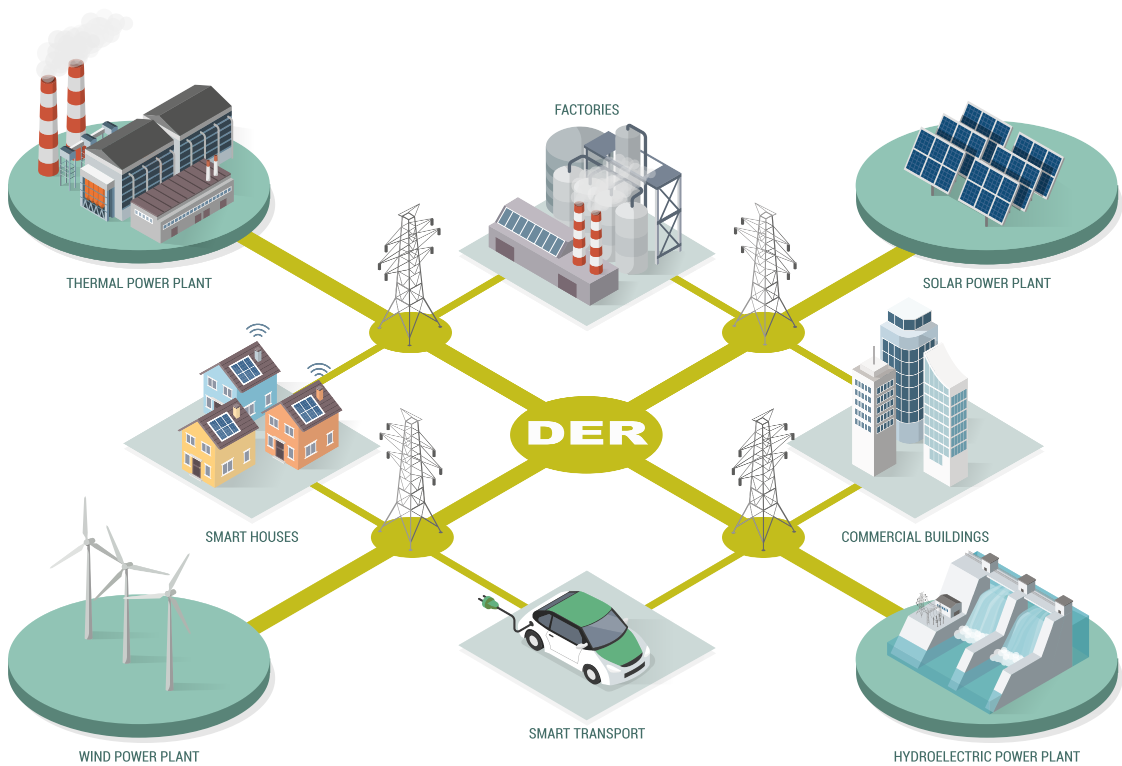
DER Control and How to Implement Smart Inverter Management with OpenADR


FACTORIES
THERMAL POWER PLANT
SOLAR POWER PLANT
DER
SMART HOUSES
COMMERCIAL BUILDINGS
WIND POWER PLANT
SMART TRANSPORT
HYDROELECTRIC POWER PLANT

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Background

In recent years, the technology focus of DSM has moved from what might be termed "traditional" peak load management towards integrating and managing a variety of decentralized resources (DR and DER). These resources can be characterized as load shedding, energy generating, or energy storing. The common interface point between the grid and energy generating and storing resources is the inverter, which converts DC voltage from renewable energy and storage systems into usable, grid-quality AC voltage.

Utilities are needing to find ways to ensure stability and control of the increasingly high levels of independent energy resources pouring into the grid

While the cleantech industry, as well as energy consumers and policymakers, appreciate the rapid growth of renewable energy and storage solutions, utility operations are now charting unknown territory: thousands, if not millions, of independent energy resources that are storing and pouring varying amounts of energy into the grid. This new environment creates many challenges to grid stability and power quality, which in turn compels utilities to seek ways to ensure a level of control over these resources. It is not yet clear, however, how much control is needed, desired, or justifiable.

All of these changes create challenges for the utility industry for grid stability and power quality, which in turn compels utilities to seek ways to ensure a level of control over these resources.

As a result, California Rule 21 is mandating better communications and automated control to manage voltage and quality fluctuations that could result from distributed-generation resources, such as solar. Today there are many choices but the two solutions that best fit these requirements are OpenADR for a decentralized and Demand Response focused approach and IEEE 2030.5 for direct smart inverter control and adjustments. The IEEE 2030.5 protocol supports a wide range of DER control applications, with inverter control representing a subset of that functionality. However both OpenADR and IEEE 2030.5 have a place inDER management.

OpenADR typically relies on a gateway device, building EMS, or aggregator to translate utility DR/DER requirements into specific device behaviors, while IEEE 2030.5's forte is to connect and directly control devices.

Using OpenADR for Smart Inverter control can offer utilities many advantages over directly controlling a large number of inverters. OpenADR does not intend to duplicate or replace IEEE2030.5 in the context of Rule 21. However, utilities throughout the world have invested in OpenADR infrastructure because the customer is and remains in control as the utility asserts control via motivation. This provides the Utility with a clear demarcation point to reduce Cyber security risks and potential customer complaints.

The OpenADR protocol is very flexible and has been adapted to a variety of use cases. The new draft DER Addendum outlines how OpenADR 2.0b can be used to achieve the general intent of communicating with smart inverters. This addendum addresses Version 2.1 of the Common Smart Inverter Profile Implementation Guidelines (CSIP Guidelines), released in March 2018 by the California PUC. The draft version of the addendum can be found **here** and is meant as a starting point for future developments. Comments and ideas can be sent to **comments@openadr.org**.

The DER addendum is a “how to” guide defined by the CSIP Guidelines that are relevant to achieving the intent of Rule 21 and show how those requirements can be implemented using OpenADR to achieve grid stability, reliability and resilience in the face of rapidly expanding DER resources.

An Introduction to OpenADR

For almost a decade the OpenADR Alliance has been setting a worldwide standard in Demand Response (DR) and Distributed Energy Resource (DER) automation, connecting homes and businesses with their utilities to make it easy to power down during peak demand, manage fluctuations, or avoid electricity emergencies.

OpenADR 2.0 is a highly secure, flexible data model and communications protocol that facilitates common information exchange between electricity service providers, aggregators, and end users. The concept of an open specification is intended to allow anyone to implement the two-way signaling systems, whether in servers, which publish information (Virtual Top Nodes or VTNs) or in client systems, which subscribe to the information (Virtual End Nodes, or VENs).

The OpenADR 2.0 profile specification covers the signaling protocol between VTN and VEN (or VTN/VEN pairs) and includes information related to specific DR/DER energy reduction/increase, shifting strategies, prices, or other actions which are taken at the facility.

The OpenADR Alliance also manages the testing and certification program for VTN and VEN implementations. Currently there are 8 test labs across the globe and approximately 190 certified solutions.

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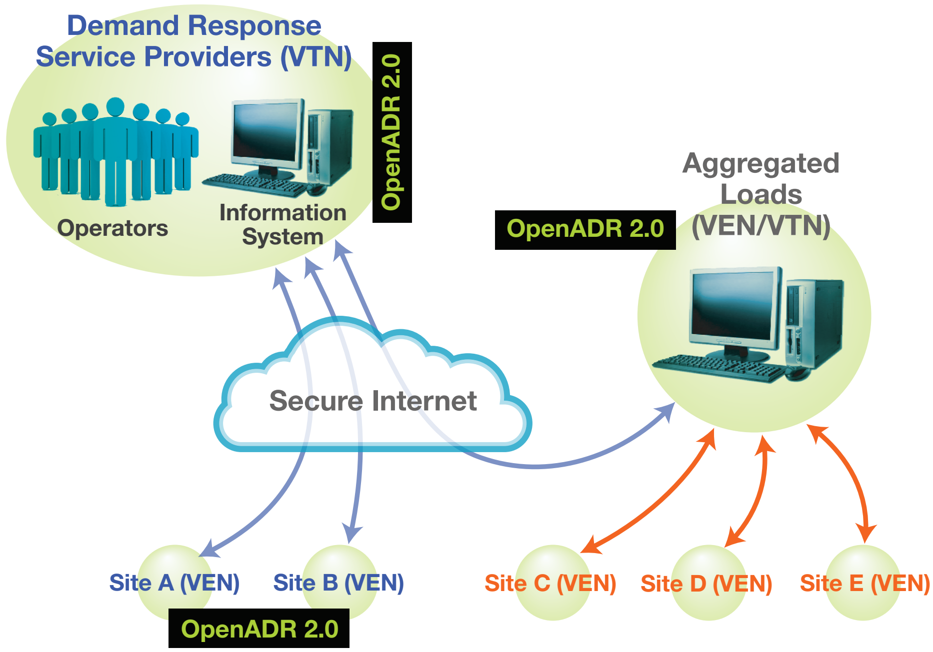
It should be noted that while some signals in OpenADR can be interpreted as direct load control, the primary notion of OpenADR is to “inform and motivate” (a term coined by former EPRI engineer Walt Johnson) the resources to participate and adjust their energy consumption based on their own analysis and intelligence.

This approach - to inform and motivate – provides the utility with a reasonably clear demarcation point between the grid and customer-owned resources, thereby avoiding unwanted repercussions should a customer-owned system not work properly.



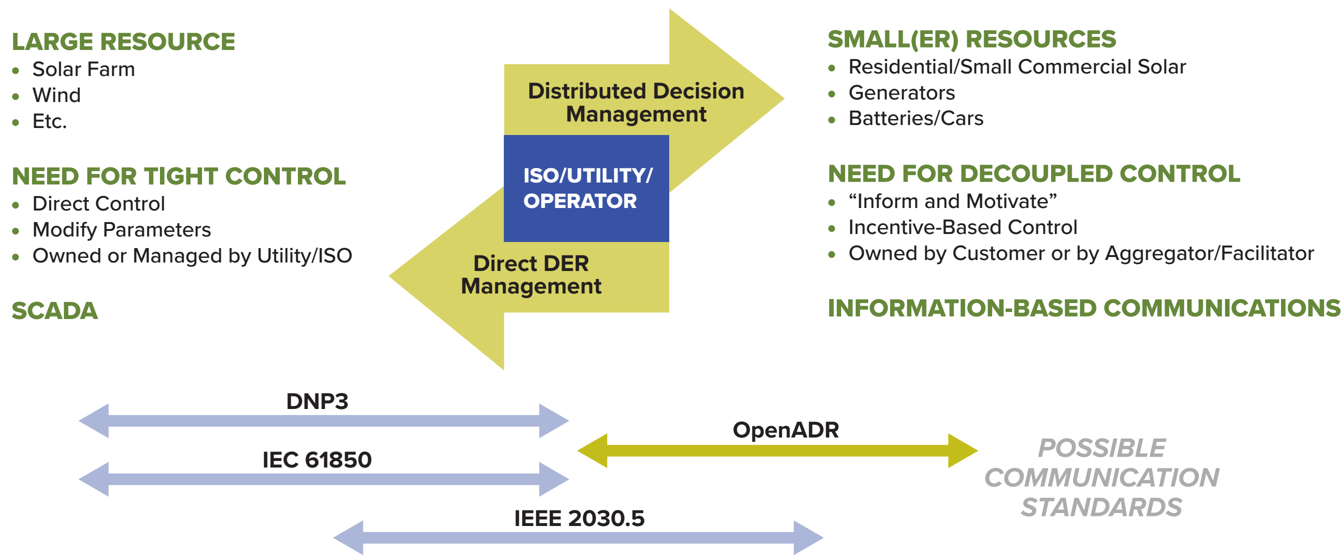
High-Level OpenADR Architecture

Distinguishing Decision Management from Resource Management

There are a number of inevitable facts that grid operators will be facing. As the grid evolves to a next-generation architecture, characterized by distributed resources, digital technologies, and the need for highly decarbonized generation, utilities have to look beyond their common operating processes.

- An increasing number of DER and DR resources on the customer side
- DERs will need to be used as DR resources with up and down regulation mechanisms
- Customer owned devices and resources will have to contribute to grid stability
- Potential issues include:
  - Allowing the utility to control the systems and devices can have a negative impact
    - Customers may be unhappy about changes pushed by the utility
    - Customers may call the utility in case of device problems (utility related or not)
    - The utility may experience control issues when managing thousands or millions of devices
    - IoT manufacturers may not be inclined to give up control
  - Cyber Security
    - Implementing a direct control loop with millions of customers can negatively impact the cyber security of the grid

For the purpose of this document, we differentiate between large scale DERs (solar and wind farms, grid-scale battery storage, etc.) owned by utilities or other corporations, and smaller resources such as residential solar, batteries, generators, electric vehicles, etc. It should be noted that we do not yet know where the line between these large- and small-scale resources will fall. Such a demarcation will be for the industry to decide and may vary by implementation and ownership requirements. In the absence of a better term, we distinguish between "Direct DER Management" (larger resources) and "Distributed Decision DER Management" (smaller resources).



Standards for Direct vs. Distributed Decision Management

Advantages of Distributed Decision Management using OpenADR

- Customer is and remains in control
- Utility asserts control via motivation
- Utility retains a demarcation point
- Cyber security less of an issue
- Cost-effective
- Easier integration
- Can use standards and existing products
- Faster time to market

OpenADR for California Rule 21 – CSIP Requirements

California's Public Utilities Commission Rule 21 mandates that generating facilities, such as solar panels, wind turbines, and in some cases batteries, etc., that utilize inverter-based technologies to interconnect with Investor-Owned Utilities (IOUs), must support an application layer communications protocol. This protocol is used by the utilities to configure advanced inverter functions and to receive status information from the inverters.

Rule 21 and the underlying Common Smart Inverter Profile (CSIP) reference the functionalities of the IEEE 2030.5 protocol to communicate with the inverter or point of aggregation, although other protocols are permitted. The IEEE 2030.5 protocol supports a wide range of DER applications, with inverter control representing a subset of that functionality. The major California IOUs created the Common Smart Inverter Profile Working Group to define the formal CSIP guidelines targeted at supporting the Rule 21 requirements. The CSIP Guidelines lay out a set of general requirements defined by Rule 21 and a set of IEEE 2030.5 protocol-specific requirements defining how the general requirements can be achieved within the context of IEEE 2030.5. The latter, however, assumes that utilities want to deal directly with millions of customer-owned inverters, creating challenges for customer service, data analysis, communication infrastructure, and many more.

OpenADR typically relies on a gateway device, building EMS, or aggregator to translate utility DR/DER requirements into specific device behaviors, while IEEE 2030.5 is designed primarily to directly control devices.

How OpenADR Compares with IEEE 2030.5

OpenADR and IEEE 2030.5 have distinctly different target use cases. OpenADR typically relies on a gateway device, building EMS, or aggregator to translate utility DR/DER requirements into specific device behaviors, while IEEE 2030.5 is designed primarily to directly control devices. OpenADR does not intend to duplicate or replace 2030.5 in the context of Rule 21 as previously mentioned.

While originally aimed at facilitating Demand Response (DR), the OpenADR protocol is very flexible and has been adapted to a variety of use cases beyond traditional DR, including the control of smart inverters and DER resources in general – ranging from electric vehicle infrastructure to Virtual Power Plants. The OpenADR Alliance is currently working on two addenda to the widely used OpenADR 2.0b Profile Specification to enable more specific DER communication (DER Addendum – draft available) and Transactive Energy interactions (TE Addendum – expected at the end of 2020)

The DER Addendum outlines how OpenADR 2.0b can be used to achieve the general intent of communicating with smart inverters as outlined in Version 2.1 of the Common Smart Inverter Profile Implementation Guidelines (CSIP Guidelines), released in March 2018 by the California PUC. The document will take each of the requirements defined by the CSIP Guidelines that are relevant to achieving the intent of Rule 21 and show how those requirements can be implemented using OpenADR. This guidance will be organized to address the following categories of CSIP Guidelines:

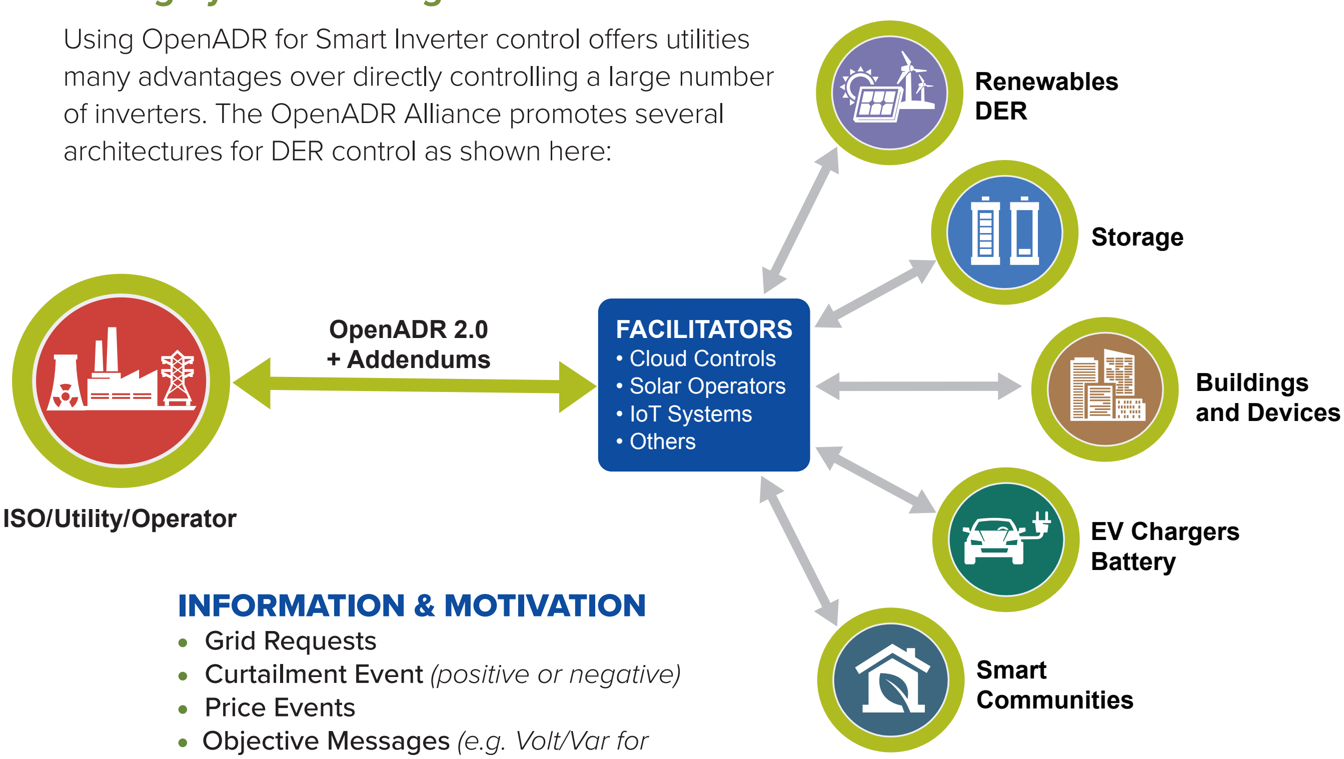
- CSIP Guidelines that can be achieved through best practices recommendations, such as specific event signal definitions for communicating advanced inverter functions
- CSIP Guidelines that are supported by OpenADR and require little guidance, such as the security infrastructure
- CSIP Guidelines that are unrelated to the general intent of Rule 21, such as requirement for pub/sub or access control list functionality, or CSIP Guidelines that are outside OpenADR's usage model such that they would not make sense to implement. No attempt will be made to conform to these requirements.

Where practical, the sample payloads used in the addendum to illustrate the OpenADR best practices will retain the IEEE 2030.5 data model (which in turn is derived from IEC 61850-7-420.

In no way should this Addendum be construed as an OpenADR version of CSIP itself. As noted, there are many implementation strategies in CSIP and some may be impractical to implement using OpenADR. Rather, the Addendum can be used as a guide to using OpenADR to achieve the general intent of CA Rule 21. This will enable users to scale the monitoring and management of DER behaviors to achieve grid stability, reliability and resilience in the face of rapidly expanding DER resources.

Controlling Systems through a Facilitator

Using OpenADR for Smart Inverter control offers utilities many advantages over directly controlling a large number of inverters. The OpenADR Alliance promotes several architectures for DER control as shown here:



INFORMATION & MOTIVATION

- Grid Requests
- Curtailment Event *(positive or negative)*
- Price Events
- Objective Messages *(e.g. Volt/Var for inverters in geographical area)*
- Others

Summary

Customer-owned DER may be the fastest growing category - from solar to electric vehicle chargers to smart thermostats - and OpenADR provides a consistent way to inform and motivate DER integration into utility demand management and renewable resource programs

For comments and questions, please contact us at **info@openadr.org**.
Visit **www.openadr.org** for more information.