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California Investor Owned Utilities Comments - FDAS BESS RFI Comments

This letter comprises the comments of the Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE), collectively referred to herein as the California Investor-Owned Utilities (CA IOUs), in response to the California Energy Commission request for information (RFI) regarding Flexible Demand Appliance Standards (FDAS) for Battery Energy Storage Systems (BESS).

Additional submitted attachment is included below.

December 12, 2025

Efficiency Division, Load Flexibility Branch
California Energy Commission
715 P Street
Sacramento, CA 95814

Docket Number: 25-FDAS-01
TN Number: 266464

Topic: Request for Information (RFI) on Flexible Demand Appliance Standards for Battery Energy Storage Systems

Dear Commission Staff,

This letter comprises the comments of the Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE), collectively referred to herein as the California Investor-Owned Utilities (CA IOUs), in response to the California Energy Commission request for information (RFI) regarding Flexible Demand Appliance Standards (FDAS) for Battery Energy Storage Systems (BESS).

The CA IOUs comprise some of the largest utility companies in the nation, serving over 32 million customers in the Western United States. We are committed to helping customers reduce energy costs and consumption while striving to meet their evolving needs and expectations. Therefore, we advocate for standards that accurately reflect the climate and conditions of our respective service areas.

We respectfully submit our responses to the CEC's RFI questions, accompanied by an executive summary.

EXECUTIVE SUMMARY

The CA IOUs recommend the CEC adopt a broad, future-proof scope for BESS standards. Specifically, the CA IOUs urge the CEC to include commercial-scale systems to align with Title 24 requirements and to remove hard capacity caps, which risk stifling innovation as battery costs decline and customer needs evolve. The utilities further recommend establishing a technology-agnostic framework that relies on local device intelligence to resolve conflicts between grid signals and customer preferences, ensuring interoperability across diverse architectures (e.g., AC- vs. DC-coupled systems) without mandating specific hardware designs.

Regarding connectivity, the CA IOUs recommend that FDAS require multi-modal communication capabilities (cellular and Wi-Fi) to ensure reliable access. For grid reliability and interoperability, the CA IOUs support open standards rather than relying on vendor-specific APIs. Recognizing that authentication, authorization, and data privacy present major cybersecurity challenges, the CA IOUs advise FDAS to follow leading practices, including IEEE 1547.3, the NIST Cybersecurity Framework, and certification for OpenADR and IEEE 2030.5, to support secure and reliable operations. The CA IOUs also recommend incorporating fallback mechanisms that allow consumers to switch cloud providers, preventing "stranded assets" if a manufacturer exits the market. Finally, the CA IOUs recommend that the CEC create an equity-focused FDAS that mitigates barriers related to cost, internet access, and overall accessibility.

1. **Scope:**
    - **Please provide information to assist the CEC in assessing whether Table 1 captures an adequate range of devices within the broader class of BESS.**
    - **Should the CEC consider expanding the scope of FDAS to include commercial-scale, greater than 20kWh, BESS? What are the potential benefits, limitations, and challenges of including commercial BESS alongside residential systems in this regulation? Are there specific market segments, system sizes, or control capabilities that would make commercial BESS appropriate for inclusion?**

The CEC should consider a broader scope for FDAS for BESS, but doing so comes with challenges and should be carefully evaluated. FDAS for BESS should be able to adapt to future markets while providing clear guidance to manufacturers developing or selling new products in California.

BESS Capacity

The proposed hard caps on maximum battery capacity could quickly become outdated and distort the market as costs decline and customer needs evolve. Research by the National Renewable Energy Laboratory (NREL) estimates residential battery storage capital expenditures (CAPEX) reduction ranges from 17% (conservative) to 52% (advanced) between 2022 and 2035.[1] It clearly indicates a substantial long-term decline in battery storage cost. A battery capacity cap might dampen innovation, constrain customer resilience, and reduce peak-shaving potential.

Commercial-Scale BESS

Moreover, limiting the scope to residential systems could miss a significant part of the market that the CEC already regulates. Title 24, Part 6, Section 140.10.(b) establishes requirements for BESS in non-residential buildings when a photovoltaic (PV) system is installed under section 140.10.(a) to support load management and demand response.[2] The capacity of the required PV system dictates the necessary battery storage capacity, which typically exceeds 20 kWh. Therefore, extending the scope to cover commercial-scale BESS would align with Title 24's communication and control requirements for grid-interactive demand response and load management. Specifically, larger BESS operations, which can support substantial load shifting, can reliably respond to grid requests and operate consistently with residential BESS under a future FDAS structure.

Commercial-scale BESS units, defined as those with a capacity greater than 20 kWh, can deliver significant

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[1] National Renewable Energy Laboratory, *Residential Battery Storage | Electricity | 2024 | ATB*. (Golden, CO: NREL, 2024), https://atb.nrel.gov/electricity/2024/residential_battery_storage.

[2] California Energy Commission. *2022 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, Title 24, Part 6, and Associated Administrative Regulations in Part 1.* https://www.energy.ca.gov/sites/default/files/2022-12/CEC-400-2022-010_CMF.pdf#page=309.

cost savings per dollar invested by autonomously shifting energy in response to signals.[3] They also offer enhanced demand flexibility and help reduce peak loads. However, such installations face challenges, including more variability in configurations and more complex safety compliance requirements. The National Fire Protection Association (NFPA) 855 sets rigorous standards regarding location, fire protection, safety, emergency response, and certification, which are essential for safe and reliable deployment.[4]

3. **Capabilities: What software and hardware capabilities could enable residential BESS to relieve/eliminate grid congestion? How can control software be configured to respond to automated and/or manual override signals from the customer's BESS?**

BESS hardware includes a battery, a battery charger, an inverter that converts DC to AC power (and possibly AC to DC), and a grid-interactive gateway that manages energy flow. BESS software optimizes BESS charging and discharging based on grid signals, and a secure API framework allows an aggregator to manage thousands of BESS as a virtual power plant (VPP). However, just because a BESS can respond to demand response signals does not necessarily mean that it can both receive electricity from, and export electricity back to the grid. For some BESS, demand response signals only control when the battery charges.

BESS manufacturers develop proprietary software and hardware to serve different markets, tailored to customers' circumstances and objectives for their BESS. These hardware/software packages are constantly evolving as new technologies and new distributed energy resource management systems (DERMS) become available. Functional remote command capabilities that enable residential BESS to relieve or remove grid congestion include active power curtailment or preventing the battery from charging (possible with any connected BESS), reactive power control for frequency and voltage management (which requires a bi-directional inverter), and DER disconnect/reconnect for maintenance and safety reasons.

VPPs

NREL has been investigating how advanced distribution management systems (ADMS) and distributed energy resource management systems (DERMS) can be coordinated to moderate the dispatch of distributed energy resources, such as BESS, within a virtual power plant (VPP) to relieve grid congestion. A recent simulation study by NREL demonstrated this layered approach on a real feeder model: the utility's ADMS lowered feeder voltage to reduce demand, and a prototype DERMS optimally dispatched dozens of home BESS to cut the peak load and maintain voltage within limits.[5] During this coordinated control, the DERMS used real-time optimization (based on power flow models) to decide how much each battery should charge or discharge, not only shaving the peak but also injecting or absorbing power at key locations to keep voltages stable.

This VPP concept showed that aggregated BESS fleets, controlled via advanced software, could provide grid

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[3] Galen Barbose and Will Gorman, *Behind-the-Meter Solar+Storage Trends: 2022 Annual Update* (Berkeley, CA: Lawrence Berkeley National Laboratory, November 2022), https://eta-publications.lbl.gov/sites/default/files/btm_solarstorage_trends_final.pdf.

[4] National Fire Protection Association, *NFPA 855: Standard for the Installation of Stationary Energy Storage Systems* (Quincy, MA: National Fire Protection Association, current edition 2026), https://www.nfpa.org/codes-and-standards/nfpa-855-standard-development/855.

[5] National Renewable Energy Laboratory, *Battery Storage for Residential Applications: Modeling and Simulation Results* (Golden, CO: National Renewable Energy Laboratory, 2024), https://docs.nrel.gov/docs/fy24osti/81105.pdf#:~:text=reduces%20the%20peak%20demand%20through,time%20simulations.

services such as peak leveling and voltage regulation concurrently.

DERMS enable BESS aggregators to monitor fleet state-of-charge and dispatch multiple BESS in unison to follow a desired load shape or respond to a grid signal. In effect, a fleet of residential BESS under a DERMS behaves as a dispatchable demand-side resource that grid operators could call upon to maintain reliability. The CA IOUs demonstrated this concept on July 29, 2025, by dispatching 100,000 residential BESS installed by Tesla and Sunrun that provided approximately 535MW of energy to the CA grid between the hours of 7 p.m. and 9 p.m.[6]

Between 2019 and 2022, PG&E also successfully conducted the EPIC 3.03 "Distributed Energy Resource Management System (DERMS) and Advanced Distribution Management System (ADMS)" project to enable the utility to leverage DERs for grid and local reliability benefits and realize value from distributed energy resources. The project implemented the IEEE 2030.5 protocol over the public Internet to communicate between customer-owned devices or aggregation platforms and PG&E's DER Headend Server.[7]

A 2024 report by the Clean Energy State Alliance (CESA) summarizes a few of the approaches.[8] The Hawaii *Bring Your Own Device* (BYOD) program,[9] the Green Mountain Power *BYOD* program,[10] and the Massachusetts' *Clean Peak Standard* program[11] are designed around a customer dispatch model, where customers opt into programs to dispatch their BESS during peak demand periods. A utility dispatch model offers greater flexibility to utilities or grid operators, but at an added cost, since utilities generally must invest in DERMS and forecast regional demand peaks to accurately time dispatch. National Grid's *Connected Solutions* program[12] and Maryland's *Elk Neck Battery Pilot Program*[13] are examples of utility-driven dispatch. In both cases, customers opt into the program and receive remote signals from the utility or its contractor.

Non-VPP BESS Applications

VPPs represent an emerging application of BESS. Most customers with behind-the-meter BESS today installed them primarily for emergency back-up, to maximize self-consumption of PV generation, or to enable price arbitrage under time-varying electricity rates.[14]

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[6] Tina Casey, "California VPP Links 100,000 Residential Storage Batteries," *CleanTechnica*, August 11, 2025, https://cleantechnica.com/2025/08/11/california-vpp-links-100000-residential-storage-batteries/.

[7] Pacific Gas and Electric Company, *EPIC Project 3.03: Demonstration of Residential Battery Storage for Grid Support* (San Francisco: Pacific Gas and Electric Company, 2020), https://www.pge.com/assets/pge/docs/about/corporate-responsibility-and-sustainability/PGE-EPIC-Project-3.03.pdf.

[8] Clean Energy Group, *Energy Storage Program Design for Peak Demand Reduction* (Montpelier, VT: Clean Energy Group, 2019), https://www.cleanegroup.org/publication/energy-storage-program-design-for-peak-demand-reduction/.

[9] Hawaiian Electric, *Battery Bonus Program* (Honolulu: Hawaiian Electric, 2025), https://www.hawaiianelectric.com/products-and-services/customer-incentive-programs/battery-bonus

[10] Green Mountain Power, *Bring Your Own Device Program* (Colchester, VT: Green Mountain Power, 2025), https://greenmountainpower.com/rebates-programs/home-energy-storage/bring-your-own-device.

[11] Massachusetts Department of Energy Resources, *225 CMR 21.00: Clean Peak Energy Portfolio Standard (CPS)* (Boston: Massachusetts Department of Energy Resources, current regulation, 2025), https://www.mass.gov/regulations/225-CMR-2100-clean-peak-energy-portfolio-standard-cps.

[12] National Grid, *ConnectedSolutions Program* (Waltham, MA: National Grid, 2025), https://www.nationalgridus.com/connectedsolutions.

[13] Pepco Holdings, "Battery Storage Helps to Power Maryland," *The Source*, September 14, 2021, https://thesource.pepcoholdings.com/battery-storage-helps-to-power-maryland/.

[14] Utility Dive, "Energy Storage 101: How Energy Storage Works," *Utility Dive*, March 29, 2022,

The hardware and software requirements for these older applications overlap with those needed for BESS VPPs, but they are not identical. For example, the three non-VPP applications listed above do not require a BESS to be capable of exporting electricity to the grid.

Relevant Regulations on Controls

Key standards govern how BESS connect to and interact with the grid. IEEE 1547-2018 establishes the interconnection rules, while UL 1741 serves as the companion testing standard that verifies compliance with IEEE 1547 requirements. UL 1741 also requires testing for communication protocols, using one of three named options: IEEE 1815 DNP3, IEEE 2030.5, or SunSpec Modbus—each with distinct strengths and applications.

In California, Electric Rule 21 applies to BESS connecting to investor-owned utility distribution systems. Rule 21 requires compliance with IEEE 1547-2018 and mandates the use of IEEE 2030.5 as a communication protocol. However, utilities may, by mutual agreement, adopt IEEE 1815 DNP3 or IEC 61850 as alternatives to IEEE 2030.5.[15]

Similar to other "smart" electric technologies such as electric water heaters or electric vehicle supply equipment (EVSE), BESS customer interfaces typically include options that allow customers to override grid commands manually. In addition, BESS charging algorithms may include automatic overrides triggered by conditions such as the state of charge falling below a preset threshold, depending on the system configuration.

For example, just as a smart electric water heater may override a "shed" demand-response signal and turn on when the tank temperature drops below a set-point to ensure an adequate hot water supply, a BESS configured for emergency backup may prevent its state of charge from falling below a minimum level when participating in a VPP, ensuring some reserve capacity remains available to provide power during an outage.

4. **Technology: How can a standard that integrates battery operation with grid conditions account for different BESS (AC coupled versus DC coupled) and use cases (self-consumption, backup power, and DR events)? What technical constraints could limit a BESS's ability to participate in flexible demand programs? What are the various operational modes (ex. backup, self-consumption, etc.) used for BESS, and how does BESS software prioritize between modes? What hardware and software are needed to enable BESS to provide grid services and optimize costs for customers? What percentage of residential BESSs currently receive grid signals (e.g., electricity prices, GHG emissions, and California Independent System Operator Flex Alerts) to schedule load shifting, demand response?**

A BESS FDAS standard should account for different BESS configurations, including AC and DC coupled, and use cases by establishing a technology-agnostic framework that relies on local intelligence within the BESS to resolve conflicts between grid commands and user priorities. As stated above, functional remote

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https://www.utilitydive.com/spons/energy-storage-101-how-energy-storage-works/627194/.

[15] Pacific Gas and Electric Company, *Electric Rule No. 21: Generating Facility Interconnections* (San Francisco: Pacific Gas and Electric Company, 2020), https://www.pge.com/assets/pge/docs/about/doing-business-with-pge/elec-rules-21.pdf; and QualityLogic, *OpenADR Protocol Selection Guide* (Santa Rosa, CA: QualityLogic, 2019), https://www.openadr.org/assets/QualityLogic_Protocol%20Selection%20Guide.pdf.

command capabilities that enable residential BESS to relieve or remove grid congestion include active power curtailment or preventing the battery from charging (possible with any connected BESS), reactive power control for frequency and voltage management (which requires a bi-directional inverter), and DER disconnect/reconnect for maintenance and safety reasons.

Crucially, the FDAS standard would define a set of operational modes while requiring each BESS to be capable of executing commands within user-defined constraints. Local BESS intelligence could, for example, manage complex scenarios such as prioritizing solar self-consumption until a grid congestion event is signaled and the BESS would respond to remote demand response commands. This layered functionality would allow utilities to dispatch a diverse fleet of BESS as a reliable grid resource while meeting primary customer needs for resilience and economic value.

An FDAS might also establish a priority hierarchy of DR commands. For example, at the highest priority level, a grid emergency command might be able to override all algorithms running in the BESS to stop the flow of power to and from the grid. At the second priority level would be commands that could change the outcome of whatever customer-selected algorithm has been chosen to maximize solar self-consumption, minimize electricity costs with time-varying rates, etc. This second group would be different for different BESS manufacturers and BESS configurations and would include most demand response commands. The third priority level would be commands that do not change the outcome of the customer-selected algorithm when there is no grid emergency.

How second priority level demand response commands interact with the customer chosen algorithm is a component of the value proposition that BESS manufacturers and VPP operators offer their customers. For example, in a BESS installed primarily to provide backup power, the on-board algorithm may automatically cease discharging if the battery's state of charge (SOC) approaches the homeowner's preset backup reserve. The customer might allow their BESS to respond to a command calling for discharge below the backup reserve SOC if they are offered compensation and if they feel confident that there is lower chance of an outage.

Interoperability is critical because BESS architectures are chosen to optimize for specific applications, where cost and efficiency advantages may favor one design over another. Ensuring interoperability also helps avoid stranded assets if a manufacturer exits the market.

A universal communications protocol allows a BESS's internal software to dynamically manage both AC-coupled and DC-coupled systems and competing priorities, such as backup power or self-consumption, as chosen by the customer. The goal is to enable each BESS to respond to grid commands within its available capacity and constraints, thereby supporting reliability without compromising customer objectives. For this reason, a standard for grid-integrated battery operation should adopt a universal communication protocol[16] to ensure all BESS—whether AC-coupled or DC-coupled—can respond uniformly to grid signals.

Different BESS architectures and applications face several technical constraints. For example, the hardware and software for a BESS sold as a backup power source for unscheduled outages may be designed to maintain a maximum SOC at all times, its inverter may not be capable of exporting power to the grid, or the interconnection agreement may have a non-export requirement. These software and hardware characteristics limit the system’s ability to support broader grid reliability. Similarly, a BESS designed to maximize solar self-consumption may provide only limited grid services compared to a system configured

[16] See standards including, but not limited to, *IEEE 2030.5: Smart Energy Profile Application Protocol* (New York: Institute of Electrical and Electronics Engineers, current edition, 2025).

for VPP participation. In addition, if a BESS's batteries are not warrantied for frequent full cycling, discharge capabilities may be constrained. Quick charging and discharging associated with providing grid services such as frequency response or voltage regulation can also accelerate battery degradation and shorten useful life.

Beyond hardware limitations, a review of the literature suggests that no single, widely adopted software exists for automating mode switching to maximize value stacking. Developing such approaches presents innate challenges, as systems must balance customer priorities with grid service requirements in real time.[17]

The California IOUs are uncertain of the percentage of BESS that receive grid signals. However, in a recent *Utility Drive* article,[18] Sunrun reported having 217,000 customers nationwide with solar paired to behind-the-meter BESS. Of these customers, 106,000 were enrolled in VPP programs. Sunrun also claims to account for 42% of all energy storage installations. Sunrun's experience suggests that more than half a million behind-the-meter BESS are installed nationwide, with roughly half capable of responding to grid signals. The California Energy Storage System Survey[19] reports 280,423 residential BESS in the state. Applying Sunrun's participation ratio, approximately 137,000 California BESS could be capable of VPP participation.

5. **Connectivity: What are the most common methods for communicating grid signals to BESSs (e.g., Ethernet, Wi-Fi, Cellular)? What are the costs and benefits of these methods that are identified? What are the strategies and technologies employed to enhance communication and connectivity for BESS in areas with limited infrastructure, poor communication, and connectivity?**

While residential BESS typically uses home Wi-Fi for homeowner apps and smart home integration, grid signals are relayed separately. Aggregators rely on proprietary cloud platforms to send control instructions to the BESS, often preferring a proprietary cellular connection for this grid-facing communication.[20]

Cellular is favored over Wi-Fi for real-time grid signals because it is scalable, reliable, secure, and independent of the customer's home network. Home networks may lack reliable bandwidth, may be unavailable (as in 12% of California homes),[21] or may not be fully compliant with cybersecurity requirements. BESS focused on local functions, such as backup power or time-of-use (TOU) rate arbitrage, that do not require continuous real-time connectivity and may rely only on home Wi-Fi. When both cellular

[17] Owen Zinaman, Thomas Bowen, and Alexandra Aznar, *An Overview of Behind-the-Meter Solar-Plus-Storage Regulatory Design* (Golden, CO: National Renewable Energy Laboratory, 2020), NREL/TP-7A40-75283, https://www.nrel.gov/docs/fy20osti/75283.pdf.

[18] Kavya Balaraman, "Sunrun Sees 400% Growth in Virtual Power Plant Participation," *Utility Dive*, November 25, 2025, https://www.utilitydive.com/news/sunrun-sees-400-growth-in-virtual-power-plant-participation/805169/.

[19] California Energy Commission, *California Energy Storage System Survey* (Sacramento: California Energy Commission, 2025), https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/california-energy-storage-system-survey.

[20] U.S. Department of Energy, *Distribution Grid Orchestration* (Washington, DC: U.S. Department of Energy, November 18, 2024), https://www.energy.gov/sites/default/files/2024-12/2024-11-18%20Distribution%20Grid%20Orchestration_Clean.pdf.

[21] USC Annenberg Research Network on International Communication, *2023 Statewide Digital Equity Survey: Final Report* (Los Angeles: University of Southern California, December 2023), https://arnicusc.org/wp-content/uploads/2023/12/2023-Statewide-Digital-Equity-Survey-Final-Report.pdf.

and homeowner broadband are available, some aggregators reduce costs by using broadband as the primary channel and cellular as backup.[22] The stringent availability and telemetry requirements mandated by California Rule 21[23] effectively compel aggregators to utilize cellular connectivity as a primary or redundant communication interface, thereby ensuring the reliable dispatch of distributed energy resources independent of the vulnerabilities inherent in unmanaged residential local area networks. The primary limitation of cellular is higher latency than Ethernet.

Ethernet offers the most reliable, lowest-latency option, and is common for commercial-scale BESS. However, it is rarely used for residential grid connectivity due to the high cost of dedicated wiring. Aggregators will default to Ethernet if available, and ultra-low latency VPP functions such as frequency regulation may require it.

Decentralized networks (e.g., peer-to-peer or mesh) are not yet common for BESS grid communication and remain in pilot and demonstration phases. While they offer benefits such as reduced latency and rapid local response, their complexity and the need for new control architectures are barriers to wider deployment.

To enhance BESS communication in areas with limited infrastructure, the challenge is to reduce reliance on high-availability, IP-based standards such as IEEE 2030.5. Strategies are to focus on device autonomy, alternative communication pathways, resilient network design, and efficient data protocols. Device autonomy ensures the BESS remains functional even when disconnected from a central network.[24]

Emerging options include Cellular IoT (LTE-M / NB-IoT),[25] which offers low-power, low-bandwidth cellular protocols that are more widely available and cost-effective in rural areas. Bandwidth-efficient protocols such as DNP3,[26] designed for Supervisory Control and Data Acquisition (SCADA) systems, conserve bandwidth by transmitting data only when a value changes significantly, ensuring integrity while minimizing network load.

Further discussions of operations during connectivity loss are provided below in response to the Resilience question.

6. **Protocols and Interoperability: What are the communication protocols or components of existing communication protocols that are used to enable load shifting capabilities for residential BESSs? What are the advantages and disadvantages of each of the communication protocols? What is the implementation status of these communication protocols? What are the industry-wide standard communications protocols currently in use or planned for BESS?**

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[22] Tesla, *Powerwall Internet Connectivity* (Palo Alto, CA: Tesla, 2025), https://www.tesla.com/support/energy/powerwall/own/internet-connectivity.

[23] California Public Utilities Commission (CPUC), *Electric Rule No. 21, Generating Facility Interconnections*, Section Hh.5 (Communications Requirements) and Section Hh.8 (Control Through Communication Capabilities), https://www.cpuc.ca.gov/Rule21/.

[24] National Renewable Energy Laboratory, *Distribution Grid Services from Behind-the-Meter Solar and Storage* (Golden, CO: National Renewable Energy Laboratory, 2024), NREL/TP-6A40-87629, https://docs.nrel.gov/docs/fy24osti/87629.pdf.

[25] Digi International, *LTE-M Versus NB-IoT: A Comparison of Low-Power Wide-Area Cellular Technologies* (Hopkins, MN: Digi International, 2023), https://hub.digi.com/dp/path=/markrting/asset/lte-m-versus-nb-iot-white-paper.

[26] Institute of Electrical and Electronics Engineers, *IEEE Standard for Electric Power Systems Communications—Distributed Network Protocol (DNP3), IEEE Std 1815-2012* (New York: IEEE, 2012), https://ieeexplore.ieee.org/document/6327578.

What are the gaps and challenges to implementing load shifting capabilities? How can the standard ensure interoperability between BESS and other flexible demand appliances (e.g. EVSE, space conditioning and electric water heating), and various control systems (such as home management systems)?

Communication Protocols

Supporting load shifting control with BESS typically requires two layers of communication: signals from utilities or aggregators conveying event-based or pricing information, and device-level controls that execute commands through the inverter or energy management system.

Protocols include:

- **Open ADR 2.0/3.0**: A common DR signaling standard that sends event or price information to aggregators/energy management systems.
- **IEEE 2030.5:** An application-layer DER standard that conveys signals from utilities or aggregators to the BESS gateway. The DER function set can directly adjust inverter power and scheduling at the device level.
- **SunSpec Modbus**: A widely adopted protocol for behind-the-meter (BTM) BESS control, which is referenced in IEEE 1547-2018 as a recognized protocol for DER interoperability.
- **Vendor-specific APIs**: Proprietary interfaces used by most major BESS vendors for both signaling and device control, offering flexibility but limiting standardization.
- **Matter:** A standardized HEMS (Home Energy Management System) protocol for smart home and IoT devices.

Gaps and Challenges

Many gaps and challenges remain in BESS communication protocols. Fragmented ecosystems, uneven feature parity across BESS vendors, and complicated mapping for core functions such as State-of-Charge (SOC) targets and event priority all hinder seamless integration.

The interoperability goal is for different brands and types of devices to communicate using a shared, standardized language. That goal is achieved by using open standards as the primary communication interface at two levels: external signals from utilities and aggregators, and internal commands to device hardware. IEEE 2030.5 is emerging as the unifying protocol capable of handling DER communications in both layers. This ideal end-to-end standardization reduces protocol translation complexity and enables streamlined coordination between utilities, aggregators, and BESS. California's Rule 21 reinforces this trajectory and requires IEEE 2030.5 messaging as the default application-level protocol for smart inverters connected to CA IOUs.[27] Also, following Rule 21 phase 2,[28] IEEE 2030.5 messaging has been required as the communication protocol for Behind-The-Meter (BTM) DER.

However, there are limitations in adopting IEEE 2030.5 for device control, as it cannot support product-specific functionalities. For example, IEEE 2030.5 cannot directly set a BESS reserve State of Charge (SOC), although it can issue energy-flow control to maintain an energy floor. Consequently, almost all major BESS vendors opt to use proprietary APIs for device-level control to maintain full control over performance and functionality, fast innovation, and market differentiation.

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[27] SunSpec Alliance, *Common Smart Inverter Profile (CSIP) Implementation Guide, Version 2.1, March 15, 2018* (San Jose, CA: SunSpec Alliance, 2018), https://sunspec.org/wp-content/uploads/2019/08/CSIPImplementationGuidev2.103-15-2018.pdf.

[28] SunSpec Alliance, "California Rule 21 Phase 2 Goes into Effect This Month," *SunSpec Alliance*, August 2019, https://sunspec.org/california-rule-21-phase-2-goes-into-effect-this-month.

Interoperability between BESS and other flexible demand appliances
Requiring a single device-level standard to directly control diverse flexible assets such as BESS, EVSE, and HVAC would be impractical because each appliance requires fundamentally different control primitives. For example, a BESS sets the SOC level, whereas a smart thermostat controls the temperature setting. Interoperability across these appliances would be better achieved through a layered approach. At the upper layer, a standard such as IEEE 2030.5 and OpenADR can uniformly communicate price signals and peak events across all appliances. At the lower layer, a home energy management system (HEMS) translates the standardized signals into device-specific commands to each protocol, such as Sunspec Modbus for BESS and Matter for smart thermostats.

The CA IOUs support open standards for BESS interoperability rather than relying on vendor-specific APIs to reduce the risk of stranded assets. We acknowledge the challenges of mandating strict compliance with open standards, especially given the rapid pace of technological evolution. Locking manufacturers into specific protocol versions risks obsolescence. Therefore, the CA IOUs recommend that when the CEC adopts FDAS requirements, they should be based on minimum verifiable performance criteria required by standards. This approach allows industries to continue advancing technology while ensuring interoperability. In other words, FDAS communication standard requirements should be structured to remain future-proof and adaptable to technological updates.

7. **How can residential BESSs best utilize the CEC's Market Informed Demand Automation Server (MIDAS), which provides free access to utilities' time-varying rates, GHG emission signals, and California Independent System Operator (California ISO) Flex Alerts?**
    - **Are there options for BESS systems to leverage signals from CEC MIDAS? Are there changes to MIDAS that would better support BESS load flexibility than the existing configuration?**
    - **Are there any strategies to best utilize BESS with Demand Response events?**

The CA IOUs support FDAS requirements for secure, bi-directional, reliable, and open standard-based communication features that enable devices to receive and respond to demand flexibility signals from the CEC's Market Informed Demand Automation Server (MIDAS), utilities, or authorized third parties. MIDAS has the potential to serve as a source of price signals, greenhouse gas (GHG) emissions data, and demand response event notifications for BESS. However, BESS manufacturers have not yet widely integrated with MIDAS. To spur the software investment and ongoing maintenance required for integration with MIDAS, technology providers need a clear value proposition that demonstrates how MIDAS signals can be leveraged to deliver consumer benefits.

At present, information offered in MIDAS does not address local distribution issues; however, if BESS providers do integrate with MIDAS, systems could retrieve and respond to signals to provide some grid services and enhance customer outcomes. For example, customer-specific price signals or rate information, based on the end-use customer's specific rate identification number, could inform a BESS's charge and discharge schedule to minimize electricity costs. Additionally, Flex Alert information from MIDAS could trigger BESS discharge or power customer loads during event periods, reducing grid peak demand.

Because BESS have significant power demand, it is critical that signals for this technology be locationally specific, as their operation can have sizable effects on local distribution circuits. The CEC should ensure that BESS are not required to respond to regional or statewide signals, such as GHG signals, that do not align with local distribution needs. At present, MIDAS does not offer a sufficiently diverse signal set to maximize all demand flexibility use cases. For example, it does not support granular, local load-shape signals needed for grid reliability, nor does it provide signals that BESS could use for grid frequency regulation. Given the large data volumes and low latency requirements of these use cases, MIDAS may not be a suitable platform for storing and deploying such information. Accordingly, FDAS requirements for BESS should remain broad enough to accommodate demand flexibility services that do not rely exclusively on MIDAS signals. Such services include, for example, a future use case where BESS could communicate with utility advanced metering infrastructure (AMI) and respond to utility signals.

To deliver a variety of grid services, automation service providers, aggregators, or technology vendors may need to combine MIDAS signals with signals from other sources and then optimize a BESS's operation based on consumer benefits, preferences, and grid needs. Aggregated fleets of BESS can also be operated to provide grid services. This complex optimization is often performed in the cloud rather than on end-use devices, so we suggest that the CEC allow cloud-based platforms to retrieve MIDAS signals rather than requiring BESS device-level integration with MIDAS.

Customers should be adequately compensated for providing grid services, whether through rate savings, demand response incentives, or participation in virtual power plant programs. Compensation both reflects the value of service and accounts for the additional wear a BESS may experience when providing it. While MIDAS signals could theoretically be broadcast to promote widespread demand flexibility, FDAS requirements should not mandate default BESS response to MIDAS signals without a clear compensation mechanism.

Finally, any proposed MIDAS changes that would require utility investment should be coordinated with the appropriate California Public Utilities Commission proceedings to ensure proper cost recovery. Potential upgrades to MIDAS should also be considered by the CEC due to a large increase in Rate Identification Numbers (RIN) from locational price signals as ordered in D.25-08-049.[29]

8. **Cybersecurity: What are the cybersecurity challenges and needs associated with communicating signals from the grid or a third-party, and interacting with BESS? How would these cybersecurity protocol challenges be used to address the risks to both customer data and grid reliability? What are the risks and benefits of enabling remote software updates to incorporate new standards, and what processes can be used to mitigate these risks?**

Cybersecurity for residential BESS is typically implemented through a layered network architecture.[30] DR protocol signaling operates at higher-layer while lower-layer standards, such as TCP/IP, protect the DR signals riding on top of it across the network. For example, when a utility sends a DR instruction to a Wi-Fi connected residential device using secure internet protocol, transport layer security (TLS) is automatically applied to encrypt the message, ensuring confidentiality and integrity.

Challenges and Risks

Two primary cybersecurity challenges affect DR communication systems. The first is authentication and

[29] D.25-08-049 COL 14 at 141.

[30] A. Vaddiraj and W. Johnson, *Communication Protocols and Standards for Residential Demand Response* (Palo Alto, CA: Electric Power Research Institute, September 2021); Electric Power Research Institute (EPRI), *Residential Demand Response: Final Report, DR18.12* (Palo Alto, CA: Electric Power Research Institute, December 14, 2021), https://www.dret-ca.com/wp-content/uploads/2022/09/DR18.12-Final-Report-Residential-Demand-Response-20211214-.pdf.

authorization across multiple parties. Utilities, aggregators, vendors, and devices all participate in the communication link. Each entity requires mutual authentication, and the principle of least privilege (PoLP), which means that only the minimal necessary permissions should be granted, must be applied across both the upward path (utility/aggregator) and the downward path (BMS/inverter).

The second challenge is the privacy risk of data sharing, which has significant consumer implications. Aggregators and utilities routinely collect telemetry data that can reveal household behavior patterns such as energy usage and occupancy. Without strong privacy controls and encryption, this sensitive data could be misused or exposed.

Protocols and Practices

IEEE 1547.3 provides security guidance and recommendations for how DERs should communicate with Electric Power Systems (EPS). These security practices support the communication requirements mandated in IEEE 1547.[31] It requires strong mutual authentication, such as PoLP, to ensure that only trusted entities can access DER functions. For data privacy, IEEE 1547.3 mandates encrypted communication and access control to protect customer data.

The NIST Cybersecurity Framework (CSF) offers a structured approach tailored to stakeholder groups, including utilities, aggregators, BESS vendors, and customers.[32] The Framework emphasizes the functions of protect, detect, respond, and recover. It requires organizations to restrict access to authenticated entities and to implement role-based or attribute-based access control for authorization.

Both OpenADR and IEEE 2030.5/CSIP certifications define cybersecurity requirements that mandate encrypted communication, and certificate- or token-based authentication and authorization.[33,34] These certifications verify that systems meet the essential security needed for reliable operation.

BESS systems should clearly disclose to consumers all data that is collected, including any personally identifiable information, and obtain explicit, informed, and granular consent. Consumers must be able to join or leave programs or opt out of data collection without losing core functionality. Systems should follow strict minimization principles, collecting only what is necessary for operational and regulatory purposes, while leveraging frameworks such as NIST CSF[32] to support strong authentication and encryption. Any third-party data-sharing arrangement must be disclosed to consumers, and all parties must meet equivalent privacy and security standards.

Finally, voluntary cybersecurity standards such as SOC 2 Type 2 or ISO/IEC 27001 are increasingly important in strengthening data privacy protections. These frameworks establish rigorous, independently verified controls for securing sensitive customer and operational data, complementing regulatory and certification requirements.[35]

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[31] IEEE Standards Association, *IEEE Guide for Cybersecurity of Distributed Energy Resources Interconnected with Electric Power Systems, IEEE Std 1547.3-2023* (New York: IEEE Standards Association, 2023), https://standards.ieee.org/ieee/1547.3/10173/.

[32] National Institute of Standards and Technology, *Cybersecurity Framework (CSF) 2.0* (Gaithersburg, MD: National Institute of Standards and Technology, February 2024), https://nvlpubs.nist.gov/nistpubs/CSWP/NIST.CSWP.29.pdf.

[33] OpenADR Alliance, *OpenADR Certification Process*, *OpenADR Alliance*, https://www.openadr.org/certification-process.

[34] SunSpec Alliance, *IEEE 2030.5/CSIP Certification*, *SunSpec Alliance*, https://sunspec.org/ieee-2030-5-csip-certification.

[35] Ashwin Chaudhary, *"SOC Reports for Cloud Security and Privacy," ISACA Journal*, vol. 6 (December 2019),

Remote Software Update
Enabling remote software updates provides several significant benefits. Updates allow the deployment of new features and profiles that expand grid-service capabilities, while also enabling rapid patching of security vulnerabilities. Updates also extend product life by keeping systems current with evolving standards and help ensure ongoing regulatory compliance.[36]

At the same time, remote updates introduce risks. A failed update may render a device inoperable. Version fragmentation across a BESS fleet can complicate management and coordination, and updates performed without careful planning may disrupt ongoing operations.

To mitigate the risks, best practices have emerged. A/B partitioning ensures that devices can roll back to a stable version if an update fails. Version-control logic at the device helps maintain consistency across fleets, and maintenance-aware scheduling minimizes operational disruption by aligning updates with periods of low demand or planned downtime.

9. **Resilience: In the event of a loss of communication and/or connectivity, how should the residential BESS function? What are the potential risks and benefits of each approach, especially in terms of grid reliability, user experience, and long-term sustainability? What is the current status of interoperability standards that would allow previously installed BESS to point to a different cloud-software control layer if the original control layer is disbanded for business reasons?**

Behavior in Loss of Communication
Title 24, Part 6, JA12 specifies that during a power interruption—defined as a loss of connectivity—a system shall switch to backup power mode.[37] Once the power and connection are restored, the system must immediately revert to the previously programmed control strategy. In backup mode, the BESS relies on the last known on-device schedule and prioritizes on-site load, ensuring continued support for local energy needs and avoiding unexpected behavior without cloud oversight. However, in this mode, the device can no longer respond to DR signals.

By contrast, IEEE 2030.5/CSIP requires a BESS to complete any scheduled event and then revert to its prior configuration setting as determined by the site host or tariffs and contracts. This requirement provides predictable behavior for resilience and security. It also means the BESS cannot respond to new signals or commands from utilities, reducing real-time coordination with the grid.

Taken together, JA12 and IEEE 2030.5/CSIP address different aspects of BESS behavior operation when communication is lost. JA12 emphasizes safe, customer-centric operation, requiring the BESS to maintain essential functions locally. In contrast, IEEE 2030.5/CSIP focuses on grid-facing requirements, ensuring

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https://www.isaca.org/resources/isaca-journal/issues/2019/volume-6/soc-reports-for-cloud-security-and-privacy.

[36] Jay Johnson and Ingo Hanke, *Recommendations for Distributed Energy Resource Patching, SAND2021-11150* (Albuquerque, NM: Sandia National Laboratories, 2021), https://sunspec.org/wp-content/uploads/2025/01/Recommendations-for-Distributed-Energy-Resource-Patching-SAND2021-11150.pdf.

[37] California Energy Commission, *Title 24, Part 6, Appendix JA12 – Qualification Requirements for Battery Storage System, 2022 Building Energy Efficiency Standards* (Sacramento, CA: California Energy Commission, 2022), https://www.energy.ca.gov/sites/default/files/202406/JA12_Qualification_Requirements_for_Battery_Storage_System_ada.pdf.

autonomous smart inverter functions continue in line with contractual or tariff obligations. Combined, these standards provide complementary safeguards, enabling BESS to operate safely for both the customer and the grid during periods of communication loss.

Interoperability with Alternate Cloud Services

JA12 does not mandate or standardize re-pointing to alternate servers, and IEEE 2030.5/CSIP similarly provides no guidance on how a previously installed BESS could be retargeted to another cloud server without the manufacturer's cooperation. With no standard or guideline available for the scenario described by the CEC, the CA IOUs recommend that the CEC establish requirements for BESS manufacturers to implement a fallback architecture. Such an approach would allow users to switch to another cloud service without relying on the original manufacturer for intervention.

A precedent exists in the Mercury Consortium's requirements for EVSE (Electric Vehicle Supply Equipment).[38] These requirements mandate fallback functionality if a manufacturer removes support, closes cloud services, or enters insolvency. This protects users from being locked into a single service provider and maintains continued participation in demand flexibility programs. Applying a similar framework to BESS would protect customers, preserve grid services, and strengthen resilience against stranded assets.

10. **Valuation Tools: Staff is considering using the California Public Utilities Commission's (CPUC) Avoided Cost Calculator (ACC) for internal data evaluation while CEC continues to draft a standard for residential BESS. To what extent is the ACC a reliable and valuable tool for forecasting hourly value for electricity import or export to the grid? Are there specific strengths or limitations in the ACC's methodology or assumptions that should be considered when valuing Net Billing Tariff for BESS? Are there other sources that CEC staff should consider in valuing or forecasting hourly value for electricity imports or exports to the grid?**

The CPUC's ACC[39] offers both strengths and limitations when applied to forecasting and valuing hourly benefits for BESS.

Strengths

- **Authoritative source for hourly export compensation rates**: For forecasting Net Billing Tariff (NBT, or NEM 3.0) revenue, it is the definitive tool, as its 8,760 hourly values directly represent compensation rates.
- **Comprehensive value stacking**: The ACC is not a single energy price. It incorporates multiple, time-differentiated value streams, including avoided energy, generation capacity, transmission and distribution (T&D), and GHG costs.
- **Transparent methodology:** Developed by E3, the model and its underlying methodology are publicly available, allowing stakeholders to fully vet the logic.
- **Regulatory consistency:** The ACC provides valid long-term forecast by utilizing approved state planning inputs, including CEC IEPR gas forecasts and CPUC Integrated Resource Plan (IRP)[40] data.

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[38] Mercury Consortium, *EVSE Functional Requirements, Version 0.9a* (Palo Alto, CA: Electric Power Research Institute, 2019), https://restservice.epri.com/publicattachment/93615.

[39] California Public Utilities Commission, *2024 Distributed Energy Resources Avoided Cost Calculator Documentation* (San Francisco, CA: California Public Utilities Commission, 2024), https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-side-management/acc-models-latest-version/updated-2024-acc-documentation-v1b.pdf.

[40] California Public Utilities Commission, *Integrated Resource Plan and Long Term Procurement Plan (IRP-LTPP)*,

Limitations

- **Models export value only:** For forecasting benefits of BESS, the ACC's most significant limitation is that it only values electricity exported to the grid. It ignores the customer's primary BESS value stream of retail tariff arbitrage (savings from avoiding high-cost grid imports).
- **Ignores customer and societal value:** As a utility-centric tool, the ACC intentionally excludes key customer-side benefits (such as resilience/backup) and broader societal benefits (such as public health from reduced peaker plant emissions).
- **Forecast vs. real-time market value:** Based on Day-Ahead market simulations, the ACC fails to capture the significant volatility—and potential value—of the Real-Time market.
- **Averaged T&D valuation:** The ACC's valuation of T&D is not particularly specific.
    - **Averaged, not locational:** The ACC calculates broad *averaged* T&D values, missing the higher locational 'surgical value' of a BESS deferring upgrades in a *specific* congested hotspot.
    - **Deferral vs. elimination:** It assumes BESS *defers* T&D upgrades for only a few years, rather than *eliminating* them, lowering the calculated value.
    - **Limited non-capacity value:** It currently focuses on deferring *capacity* upgrades while largely ignoring services such as voltage support or reactive power.

Because the ACC alone cannot capture the full value of BESS, the CEC may want to consider the following additional tools:

- **CAISO Market Data:** Provides the actual wholesale market value of BESS dispatch, as opposed to the tariff value (NBT). Analyzing historical Day-Ahead and Real-Time Locational Marginal Prices (LMPs) of Default/Sub Load Aggregation Points (LAPs) from CAISO reveals the "market-facing" value of a BESS, which can be compared to the ACC-defined tariff value. Historical data is available on the California ISO Open Access Same-time Information System (OASIS) site.[41]
- **Utility-Specific TOU Retail Tariffs:** Essential for calculating "bill savings" or "import avoidance"—an important data source for participant benefits for residential BESS. MIDAS[42] provides current, future, and historical data for time-dependent electricity rates (primarily TOU rates) from the CA IOUs. The OpenEI Utility Rate Database (URDB),[43] maintained by NREL, offers a comprehensive database of utility rate structures. Each CA IOU maintains an official tariff book,[44,45,46] while CPUC proceedings, such as General Rate Case, provide detailed justification of rate design.
- **Hourly Pricing Pilot Data:** Under California's Load Management Standards,[47] the CA IOUs must offer marginal cost-based rates to all residential customers beginning in 2027. This change will reshape bill savings and import-avoidance value compared to TOU rates. Data from dynamic

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California Public Utilities Commission, https://www.cpuc.ca.gov/irp/.

[41] California Independent System Operator (CAISO), *Open Access Same-Time Information System (OASIS) Portal*, *California ISO*, https://oasis.caiso.com/mrioasis/logon.do.

[42] California Energy Commission, *Market-Informed Demand Automation Server (MIDAS) Proceeding*, *California Energy Commission*, https://www.energy.ca.gov/proceedings/market-informed-demand-automation-server-midas.

[43] Open Energy Information (OpenEI), *Utility Rate Database*, *OpenEI*, https://openei.org/wiki/Utility_Rate_Database.

[44] Pacific Gas and Electric Company (PG&E), *Tariffs and Rates*, *Pacific Gas and Electric Company*, https://www.pge.com/tariffs/en.html.

[45] Southern California Edison (SCE), *Tariff Books*, *Southern California Edison*, https://www.sce.com/regulatory/regulatory-information/tariff-books.

[46] San Diego Gas & Electric (SDG&E), *Current and Effective Tariffs*, *San Diego Gas & Electric*, https://www.sdge.com/rates-and-regulations/current-and-effective-tariffs.

[47] California Energy Commission, *Load Management Standards*, *California Energy Commission*, https://www.energy.ca.gov/programs-and-topics/topics/load-flexibility/load-management-standards.

pricing pilot programs such as PG&E's Hourly Flex Pricing[48] and SCE's Flexible Pricing Rate Pilot[49] should be considered as sources for customer responsiveness under dynamic rates. Pricing data from these programs is currently available.[50,51]

- **Reference Circuit Simulations:** The EPRI DER-VET[52] tool calculates energy storage value considering local T&D constraints. Simulating BESS across a diverse set of representative California distribution circuits—ranging from uncongested nodes to those facing critical thermal overloads—would quantify the range of specific locational value of BESS. This approach would reveal the range of benefits from avoided infrastructure upgrades that the ACC's system-wide averages obscure.
- **LBNL Time-Sensitive Value Calculator:**[53] An Excel tool that integrates ACC values (exports) and retail tariffs (imports) to analyze BESS profiles. It enables researchers to plug in different value streams (ACC, a retail tariff, or CAISO LMPs) and other measure shapes (BESS dispatch strategies) to compare outcomes side-by-side, and could be used as a validation of other outputs.
- **NREL's REopt:**[54] A model designed for techno-economic optimization of DERs, including BESS. It can simulate retail tariff arbitrage and demand charge management by loading building profiles and full utility rates, including hourly energy charges, seasonal peak demand charges, and fixed costs. REopt determines optimal dispatch to minimize customer bills, quantifies annual bill savings, and supports long-term analysis (20-25 years) with escalation rates to forecast the value of the BESS under evolving market conditions.

11. **Customer Experience: What types of information or awareness campaign do the Load Serving Entities (LSE) or other entities provide participants in the BESS installation program to help customers understand the benefits BESS provides? What percentage of customers have a residential BESS? What reasons do customers give for installing BESS at their residence? Do customers with residential BESSs have options for more than one rate structure? What tariff structure or options are utilized by the installed stock of BESS? Do customers with a residential BESS prefer a specific rate structure that LSEs or other entities provide? Do customers who add a BESS to their residence stay with their previous rate structure? What financial incentives or rate structures are most effective in encouraging customers to adopt and use for BESS? What are the estimated costs and benefits for customers of participating in the flexible demand program for BESS, including potential bill savings and the impact on BESS lifespan?**

BESS Customer Motivation and Adoption

Customer motivations for installing BESS align with three main benefits: **financial** (TOU arbitrage, VPP revenue), **resilience** (backup power), and **grid support** (enabling renewables).

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[48] Pacific Gas and Electric Company (PG&E), *Hourly Flex Pricing*, *Pacific Gas and Electric Company*, https://www.pge.com/en/account/rate-plans/hourly-flex-pricing.html.

[49] Southern California Edison (SCE), *Dynamic Pricing Rate Pilot Factsheet*, *Southern California Edison*, https://www.sce.com/factsheet/dynamic-pricing-rate-pilot.

[50] Southern California Edison (SCE), *Hourly Flex Pricing Schedule*, https://www.sce.com/save-money/rates-financing/residential-rate-plans/hourly-flex-pricing-schedule.

[51] Pacific Gas and Electric Company (PG&E), *Current Hourly Flex Pricing,* https://www.pge.com/en/account/rate-plans/current-hourly-flex-pricing.html.

[52] Electric Power Research Institute (EPRI), *Distributed Energy Resources Value Estimation Tool (DER-VET)*, *Electric Power Research Institute*, https://www.der-vet.com/.

[53] Lawrence Berkeley National Laboratory, *Time-Sensitive Value Calculator*, *Energy Markets & Policy Department, LBNL*, https://emp.lbl.gov/publications/time-sensitive-value-calculator.

[54] National Renewable Energy Laboratory (NREL), *REopt: Renewable Energy Integration and Optimization Tool*, *National Renewable Energy Laboratory*, https://reopt.nrel.gov/tool.

The Impact of Tariff Structures

Residential BESS customers typically enroll in TOU rate plans. The most impactful tariff for new solar and BESS installations is the **Net Billing Tariff (NBT/NEM 3.0)**. NBT provides a highly variable—and often low—compensation for solar exports to the grid, creating a strong financial incentive to *avoid* exporting. Instead, customers are incentivized to install BESS to store solar energy for self-consumption during evening peak hours. This policy change has driven the solar-with-battery attachment rate from approximately 10% to about 60%.[55]

BESS Optimization and Grid Services

BESS optimization ranges from basic customer-side savings to advanced grid support.

- **Basic Optimization:** Minimizes customer costs by charging during off-peak hours and discharging during on-peak hours, using the TOU tariffs as price signals.
- **Advanced VPP Services:** Utilities are piloting programs for residential BESS to provide frequency regulation and voltage support. Through third-party aggregators, BESS can be grouped into a VPP to provide ancillary services (e.g., Regulation, Spinning/Non-Spinning Reserve) to the CAISO wholesale market, helping to balance the grid in real time.

Financial Incentives and Revenue Stacking

Effective financial models for BESS often "stack" multiple revenue streams. The most effective incentives include:

- **Upfront Subsidies:** Rebates, grants, and tax credits.
- **Performance Adders:** Higher upfront subsidies for BESS that are VPP-capable or for commitment to participation in event-based DR programs or VPPs.
- **Rate Design:** A significant price differential between peak and off-peak rates (for TOU) or between low-cost and high-cost hour pricing (for dynamic pricing).
- **Performance-Based Payments:** Direct payments for active participation in demand response programs, such as the Emergency Load Reduction Program (ELRP) and the Demand Side Grid Support (DSGS).

Battery Degradation and Compensation

Frequent cycling from VPP programs directly accelerates **battery degradation**. Performance loss is a critical factor, as most warranties are limited by both time and cycle count (e.g., 10 years or 4,000 cycles in JA12 warranty requirements, Section 12.2.2.1[56]). Some battery chemistries, such as lithium iron-phosphate (LFP) are longer-lasting and can sustain more charge cycles, making them better suited to frequent-cycling VPP programs.[57,58]

VPP compensation models must account for this accelerated wear and for the incremental cost of deploying batteries capable of withstanding higher cycling. To encourage customer participation,

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[55] Lawrence Berkeley National Laboratory, *California Net Energy Metering (NEM) 3.0 Technical Brief* (Berkeley, CA: Lawrence Berkeley National Laboratory, 2023), https://eta-publications.lbl.gov/sites/default/files/ca_nem_3.0_technical_brief.pdf.

[56] California Energy Commission, *Title 24, Part 6, Appendix JA12 – Qualification Requirements for Battery Storage System, 2022 Building Energy Efficiency Standards* (Sacramento, CA: California Energy Commission, 2022), https://www.energy.ca.gov/sites/default/files/2024 06/JA12_Qualification_Requirements_for_Battery_Storage_System_ada.pdf.

[57] Solar Insure, *Solar Battery Longevity*, *Solar Insure*, https://www.solarinsure.com/solar-battery-longevity.

[58] Personal communication with SonnenUSA representative, November 11, 2025.

successful models provide sufficient incentives to offset degradation or justify investment in longer-life technologies such as:

- **Premium Performance Payments:** Paying a high rate (e.g., $/kWh) for energy dispatched during an event.
- **Upfront Discounts:** Providing a large, initial discount on the BESS hardware.
- **Fixed Payments:** Offering a monthly or annual payment that transfers the degradation risk to the VPP aggregator.

VPP Program Compensation Examples

The dispatch frequency varies from a few times a year to multiple times a day, directly impacting compensation.

- **PG&E Residential Batteries as Virtual Power Plant Study:**[59] Enrollment incentive provided on top of standard metering credits.
- **Emergency Load Reduction Program (ELRP):**[60,61,62] $2.00/kWh provided during an event.
- **Demand Side Grid Support (DSGS) Program:**[63] Monthly capacity payment based on event performance (approximately $350 per season).
- **SDGE VPP Project:**[64] Free installed equipment plus $100 in gift cards for participation.

14. Multifamily Access: What options are available for tenants and occupants in multifamily buildings to access financial benefits from BESS? How would the control software need to change to support load flexibility in this configuration? What, if any, BESS software options exist to allow building owners or operators to manage demand as well as provide grid services? Are there examples of tenant-or resident-owned BESS that could provide these services and could be cost-effectively moved with residents to future residences?

A comprehensive BESS FDAS standard for multifamily installations should address both **centralized, building-level systems** and **unit-specific models** (e.g., per-apartment). Both approaches are relevant whether the building contains rental units or condominiums (owners).

Installation is most straightforward in new construction, where fire safety and infrastructure can be designed to accommodate BESS from the outset. In existing multifamily buildings, retrofits are often cost-prohibitive due to stringent fire safety codes and structural constraints. In condominiums, this challenge is complicated by the need for collective action: residents must reach a consensus to modify shared infrastructure and to establish a fair allocation of the capital costs and energy bill savings.

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[59] Emerging Technologies Coordinating Council (ETCC), *Residential Battery Virtual Power Plant (VPP) Study*, *ETCC*, https://www.etcc-ca.com/reports/residential-battery-virtual-power-plant-vpp-study.

[60] Emerging Technologies Coordinating Council (ETCC), *Residential Battery Virtual Power Plant (VPP) Study*, *ETCC*, https://www.etcc-ca.com/reports/residential-battery-virtual-power-plant-vpp-study.

[61] Tesla, *Virtual Power Plant: Southern California Edison Program*, *Tesla, Inc.*, https://www.tesla.com/support/energy/virtual-power-plant/sce.

[62] Tesla, *Virtual Power Plant: San Diego Gas & Electric Program*, *Tesla, Inc.*, https://www.tesla.com/support/energy/virtual-power-plant/sdge.

[63] The Brattle Group, *The Demand Side Grid Support Program: An Assessment of Scale and Value* (Boston, MA: The Brattle Group, August 2025), https://www.brattle.com/wp-content/uploads/2025/08/The-Demand-Side-Grid-Support-Program-An-Assessment-of-Scale-and-Value.pdf.

[64] Emerging Technologies Coordinating Council (ETCC), *Virtual Power Plant Project*, *ETCC*, https://www.etcc-ca.com/reports/virtual-power-plant-project.

These combined technical and governance barriers make BESS deployment significantly more difficult in multifamily buildings than in single-family homes, creating a clear equity challenge.

Centralized, Building-Level BESS
In multifamily rentals, the primary challenge is the split incentive: property owners bear the capital cost while tenants receive bill savings. Solutions must recapture the owner's investment while fairly distributing benefits to tenants. This issue differs from condominiums, where the collective action challenge arises: unit owners and the HOA must agree on both infrastructure modifications and the equitable allocation of costs and savings.

For both rentals and condominiums, two main allocation approaches exist:

- **Financial Allocation (via VSM): Virtual Sub-Metering** uses private meters to measure each unit's peak-hour consumption. This data enables proportional *financial allocation* of BESS savings to each residence.
- **Physical Allocation (via DPSD): Distributed Power Sharing Devices** are active controllers that *physically route* a pre-set amount of BESS power directly into each unit's circuit during peak events. The benefit is automatic, as the occupant's meter never registers the demand, lowering their bill.

Regardless of the model, tenant protection is critical. Standards must ensure transparency in BESS control and in allocation of benefits to residents.

Unit-Specific BESS
The alternative is a separate BESS for each unit, which can operate independently or be aggregated into a VPP. There are two ownership models:

- **Occupant-owned:** The occupant purchases the unit, retains complete control over participation, and receives 100% of the benefits.
- **Building-owner-owned:** The building owner purchases the BESS and recoups costs through incentives, VPP revenue, or higher rent. The occupant retains control over participation and receives resilience benefits and bill savings (e.g., the Soleil Lofts[65] model).

Portable BESS
The occupant-owned model could be more achievable in rentals if the residents were able to bring the BESS with them when they move. Most portable batteries are designed for backup use only and lack grid connectivity. However, EcoFlow and Anker are notable exceptions: both offer add-on smart panels[66,67] which enable their portable units to be fully grid-integrated and VPP-ready.

The use of portable BESS in multifamily buildings is complicated by lease agreements and local ordinances, which often prohibit the storage of batteries with a capacity above 1 kWh in habitable spaces. These restrictions align with NFPA requirements for stationary batteries and with warning labels on portable BESS certified under UL 2743.[68]

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[65] Utility Dive, *"7 Lessons from Rocky Mountain Power, Sonnen, and Wasatch Virtual Power Plant at Soleil Lofts," Utility Dive*, https://www.utilitydive.com/news/7-lessons-rocky-mountain-power-sonnen-wasatch-virtual-power-plant-solar-battery-storage-soleil-lofts/699357/.
[66] EcoFlow, *Smart Home Panel 2*, *EcoFlow*, https://us.ecoflow.com/products/smart-home-panel-2.
[67] Anker SOLIX, *Smart Home Power Kit*, *Anker SOLIX*, https://www.ankersolix.com/products/smart-home-power-kit.
[68] UL Standards, *Product Detail: UL Standard 49072*, *UL Standards*, https://www.shopulstandards.com/ProductDetail.aspx?UniqueKey=49072.

15. **Equity: What are the equity considerations for BESS, and how can FDAS address these issues in regulation? For example, are there concerns that flexible demand will be disproportionately accessible based on income level? Are there other factors or impacts that should be considered if there were to be disproportionate accessibility?**

Barriers such as high upfront costs or limited broadband connectivity may prevent low-income (LI) and disadvantaged communities (DACs) from accessing BESS benefits. Renters face additional challenges, including restrictions on modifying building infrastructure and limited ability to capture bill savings.

A 2022 study of California's Self Generation Incentive Program (SGIP) found a strong, statistically significant relationship between household income and battery storage adoption rate,[69] even though power outages disproportionately impact lower-income households.[70]

In addition, although 91% of Californians have access to high-speed internet, 12% of residents who identify as Hispanic/Latino cannot connect to the internet at home, and 13% of Californian's with incomes at or below 150% of the Federal Poverty Level do not have access to home internet.[71] Communities with language barriers and communities in rural areas also have lower-than-average broadband access and adoption.[72] Broadband adoption is about 10% lower among Hispanic/Latino residents compared to white non-Hispanic/Latino residents.[73]

Equity-centered FDAS for BESS can help ensure that the demand flexibility benefits of these technologies are widely accessible. Realized benefits depend on the availability of time-varying electricity rates, the design of BESS control strategies, and the priorities of BESS owners. To address inequalities, FDAS for BESS should explicitly support equitable access and participation by low-income and disadvantaged communities.

Potential Equity Issues

Prohibitive Costs: High upfront technology cost and required home upgrades reduce BESS adoption in DACs and LI households. A 2022 study of California's SGIP found disparities in battery adoption rates by household income and race/ethnicity demographic variables, even after controlling for time-varying and regional factors.[74]

To address these barriers, the CEC should evaluate BESS cost-effectiveness in a manner that explicitly accounts for equity across income levels, housing types, and community contexts. Analyses should be segmented by customer type and community context, with a specific focus on LI households and DACs. Additional segmentation could include income tier, housing type, ownership model, geography (rural,

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[69] David P. Brown, "Socioeconomic and Demographic Disparities in Residential Battery Storage Adoption: Evidence from California," *Energy Policy* 164 (2022), https://www.sciencedirect.com/science/article/pii/S0301421522001021.
[70] D. R. Rojas, J. Kerby, and B. Tarekegne, "Energy Justice Through Energy Storage: Supporting Energy Resilience in Disadvantaged Communities," *Current Sustainable/Renewable Energy Reports* 12 (2025): 17, https://doi.org/10.1007/s40518-025-00260-1.
[71] François Bar et al., *2023 Statewide Digital Equity Survey Report* (California Emerging Technology Fund, August 31, 2023), https://www.cetfund.org/action-and-results/statewide-surveys/2023-statewide-survey/.
[72] Bar et al., *2023 Statewide Digital Equity Survey Report*.
[73] Bar et al., *2023 Statewide Digital Equity Survey Report*.
[74] Brown, "Socioeconomic and Demographic Disparities in Residential Battery Storage Adoption."

urban, Tribal), grid vulnerability, and health vulnerability. The CEC should also aim to minimize the incremental cost associated with FDAS functionality.

In the future, the CEC could consider demand-flexibility requirements for products more accessible to LI or renter households, such as lower-capacity portable battery systems that provide resiliency without requiring permanent installation.

Internet Access: Many advanced BESS functions, including remote monitoring, cybersecurity updates, and optimized energy management, depend on continuous internet connectivity via cellular or home broadband. However, many rural, tribal, low-income, and disadvantaged communities lack reliable or affordable internet connectivity.[75] Systems that depend heavily on one connectivity method (e.g., broadband) risk excluding households in these areas from BESS benefits.

As noted in the CA IOUs' February 27, 2025 response on FDAS for EVSE, to enable low-cost, widespread demand flexibility signaling, the CEC could explore emerging communication technologies such as the AMI 2.0 network to enable low-cost, widespread demand flexibility signaling. The CEC could also consider requiring multi-modal connectivity (Wi-Fi and cellular) to ensure redundant communication capabilities.

Accessibility

Finally, the CEC should ensure that FDAS requirements for BESS interfaces are accessible across the physical and digital access spectrum, including both local and remote controls, thereby increasing usability and ensuring equitable participation for diverse populations.

[75] Bar et al., *2023 Statewide Digital Equity Survey Report*.

The CA IOUs appreciate the opportunity to provide these comments regarding the Flexible Demand Appliance Standards on Battery Energy Storage Systems. We thank the California Energy Commission for its consideration and look forward to the next steps in the process.

Sincerely,

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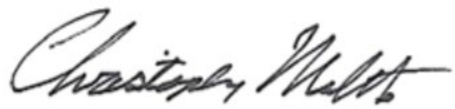

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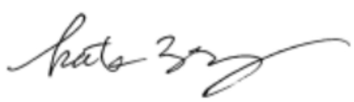

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