CLREDP with Ancillary Service Responsibility	**8.1.1.4.1(9)**	15	2

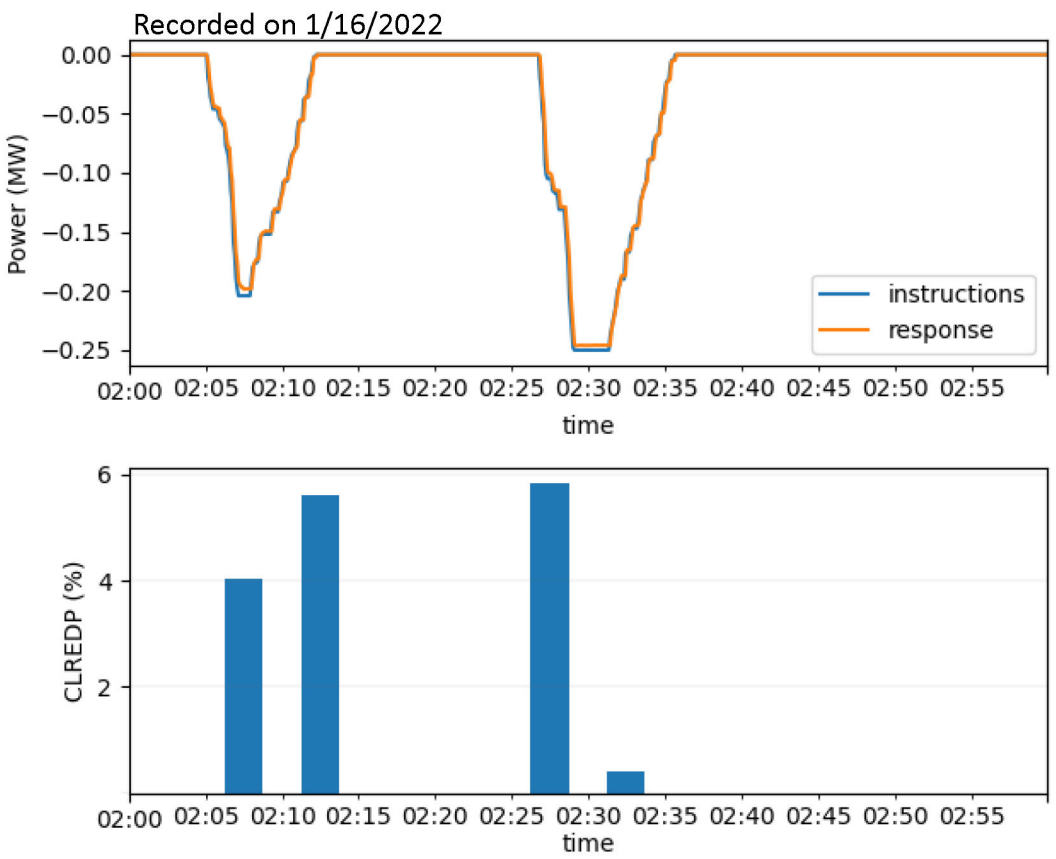
[1]https://www.ercot.com/mp/data-products/services?id=NP8-114-M

CLREDP (Controllable Load Resource Energy Deployment Performance)

CLREDP(%) for Regulation-down



CLREDP(%) for Regulation-up



Conclusion

- **Batteries are particularly well-suited** for providing regulation
  - Fast response time
  - Accurate response

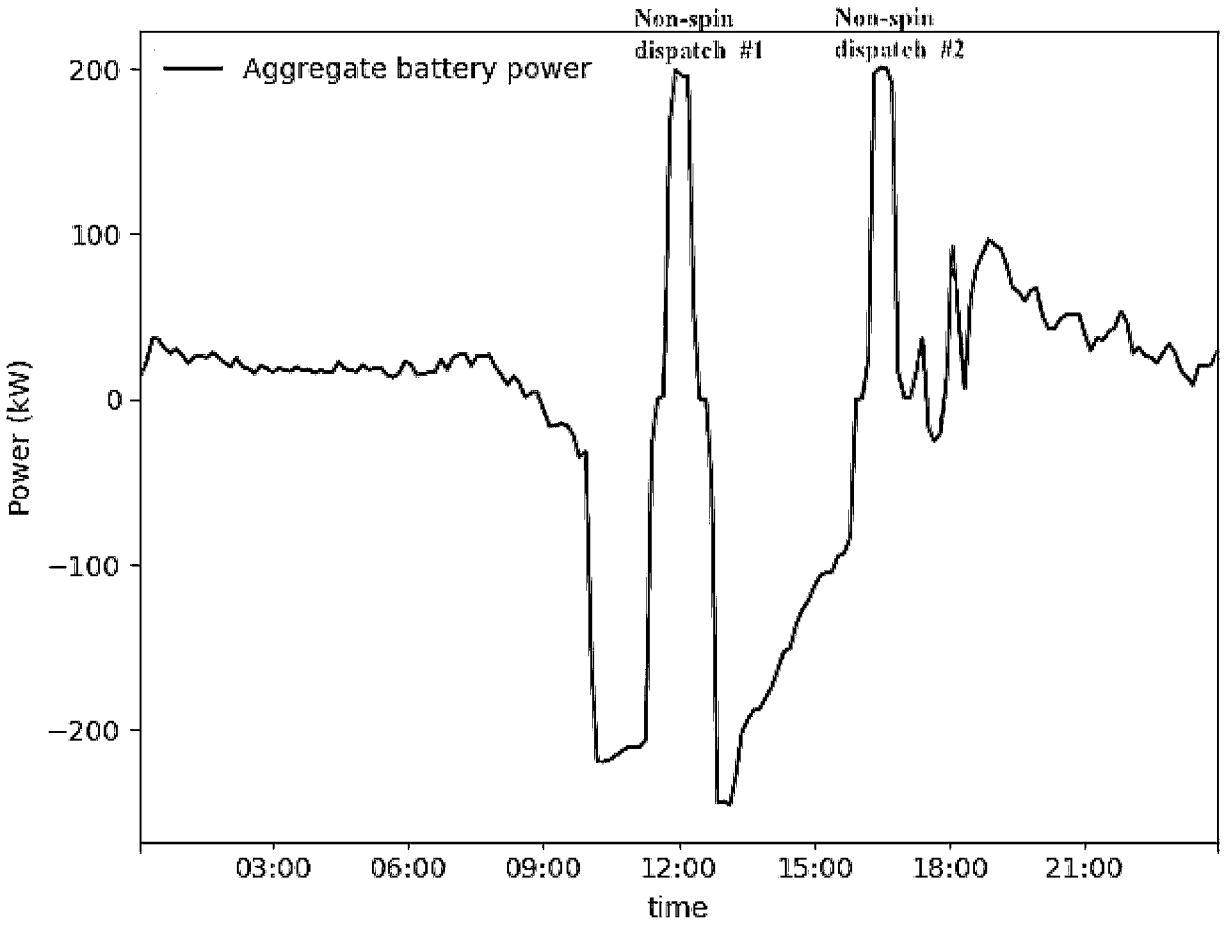
- Advantages **at scale**
  - Response time will be similar at any scale
  - Response accuracy improves as each battery is a smaller percentage of the total fleet

Tesla Demo Results #4
RRS –FFR/PFR

4/15/22

Non-spin during solar hours

Demo performed on 4/12/2022



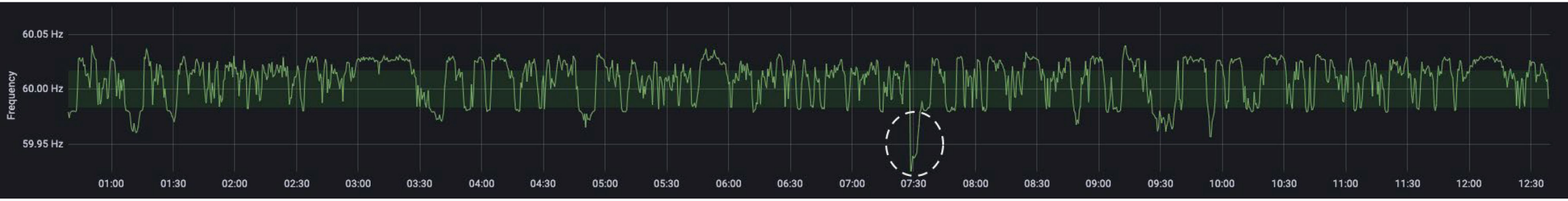
- Two sequences of non-spin dispatch commands followed on 4/12/2022 (as defined in the prequalification test)
  1. From 11:47 - 12:24 at ~200kW max discharge
  2. From 16:17 - 16:54 at ~200kW max discharge

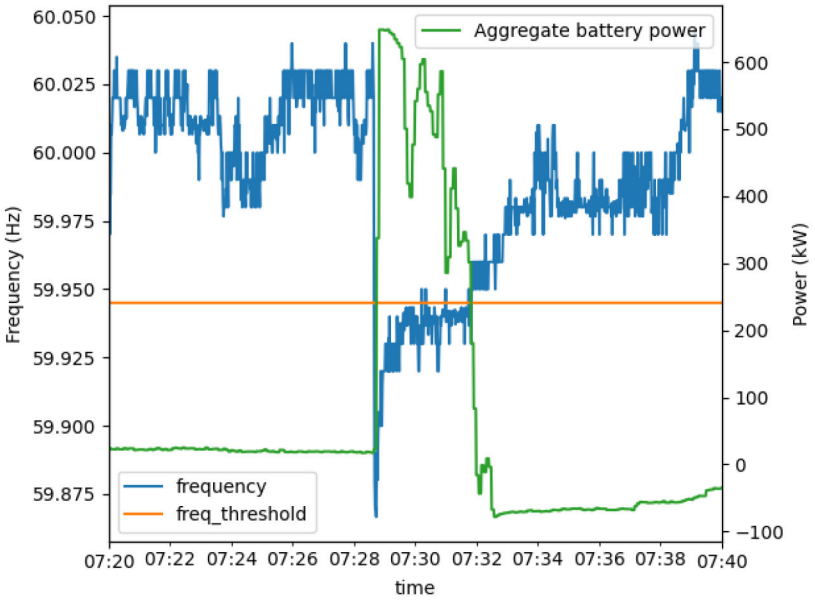
- Before each non-spin dispatch sequence, we charged the batteries to a higher SoC.

- Throughout the rest of the day, the batteries were in a local control mode.

Initial FFR demo results

- Lower frequency threshold set to 59.945Hz (> 59.85Hz)
- Droop curve set on 61 Texas sites from 4/12/22 8:36 - 4/14/22 8:36 CDT
- Frequency dipped below threshold from 7:28:40 - 7:31:51 CDT on 4/13/22



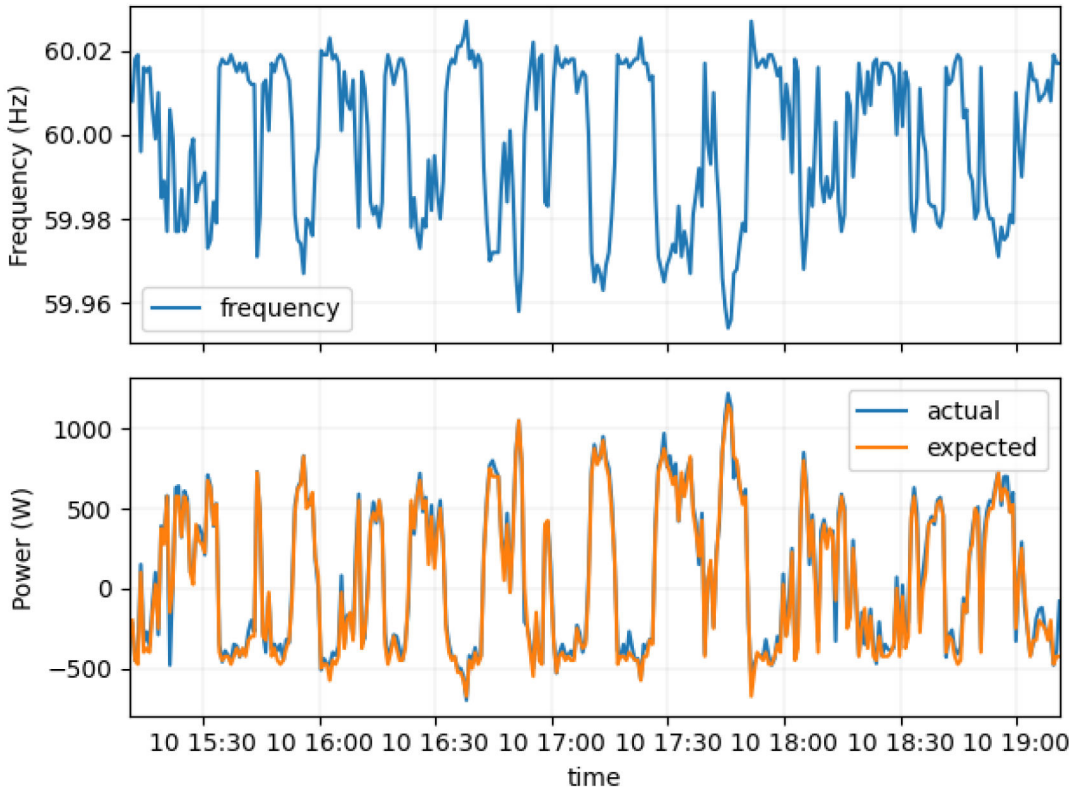


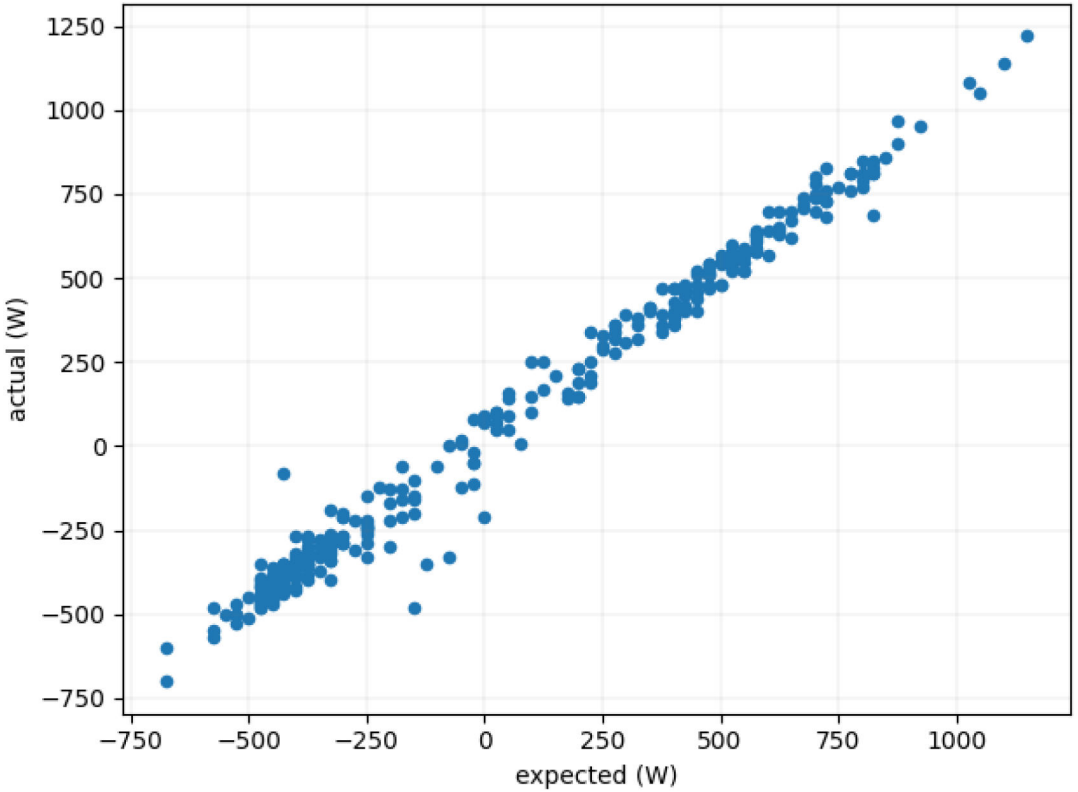
- Fleet response of an aggregate discharge power of 600kW
- As the frequency stabilizes, we proportionally adjusted our response
- Currently, the sample time is 5s

Next step: use high-frequency sampling to record response time

PFR demo results

Droop setting: 1kW at 0.04Hz, no dead band
Time: 2022-05-10 15:11:07 - 2022-05-10 19:11:07 (CDT)





- In this experiment, we use a 1kW gain to show our response to the frequency
- 40mHz and no dead band was used

Short-Term Approach:

Capturing the Full Value of DER Capacity in an ALR

(We're calling it "Clumping")

4/9/22

‘Full Value’

- Aggregate Load Resources must be net Load at all times
- Residential premises with BTM Storage and/or on-site generation (e.g., rooftop solar) can offset premise Load
  - But also occasionally inject power to the distribution system
- If the entire ALR goes positive to the grid, the exported energy does not get credited

So what is "Clumping"?

* It's our idea to get around the barrier that ERCOT systems can't see an export from a residential aggregation: populate the ALR to have other Only-Load (no possible export) sites so ALR can ensure that it **is always Net Load in ERCOT system.**

Two problems solved with one solution = exports to ERCOT + accommodate ERCOT current system limitations.

A "clumping" example

- ALR consists of a combination of residential and commercial Load sites:
  - Residential premises with BTM battery storage, and possibly on-site generation
  - Commercial Load sites could be: a building, a data center, solar-only homes, public facilities, EV stations
- The batteries follow SCED base points or Regulation instructions, providing the appropriate Ancillary Service
  - Example: Load-only sites are there just to ensure ALR is always net Load; the chargers are not responsive to market signals.
- The residential batteries offset the co-located residential Load and – when the residential sites are net positive to the grid – also offset the non-co-located loads (reduce total load, but ERCOT still sees Load).
- This ensures the Resource is always a net Load at the aggregate level while allowing the ALR to get credit for the full value of the battery response

Telemetry

- ALR provides two distinct telemetry feeds to ERCOT via ICCP:
  - Batteries only (device-level)
  - Overall ALR Load (premise-level)
- Device-level data is the primary metric used for performance measurement & verification, using the meter before/meter after evaluation methodology
- Premise-level data may be spot-checked by ERCOT as a secondary validation to ensure the grid service is being provided

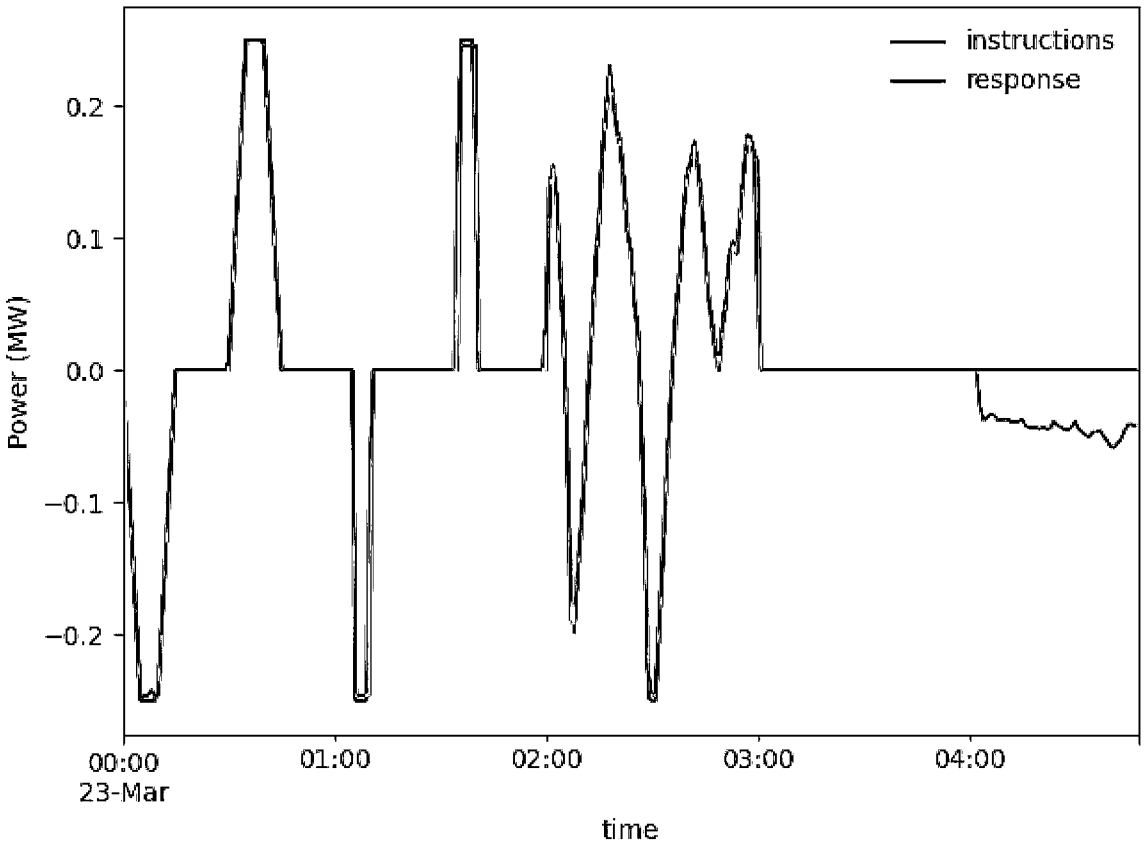
Modeling considerations

- Residential premise Load, even with BTM storage and generation, is well suited to baselining
- But load is spiky and unpredictable, which renders the full ALR incapable of being baselined
- Since batteries are providing the service, meter before/meter after is the appropriate M&V method, also allowed in current ALR Policy
- Historical data from the residential premise Load and the EV chargers can provide a metric indicating normal or typical usage patterns
  - This could enable the ISO to detect unusual behavior that would affect the provision of the service

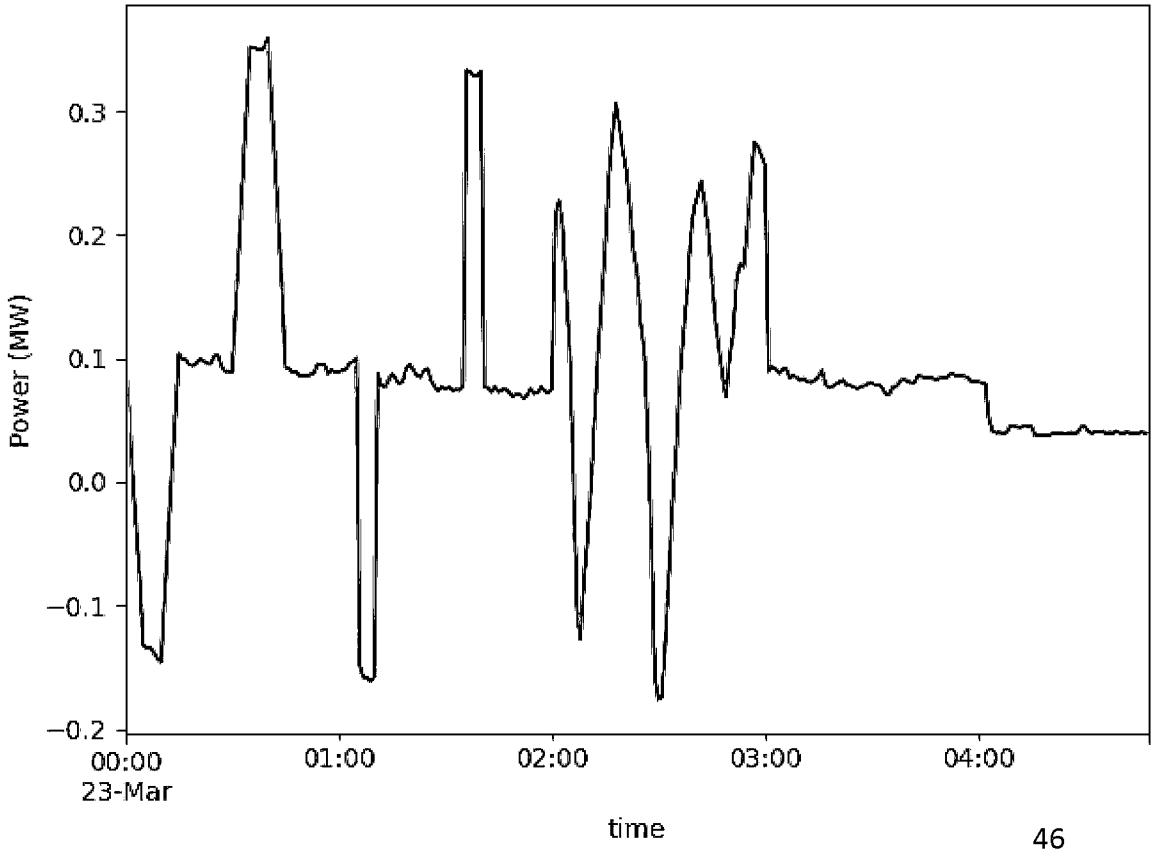
Regulation demo results

Aggregate telemetry of 61 residential sites on March 23th, 2022

Aggregate device-level telemetry



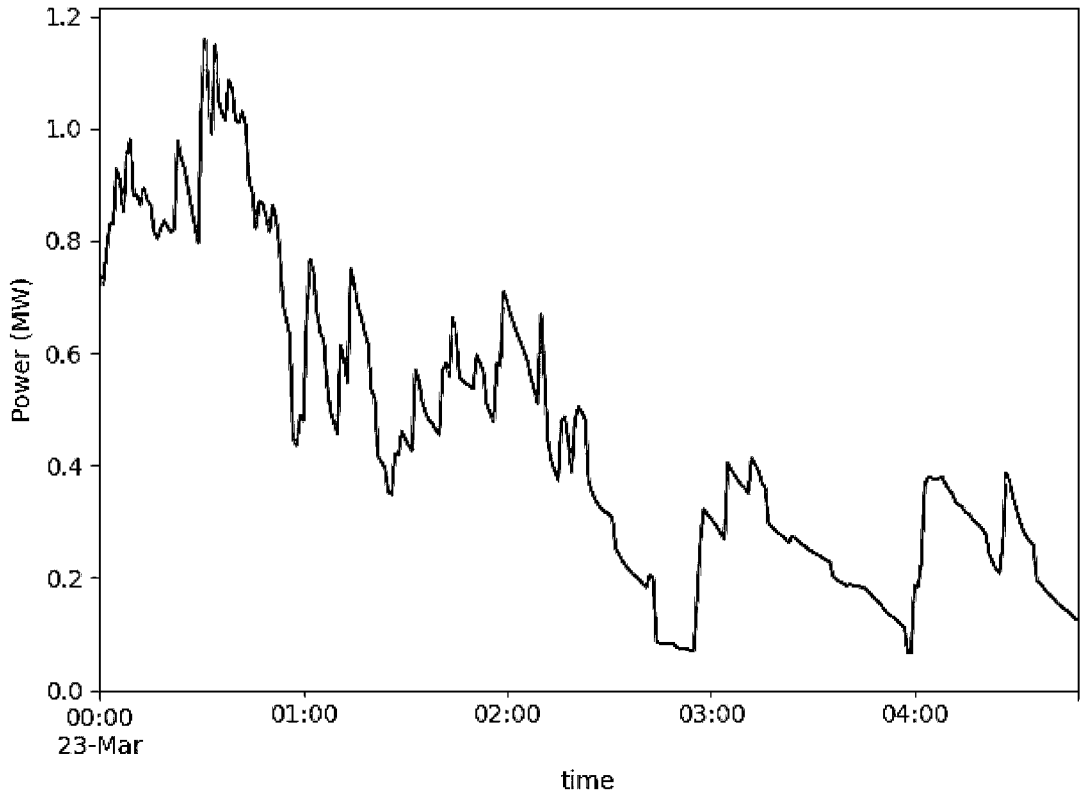
Aggregate premise-level telemetry



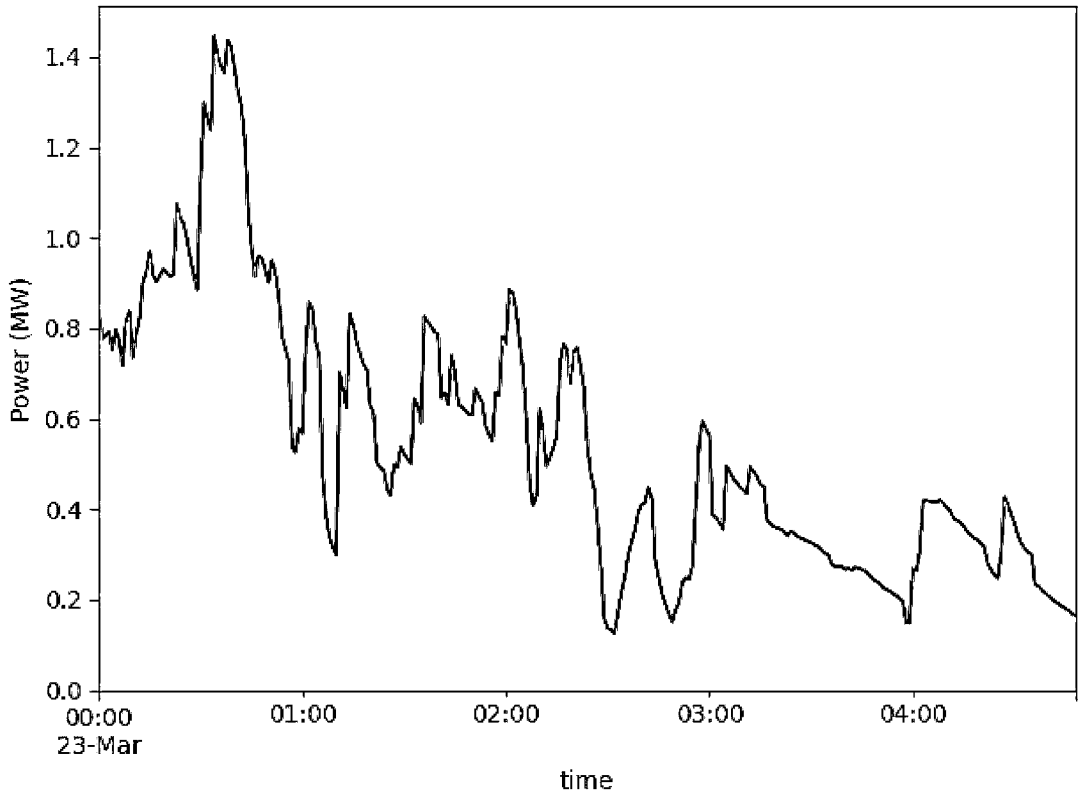
Regulation demo results

Clumping with 19 Supercharger sites in load zone North

Aggregate Supercharger telemetry



[1]Aggregate ALR telemetry



[1]Aggregate ALR telemetry = Supercharger + premise telemetry

Regulation demo results

ALR telemetry outside of regulation test period