Energy Research and Development Division

PROJECT TASK REPORT

Analysis Report of Wholesale Energy Market Participation by Distributed Energy Resources (DERs) in California

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PREPARED BY: SunSpec Alliance

Primary Author(s):
Tom Tansy
Ron Nelson
Kevin Moy
Suzanne Martinez

SunSpec Alliance
4040 Moorpark Ave., Suite 110
San Jose, CA 95117
Phone: (831) 227-1073

Contract Number: EPC-14-036

PREPARED FOR:
California Energy Commission

Hassan Mohammed
Commission Agreement Manager

Sandra Raymos
Commission Agreement Officer

Laurie Ten Hope
Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

Robert P. Oglesby
Executive Director

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PREFACE

The California Energy Commission's Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solution, foster regional innovation and bring ideas from the lab to the marketplace. The California Energy Commission and the state's three largest investor-owned utilities – Pacific Gas and Electric Company, San Diego Gas & Electric Company and Southern California Edison Company – were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The Energy Commission is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

Analysis Report of Wholesale Energy Market Participation by Distributed Energy Resources (DERs) in California is the Task 4.1 report for the *Smart Inverter Interoperability Standards and Open Testing Framework to Support High-Penetration Distributed Photovoltaics and Storage* project (Contract Number EPC-14-036) conducted by SunSpec Alliance. The information from this project contributes to Energy Research and Development Division's EPIC Program.

All figures and tables are the work of the author(s) for this project unless otherwise cited or credited.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

ABSTRACT

Distributed Energy Resources (DERs), typically consisting of solar PV and energy storage systems on homes and commercial buildings, are a growing source of power on the electric grid. DERs participate in the retail energy market, reducing energy costs by dispatching energy to offset local load. With the advent of smart inverters, DER systems now have the ability to simultaneously participate in the wholesale market and take advantage of the economic opportunities there as well. This report identifies opportunities and barriers for DER wholesale market participation, using California Rule 21 as a starting framework. This report finds that if device tariffs and communications are harmonized, DERs can participate on the wholesale market to provide additional revenue streams beyond grid stability on the retail market.

Keywords: Distributed Energy Resources, DER, smart grid, wholesale market, retail market, CSIP, Rule 21, tariff, California ISO

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EXECUTIVE SUMMARY

The State of California has set ambitious targets for decreasing greenhouse gas emissions and increasing the production and distribution of clean energy. Notably, the recently adopted SB100 – the 100 Percent Clean Energy Act of 2018 – establishes a state policy to provide 100% clean energy by 2045.

High solar photovoltaic (PV) penetration using legacy inverters on California grid feeder circuits can exacerbate problems associated with grid instability. It is currently both expensive and risky for grid operators to monitor and control diverse Distributed Energy Resource (DER) assets, including participation in ancillary service markets. While inverter power technology exists, a standard and cost-effective communication interface to monitor and control inverter operating functions and address grid operating variability is not available.

The solution is to enable high penetration of solar PV and DER beyond current Institute of Electrical and Electronics Engineers (IEEE) limits (15 percent of total circuit load) while improving grid stability and increasing cost effectiveness.

Key barriers impeding the achievement of this vision include: availability of cost-effective communication-capable smart inverters; sufficient empirical data to objectively evaluate the impact of DER installations on substations and feeder circuits; and a detailed understanding of the economic and environmental benefits of solar PV-based DER systems.

This project addressed these critical gaps hindering progress toward creating cost-effective and mass-produced smart inverters that can be integrated into diverse grid systems through standard communications. It provides concrete, real-world and actionable data, demonstrating that a standards-based approach will deliver significant benefits to California ratepayers, utilities, DER providers, and equipment manufacturers. This project delivers a smart inverter test framework and open source software tools to enable rapid product development and safety testing. A review of costs and benefits of an electric generation, transmission, and distribution network with high penetration of solar PV and DER was also completed.

The results of this project prove 100%+ renewables into the California grid is technically feasible, in combination with rapidly declining costs driven by global market efficiencies make state-level clean energy targets achievable. To achieve the necessary full DER penetration, the grid requires data communications as an essential new layer to meet the pressing needs of safe, reliable, and cost-effective clean energy. Smart inverters are one part of this and do not require significant additional costs. However, broader investment will be required in the short-term to create the network needed for a clean energy future. Costs therefore need to be assessed within the context of the larger shifts happening in California's energy sector. An evaluation platform has been developed that, coupled with a continuous improvement approach, will enable the transition from California's current electric delivery system to the necessary networked grid that will allow adequate clean energy resources to meet climate targets while maintaining safety, reliability, and cost effectiveness.

Investments in a better grid will unleash numerous economic benefits to all stakeholders, including:

- Cheaper power with annual savings of over $1B per year for all of California with 45-GW peak load.[1]
- Reduced greenhouse gas (GHG) emissions by 68.7 million metric tons with a carbon price savings of over $1B per year.[2]
- More jobs, with an anticipated future increase to the existing 500,000 clean energy jobs in California.
- Training to bridge the existing skilled worker gap in the renewables industry and ensure the workforce is prepared for the specialized nature of new jobs related to DERs and the evolving grid. Community colleges can serve as the centers for this training.
- Research and development to meet emerging industry needs to bring high penetration of solar PV and DER. Smart energy laboratories may one day be affordable to the likes of California Community Colleges, high schools, or even primary schools.
- Market support for industry sectors developing products and services to meet California's emerging needs. This project has proven that manufacturers are ready to serve the market now.
- Improved grid resiliency and reliability with avoided costs of outages (including lost productivity for customers during shutdown).
- Avoided costs for grid upgrades and savings in system design, installation, commissioning, and operations and maintenance (O&M).
- Technological leadership: California as the world leader in 100% renewables with multiplier environmental and economic effects as other jurisdictions follow this model and leverage California's policy, technical, and industry expertise.

The project supports the California Energy Commission's commitment to reduce energy costs and the environmental impacts of energy use – such as greenhouse gas emissions – while ensuring a safe, resilient, and reliable supply of energy. It also helps the State of California reach its ambitious targets for transitioning the electric grid to renewable energy as part of state level action on climate change. SB100 will not be achievable without significant changes in the way energy is produced and delivered across the state.

These latest state-level commitments will require significantly more clean-energy DERs across California. Bringing those energy resources onto the grid while maintaining reliability, safety, and affordability is the big challenge. Demonstrating the feasibility of high-penetration distributed photovoltaics and storage was therefore an urgent and essential task to ensure California's 100% clean energy targets are achievable.

This project was led by the SunSpec Alliance and supported by a team comprised of the University of California San Diego, Southern California Edison, Kitu Systems, Strategen, OSISoft,

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1 Pecenak, Z, et. al., October 2016, p.4.

2 California Air Resources Board Greenhouse Gas Emission Inventory. "2000-2016 GHG Emissions Trends Report."

and an array of Smart Inverter manufacturers including ABB, Advanced Energy, Alpha Energy, Enphase, Fronius, Ideal Power, KACO new energy, Pika Energy, SolarEdge, SMA, and Tabuchi.

CHAPTER 1: Current DER Landscape

Distributed Energy Resources (DERs), typically consisting of solar PV and energy storage systems on homes and commercial buildings, are a growing source of power on the electric grid. DERs typically participate in the retail energy market, reducing energy costs by dispatching energy to offset local load. With the advent of smart inverters, DER systems now have the ability to simultaneously participate in the wholesale market and take advantage of additional economic opportunities.

DER Growth and Potential

DERs, while a fraction of the current total generating capacity of the grid, are a rapidly growing resource. In the U.S., annual installed DER capacity additions are projected to grow almost three times faster than traditional centralized generation.[3] A Greentech Media study projects DER capacity to double from 46.4 GW in 2017 to 104 GW in 2023, with approximately half of that coming from distributed solar.[4]

In California, there is approximately 12 GW of distributed generation capacity (comprising of solar, small hydro, biomass, wind, and geothermal resources) operating on the grid.[5] The installed capacity of distributed generation equates to approximately 25 percent of recent California Independent System Operator (ISO) peaks.[6]

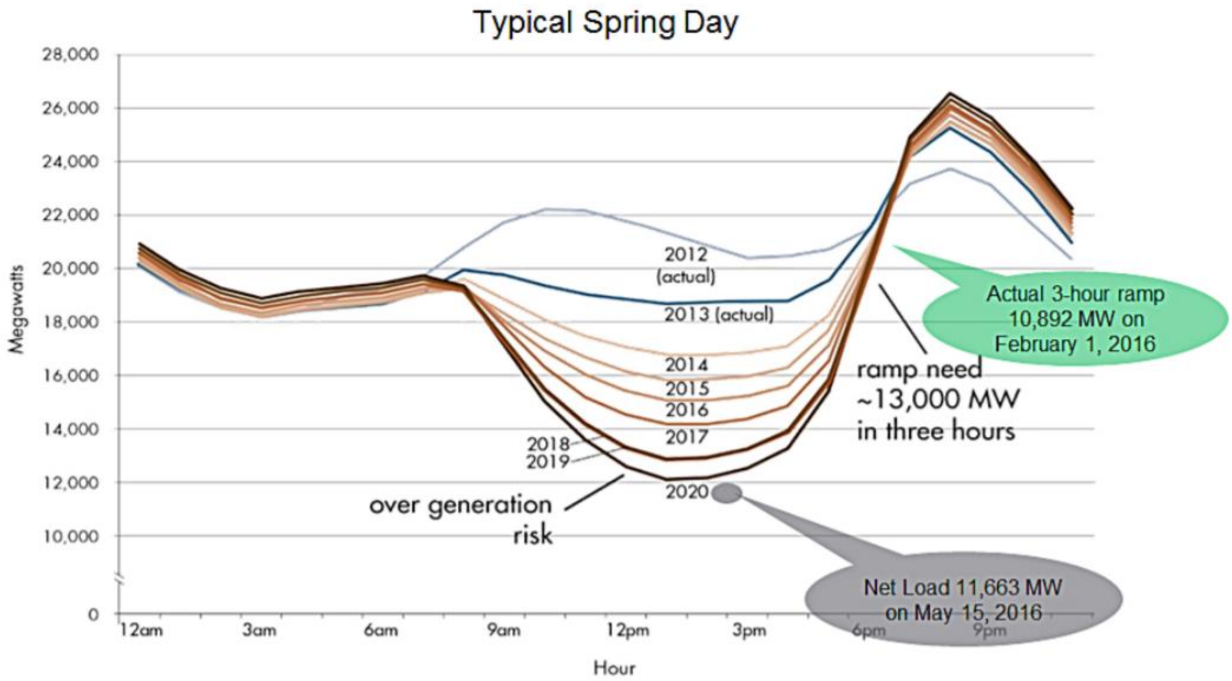
3 Vrins 2016.

4 St. John 2018.

5 California Energy Commission 2018. “California Energy Commission – Tracking Progress: Renewable Energy – Overview.”

6 California ISO 2017. “California ISO Peak Load History 1998 through 2017.”

Figure 1: California Independent System Operator Duck Curve



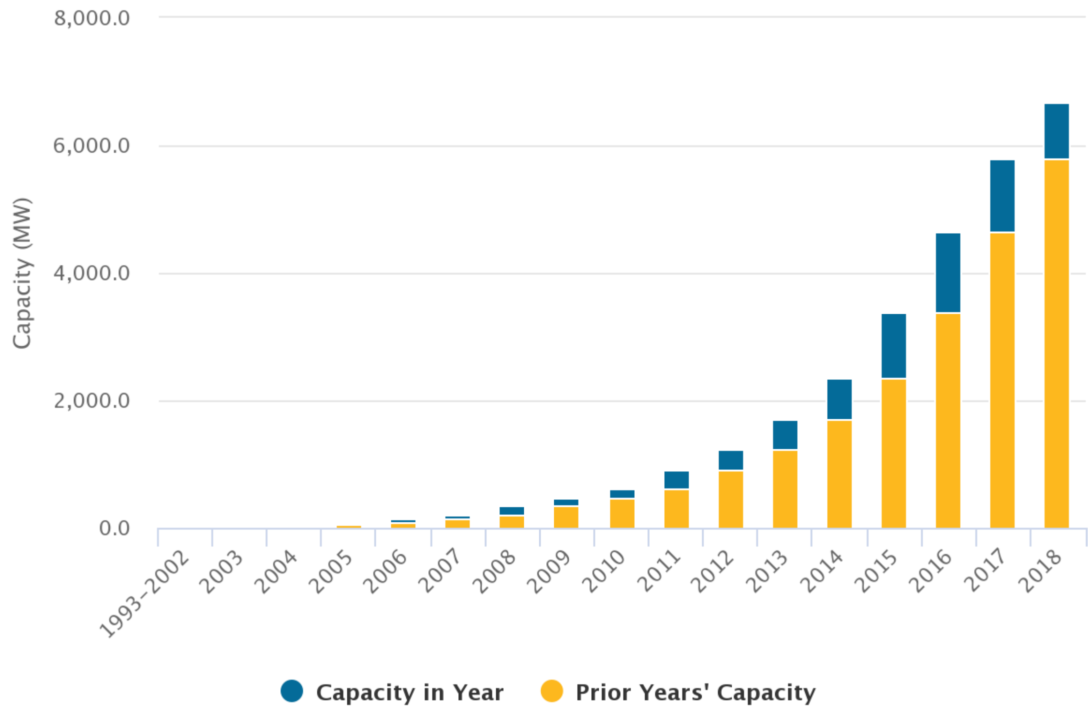
Credit: California ISO

According to the 2018 California Energy Commission Integrated Energy Policy Report, this distributed generation capacity includes approximately 7,900 MW of behind-the-meter (BTM) distributed solar throughout California.[7] Figure 1 depicts the California ISO "duck curve", which shows the risk of daytime overgeneration and severe ramp rate in the evening caused by increasing levels of solar penetration on the grid.

Figure 2 reports BTM distributed solar statistics for the three largest investor-owned utilities in California. It demonstrates that there has been exponential growth of BTM distributed solar in California.

7 California Energy Commission 2018. Publication Number: CEC-100-2018-001-V1.

Figure 2: Total and Incremental Behind-the-Meter Solar Capacity



Credit: California Distributed Generation Statistics

Of the 7,900 MW of total BTM distributed solar in California, 6,800 MW have been installed since 2011. This is a compound annual growth rate of 33%.

Additionally, California has carved out at least 500 MW of BTM energy storage for installation by 2020. Based on current growth rates and policy requirements, there will be approximately 10,000 MW of DERs installed by 2020. With policy factors, such as Title 24 building energy efficiency standards and Senate Bill 100 requiring 100% renewable energy power by 2045, DER growth rates will likely remain high. For example, Senate Bill 100 requires moving from approximately 30 percent renewable energy today to 50 percent by 2026. Reaching this milestone and beyond will continue to require large investments in DERs.

DERs in Retail Markets

California Rule 21

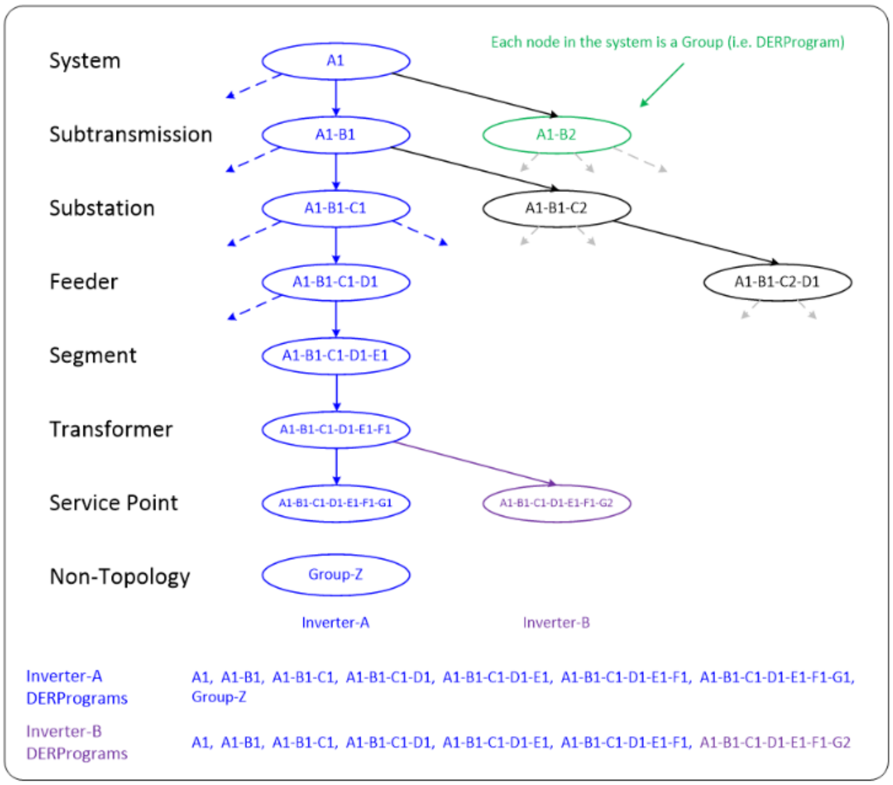
California Rule 21 describes a framework for retail market participation by DERs, in terms of interconnection, operating, and metering requirements. Rule 21 was established to allow utilities to utilize DERs for grid stability, allowing the control of DERs for frequency regulation and Volt-VAR at the retail level by dispatching or curtailing participating DER assets.

In particular, Rule 21 prescribes seven autonomous functions that smart inverter DERs must be able to perform, as well as communication, monitoring, and control between DERs and the utility, using the IEEE 2030.5 communications protocol. The Common Smart Inverter Profile (CSIP) details how IEEE 2030.5 can be implemented to satisfy the Rule 21 requirements.[8] This section describes how the functionality described in CSIP, and therefore proscribed by Rule 21, allows DERs to participate in retail markets.

Common Smart Inverter Profile

CSIP describes the group management capability of IEEE 2030.5 by applying it to DERs according to their location on the grid. This creates a network of resources, allowing for groupings of DERs at various levels of granularity. For example, in Figure 2, the node A1-B1-C1 could be used to create a tariff for DERs behind the given substation, while an individual inverter could be accessed with the node A1-B1-C1-D1-E1-F1-G2.

Figure 2: Example Network Topology as Described by CSIP



Credit: SunSpec Common Smart Inverter Profile

Other groupings are also available outside of the network topology. The framework described in CSIP allows for free association of DER assets, as long as they are connected to the utility.

CSIP also describes monitoring and control of each DER asset or grouping, including real and reactive power, frequency, voltage per phase, voltage/frequency ride through, and the operating state of each asset. In IEEE 2030.5, these are mapped to specific functions ("Grid DER Support

8 Common Smart Inverter Profile Working Group 2018.

Functions" in CSIP). These functions allow a utility operator to control DERs and groups of DERS based on setpoints and operating curves. Each DER can be controlled by the utility operator via an "event", which includes the start time, the duration of an event, and the IEEE 2030.5 function and value. For example, an event could consist of the following information: 6am start time, 2 hours duration, *opModFixedFlow* of 5kW, which would correspond to a two-hour dispatch of 5kW starting at 6am. CSIP also establishes a protocol for event priority called "primacy", allowing higher-priority events to supersede and effectively halt or prevent the DER from responding to a lower-priority event. This is described in CSIP Section 7.10 Event Prioritization.[9] Table 1 gives a summary of relevant functions by their IEEE 2030.5 function name and their operational purpose as Grid DER Support Functions.

Table 1: IEEE 2030.5 Functions with Corresponding Grid DER Support Functions

IEEE 2030.5 Functions	Grid DER Support Functions
opModFixedFlow	Active Power setpoint
opModFixedPF	Power Factor setpoint
opModFixedW	Active Power setpoint (in percentage of maximum active power in Watts)
opModFixedVar	Reactive Power setpoint
opModVoltVar	Volt-VAR operating curve
opModVoltWatt	Volt-Watt operating curve
opModFreqWatt	Frequency-Watt operating curve

CSIP also requires that DERs report monitoring data and operational characteristics, such as Real (Active) Power (W), Reactive Power (VAR), Frequency (Hz), Voltage per Phase (V), and Operational Energy Storage Capacity (kWh). Along with the IEEE 2030.5 functions and grouping, utility operators are able to properly manage and control DERs to perform grid services on the retail market. Table 2 lists retail use cases with comparisons to IEEE 2030.5 functions that can be used to satisfy those use cases.

Table 2: Comparing Retail Market Use Cases with IEEE 2030.5 Functions

Use Case	Description	IEEE 2030.5 Functions
Registration and Grouping	Static groups for targeted controls	-
Voltage Reduction Support	Reactive Power Modes - volt-var, fixed power factor, set VARs	opModVoltVar, opModFixedPF, opModFixedVar

9 Common Smart Inverter Profile Working Group 2018.

Net Load Reduction	Real Power Modes - battery charge/discharge, load curtailment	opModFixedFlow, opModFixedW
Curtailment based on Reverse Power Flow	Real Power Modes - battery charge/discharge, PV curtailment, volt-watt	opModFixedFlow, opModFixedW, opModVoltWatt
Autonomous Frequency Response	Frequency Support Mode - frequency-watt	opModFreqWatt

Finally, CSIP describes the security standards inherent in IEEE 2030.5. Specifically, communications are based on the HTTPS protocol, with mandated encryption, authentication, and authorization protocols between each DER and the utility head-end server.

Challenges with Current Wholesale Market

Given their growing capacity, DERs have great potential to provide value beyond the retail market. However, at present there is a lack of participation of DERs in the wholesale market. Instead, DER participation on the grid is limited to the retail market to offset local loads as BTM resources. The current market is not conducive to simultaneous participation in both retail and wholesale energy markets. This issue has been a concern for the Energy Commission and California ISO for many years, but little headway has been made.[10]

A recent Energy Commission report, examining the Los Angeles Air Force Base Vehicle-to-Grid Demonstration (Air Force Report), identified many of the current challenges that DERs face when attempting to participate in California ISO.[11] One specific challenge identified in the Air Force Report was proving the profitability of DER services when operating under differing retail and wholesale tariff structures. The limited success of these attempts has led California ISO to conclude that wholesale participation by DERs is not economically viable.

NREL studied the development of DER virtual power plants (VPPs) across five projects, and evaluated the efficacy of each.[12] Common challenges shared by the projects included communicating and controlling DERs to form a VPP, as well as problems with participation rates, permitting, and interconnection. The study recommendations included tariff reform to incentivize DER owners to participate in VPPs, and explicitly mentions IEEE 2030.5 as a potential platform for DER aggregation development, noting that “widespread adoption of similar open or standardized communication protocols may reduce the time and resources needed to develop and implement a DER aggregation program.”[13]

10 California Independent System Operator 2013. “Demand Response and Energy Efficiency Roadmap: Maximizing Preferred Resources.”

11 Black et al. 2018. Publication Number: CEC-500-2018-025.

12 Cook et al. 2018.

13 Cook et al. 2018, pp 20-21.

Given the current lack of economically viable wholesale market opportunities for DERs, tariff redesign and communications standards are needed to standardize retail and wholesale requirements to better enable DER transactions.

CHAPTER 2: Integration of DER Retail Market with Wholesale Market

The functions and capabilities of smart inverters defined in CSIP as applied to Rule 21 are also applicable to wholesale market operation. In Rule 21, the capability for a central controller (in the case of Rule 21, the utility) to dispatch groups of DERs is used for grid stability purposes. In order to utilize DERs on the wholesale market, the same functionality is necessary: a direct participant in the wholesale market needs the ability to group its DER assets to perform aggregated tasks, such as dispatching or curtailing power, as a resource bid into the market, with more locational specificity than is currently achieved.

Key Examples

Many key stakeholders are considering the integration of both retail and wholesale markets for simultaneous participation by DERs. For example, FERC Order 841 includes language that allows for simultaneous retail and wholesale market participation.[14] NYISO includes language to include DERs as assets both on the retail and wholesale markets in their DER Roadmap, envisioning that "those resources capable of participating in [wholesale] markets will do so directly or via third-party aggregation […] such that smaller resources (e.g., those resources less than 100 kW) can be aggregated in a coordinated fashion to respond to price signals in support of bulk system needs."[15] While many details still need to be determined to make DER participation in wholesale markets more economic and seamless, the efforts demonstrate the understanding that DERs have a strong value proposition.

California ISO has developed documentation for wholesale market participants to communicate with California ISO's energy management system. California ISO's Business Practice Manual for Direct Telemetry (BPMDT) includes requirements for telemetry content and security, many of which are satisfied by the guidelines set forth by CSIP.[16]

Requirements for Integration

Standards such as CSIP allow DERs to be controlled both as individual assets and in aggregate. However, simultaneous participation by DERs in both retail and wholesale markets is limited by conflicting regulation between the two markets. Therefore, the two markets must be aligned along two key measures: tariff structure and communications architecture.

Tariffs

14 Federal Energy Regulatory Commission 2018.

15 New York Independent System Operator 2017, pp. 14-15.

16 California Independent System Operator 2018. "Business Practice Manual for Direct Telemetry: Version 11.0."

The dispatch behavior of a DER is greatly influenced by the tariff under which the DER operates. On the retail market, DERs often optimize their operation against demand charge tariffs to reduce local load and energy costs. Once participating on the retail and wholesale markets, DERs are open to additional value streams resulting from both supporting grid stability on the retail market and bidding additional services into the wholesale market.

Because of the design of utility retail tariffs, retail optimization of DERs does not often align with wholesale market optimization. In fact, optimization objectives could be in opposition with each other. For example, a retail tariff may require a solar resource to curtail its power for grid stability, while it may have been financially advantageous to bid this power into the wholesale market. Given the prioritization structure in CSIP, only one of these events may be acted upon by the DER at any one time.

One problem exemplified with this example is that no tradeoff is considered by the retail system operator – whether curtailing the solar resource is more valuable than the wholesale service being offered is not considered, only grid stability (which may have more than one way of being addressed). The converse is also a cause for concern: if both objectives are aligned, and there are financial benefits for using a DER in both the retail and wholesale markets, how will the resource be compensated for participating in both markets? By extension, the optimal grouping of DERs may be different for each market – for example, a grouping for grid stability will typically include DERs in the same electrical location on the grid (e.g. behind a particular transformer), while a grouping in the wholesale market may have DERs in various locations, indifferent of electrical topology.

Therefore, tariffs must be harmonized across retail and wholesale markets to ensure that conflicts between the two are minimized, and any utilization of a given DER is fully defined in terms of the market, the purpose/use case for utilization, and the tariff it is participating in. This will allow the function of the DER to be properly managed between both markets.

Communications

As the tariffs are harmonized across both markets, the communications for retail and wholesale markets must also be standardized, so that DER responses align with market signals at both levels. Currently, there are two existing standards for retail and wholesale market communications: CSIP, which establishes communications between the utility and DERs, and the California ISO BPMDT, which establishes communications between the ISO and resources in the wholesale market.

The requirements contained in CSIP for telemetry reporting fulfill many of the requirements in the California ISO BPMDT, as the basic elements of monitoring and controlling power, frequency, and voltage are satisfied. The California ISO BPMDT also defines the communications protocol as Distributed Network Protocol (DNP3), which is also compatible with IEEE 2030.5. Additionally, systems operating within CSIP guidelines using IEEE 2030.5 can theoretically supply the Direct Telemetry Timing Requirements in Section 5.2.1 of the California ISO BPMDT, though this is not guaranteed and dependent on the communication network and its equipment, which is not fully specified in CSIP.

As the existing wholesale and retail markets include communications standards that are mutually compatible, the control protocols in IEEE 2030.5 can be used to harmonize the communications and operations between the utility and ISO networks. A unified IEEE 2030.5 platform not only allows simultaneous participation of a given DER in both markets, but also allows both utility and ISO to control the DER for their own purposes. IEEE 2030.5 allows DERs to belong to multiple groups, so it is permissible for a DER to belong to a "retail market" group controlled by the utility, as well as a "wholesale market" group controlled by the ISO, with an entirely different set of DERs. Primacy will allow DERs to respond to both utility and ISO signals depending on their priority and importance; for example, a DER could switch from bidding into the wholesale market to perform critical grid stability functions by the utility. A shared protocol of grouping and primacy will facilitate operation of DERs between the retail and wholesale markets.

CHAPTER 3: Recommendations and Conclusion

Recommendations

The harmonization of the retail and wholesale tariffs and communications will require continued and expanded collaboration from stakeholders. The following recommendations are intended to provide incremental progress towards more compatible tariffs and communication protocols.

First, revising tariffs that would provide significant increases in DER value propositions should be considered. For example, since Rule 21 limits the size of DER installations to match local peak load, the CPUC could investigate the possibility of increasing the size limits of DER systems beyond local load. Doing so would enable DERs to better address California ISO needs and improve the profitability of suitable projects. Altering the sizing limits may require the presence of energy storage in order to manage export limits. Allowing DERs to provide capacity greater than local peak load would increase the value proposition that DERs could provide to wholesale market and potentially the retail market. California ISO interconnection rules could also be revised such that every DER could be automatically interconnected with California ISO, irrespective of whether the DER has a current contract with California ISO to sell wholesale ancillary services.

Second, in order to start the process of harmonizing communication between the two markets, the CPUC could initiate a joint study with California ISO to use IEEE 2030.5 grouping and primacy to simultaneously address CA Rule 21 and California ISO technical and policy requirements. The CPUC and California ISO can then create a shared protocol for DER communication and operation between the retail and wholesale market operators.

Finally, another possible solution involves integrating DNP3 into the IEEE 2030.5-based aggregator software defined in CSIP. As DNP3 and IEEE 2030.5 are semantically compatible, the functions used in DNP3 (as implemented by the California ISO BPMDT) can be mapped to IEEE 2030.5 functions. SunSpec has already begun work on harmonizing DNP3 and IEEE 2030.5 with its own specifications,[17] and this work can be extended to include a DNP3 interface for IEEE 2030.5 in the CSIP framework. Aggregated groups of DER assets on the wholesale market manifests as a Virtual Power Plants (VPPs). With this integration, one could use the grouping function of IEEE 2030.5 to form VPPs, and DNP3 to facilitate interaction between VPPs and California ISO.

Conclusion

DERs are a growing presence on the electric grid, In the retail market, Rule 21 and CSIP take advantage of communications protocols, such as IEEE 2030.5, to enable utilities to aggregate,

17 SunSpec Alliance 2018.

monitor, and dispatch DERs to support grid services. However, as controllable sources of power, DERs have the potential to participate in both retail and wholesale markets.

This report demonstrates that the existing protocol for DER communications in the retail market can also be applied to a framework which supports the deployment of DERs onto the wholesale market. These two markets can also be unified under IEEE 2030.5 to provide a comprehensive communications network, under which DERs can simultaneously participate in both retail and wholesale market operations. Ultimately, utilities and ISOs must work together to determine best practices for DER operation, by harmonizing DER tariffs and communications across retail and wholesale markets.

GLOSSARY

Term	Definition
BPMDT (Business Practice Manual for Direct Telemetry)	The California ISO Business Practice Manual for Direct Telemetry establishes a standard for wholesale market participants to communicate with California ISO's energy management system.
BTM (behind-the-meter)	A behind-the-meter energy resource generates power "behind" the utility meter on-site, intended to serve the facility metered at that site.
California Rule 21	Rule 21 is a tariff that describes the interconnection, operating and metering requirements for generation facilities to be connected to a utility's distribution system. Each investor-owned utility is responsible for administration of Rule 21 in its service territory and maintains its own version of the rule.
CSIP (California Smart Inverter Profile)	The California Smart Inverter Profile describes configuration requirements for how an IEEE 2030.5 interface can be implemented to satisfy the California Rule 21 requirements.
DNP3	DNP3 is a is a set of communications protocols used between components in process automation systems. It is used as a communication interface within California ISO as described in the BPMDT.
FERC	The Federal Energy Regulatory Commission, or FERC, is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil.
IEEE 2030.5	IEEE 2030.5 is a communications standard which provides an interface between the smart grid and its users. It is the default communications interface in California for grid integration of DERs as described in CSIP.
NYISO	New York Independent System Operator is the organization responsible for managing New York's electric grid and its wholesale energy market.
VPP (Virtual Power Plant)	A Virtual Power Plant consists of a central control system and DERs. The central control system is then able to monitor, forecast, and dispatch the networked DERs as an aggregated resource.

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