PXiSE Energy Solutions

DER-Utility Network Communication Protocol Overview

Q3 2021

PXiSE DER Software Controls

Configurable and Scalable Solutions for the Evolving Grid

PXiSE Software-Based Control Solutions

- → Control over 1 GW assets deployed around the world
- → Utilize proprietary Active Control Technology (ACT) with synchrophasor data
- → Integrate solar, wind, storage, and thermal assets for a complete control solution
- → Real-time and independent control of real / reactive power at POI at up to 60 hz
- → Native support for over 450 energy asset and industrial communication protocols
- → Implemented by a team with decades of utility and industrial software experience

Expert Team

100+ years of experience in utilities and software

Innovative Approach

Novel synchrophasor application & growing patent portfolio

Proven Technology

975 MW of deployments

Blue Chip Backed

Strong financial backing from industry-leading companies

Overview - Company

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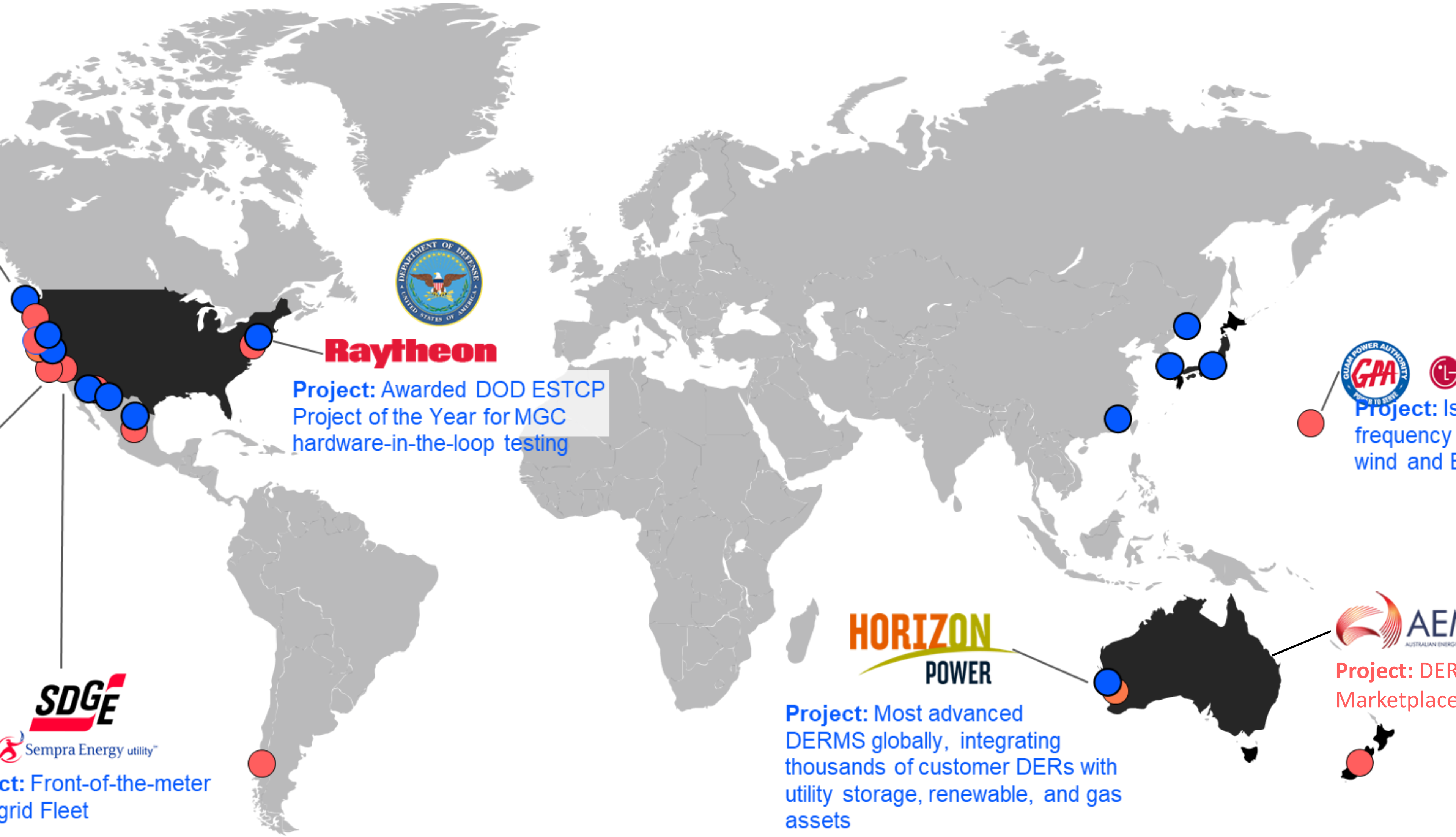

Portland General Electric

Project: Utility Microgrids for Critical Operations

Raytheon

Project: Awarded DOD ESTCP Project of the Year for MGC hardware-in-the-loop testing

GPA LG CNS

Project: Island frequency control for wind and BESS site

conEdison

Project: Control 200MW Solar with 4 separate PPAs to meet the site's complex interconnection requirements

SDGE
A Sempra Energy utility

Project: Front-of-the-meter Microgrid Fleet

HORIZON POWER

Project: Most advanced DERMS globally, integrating thousands of customer DERs with utility storage, renewable, and gas assets

AEMO

Project: DER Marketplace Pilot

Current Target Market (U.S., Japan, Australia)
Completed Projects
Awarded/Contracted Projects

Evolving DER-Utility Landscape

Evolving DER-Utility Landscape

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Increasing DER deployments drive change in relationship between utilities and DER owners

Greater Diversity of DERs in Energy Markets

Deploying DERs in increased quantities provides end users and facility owners/operators with great flexibility, but can present challenges to utility system operators in contrast to centralized generation.

- → **Distributed** (customer-owned or non-centralized)
- → **Limited dispatchability** (e.g. wind, solar)
- → **Fixed duration** of use (e.g. battery storage systems)
- → **Third-party optimized systems** – potential black box from the perspective of a network operator or facility owner
- → **Grid-tied / Island Transitioning** - ability to transition from fully-islanded to grid-tied modes of operation.

Competing Interests Among Stakeholders

- → **Utility - Grid Stability**
  Transmission and distribution system operators want increased levels of control over customer-sited resources that may interact with their grid infrastructure
- → **Customer - Grid Independence**
  Customers and C&I clients wish to have more control of their energy assets and consumption without being beholden to distribution/transmission system operators

Fragmentation of how DERs are communicated to is a natural result of these competing interests and evolving market trends - driving a need for more standardized communication methods.

Typical System Architecture Schemes

Sending information between Utilities / Aggregators and DERs

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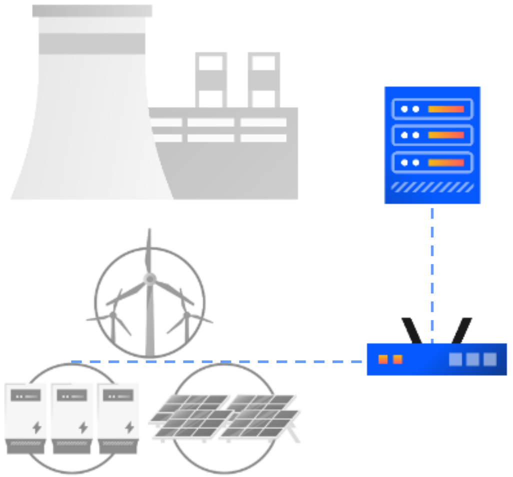
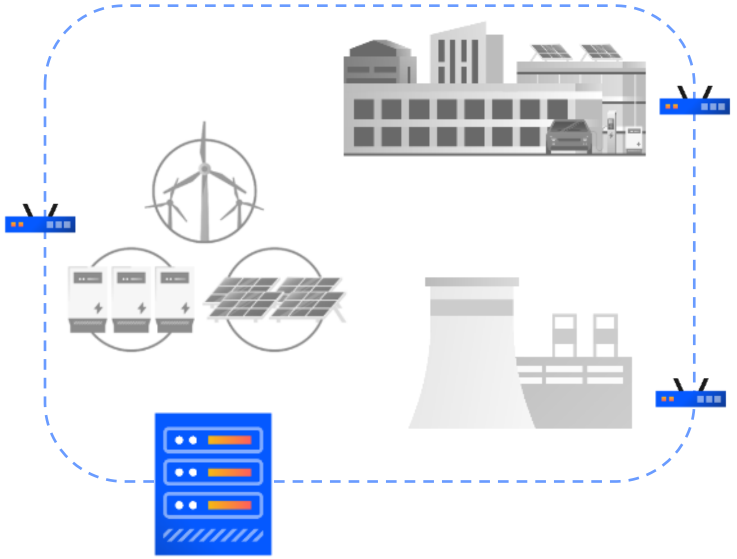
Single-Site Communication



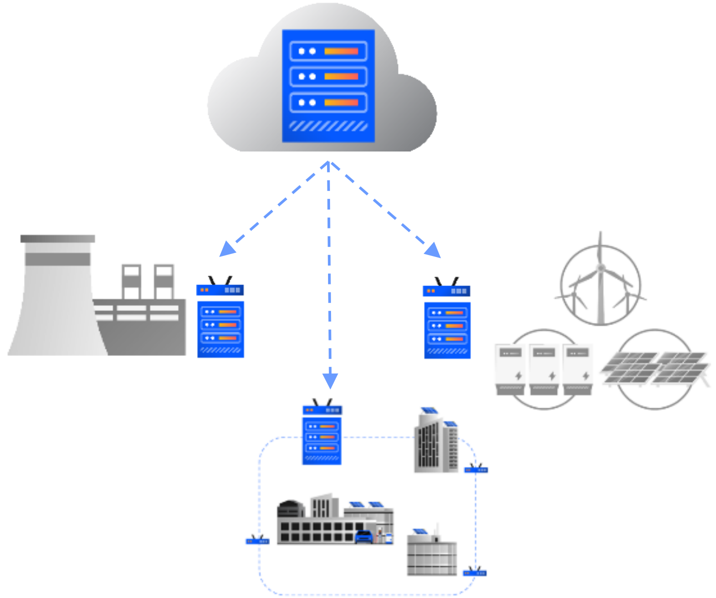
Prime User(s)	C&I Facilities, Utility Microgrid Owners
Deployment Destination(s)	• Existing on-premises network • Dedicated PLC/ Server • Existing SCADA infrastructure
Interconnection	BTM, FTM
Control Latency Required	Up to 60 hz+

Aggregated Network Communication



Prime User(s)	Campus Facility Owners Utility Networks
Deployment Destination(s)	**Server:** Hardware within IT/OT perimeter **Client:** Local IT/OT hardware, SGDs Existing SCADA infrastructure
Interconnection	BTM, FTM
Control Latency	**Local:** 60 hz (Nested MGC/PPC) **Distributed:** 15 – 30 sec (Supervisory DERMS)

Hybrid Cloud/Edge Communication



Prime User(s)	Campus Facility Owners Utility Networks
Deployment Destination(s)	**Server:** Cloud-hosted **Client:** Local IT/OT hardware, SGDs Existing SCADA infrastructure
Interconnection	BTM, FTM
Control Latency	**Local:** 60 hz (Nested MGC/PPC) **Distributed:** 15 – 30 sec (Supervisory DERMS)

These examples are for illustrative purposes only – many applications require project-specific configuration

Information Exchanges

Simple and Complex Data Exchanges Between Utilities and DERs

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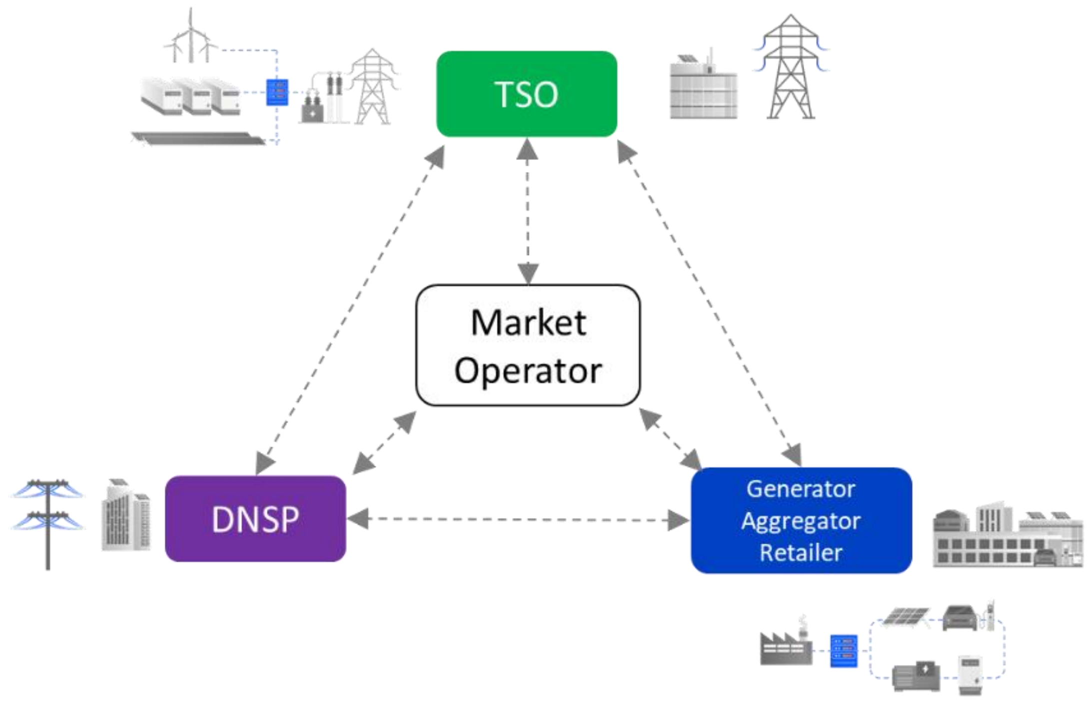
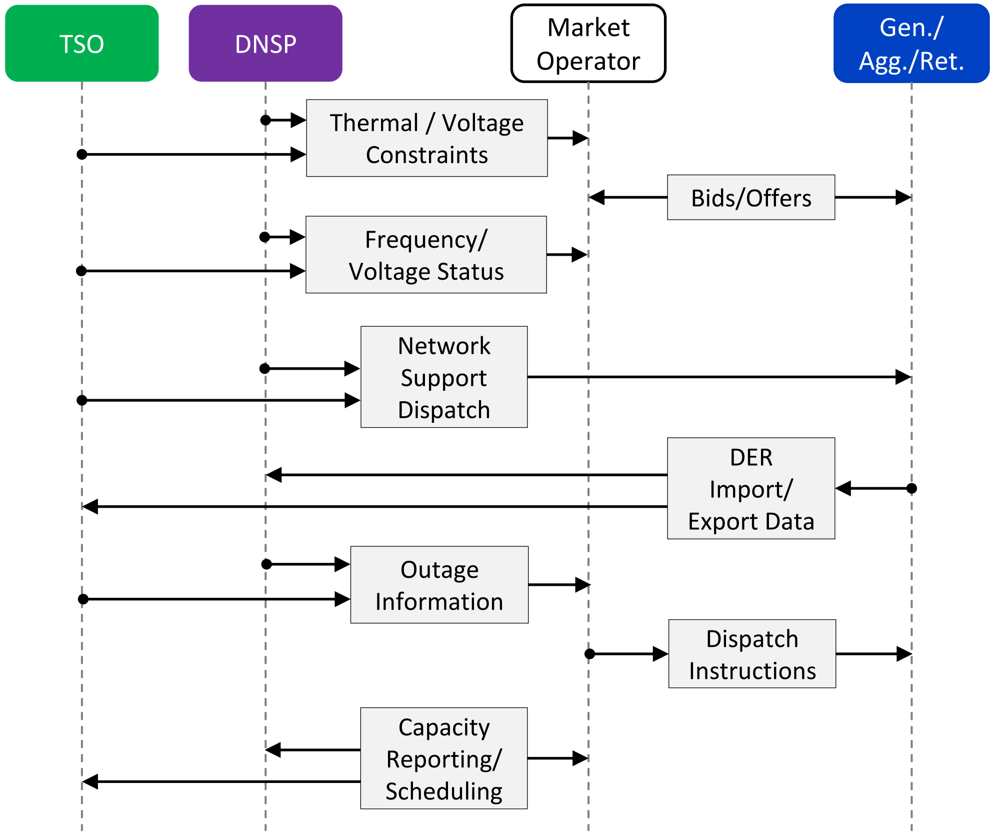
Sample Communication Throughout Market



Note: In many markets, one entity performs multiple functions (e.g. TSO & Market Operator, Generator & DNSP)



Unidirectional and bi-directional data exchanges between multiple market participants are occurring constantly at both fixed intervals and in real time

Information Exchanges

Sample Data Exchanged Between Utilities and DERs

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Standard Data Types

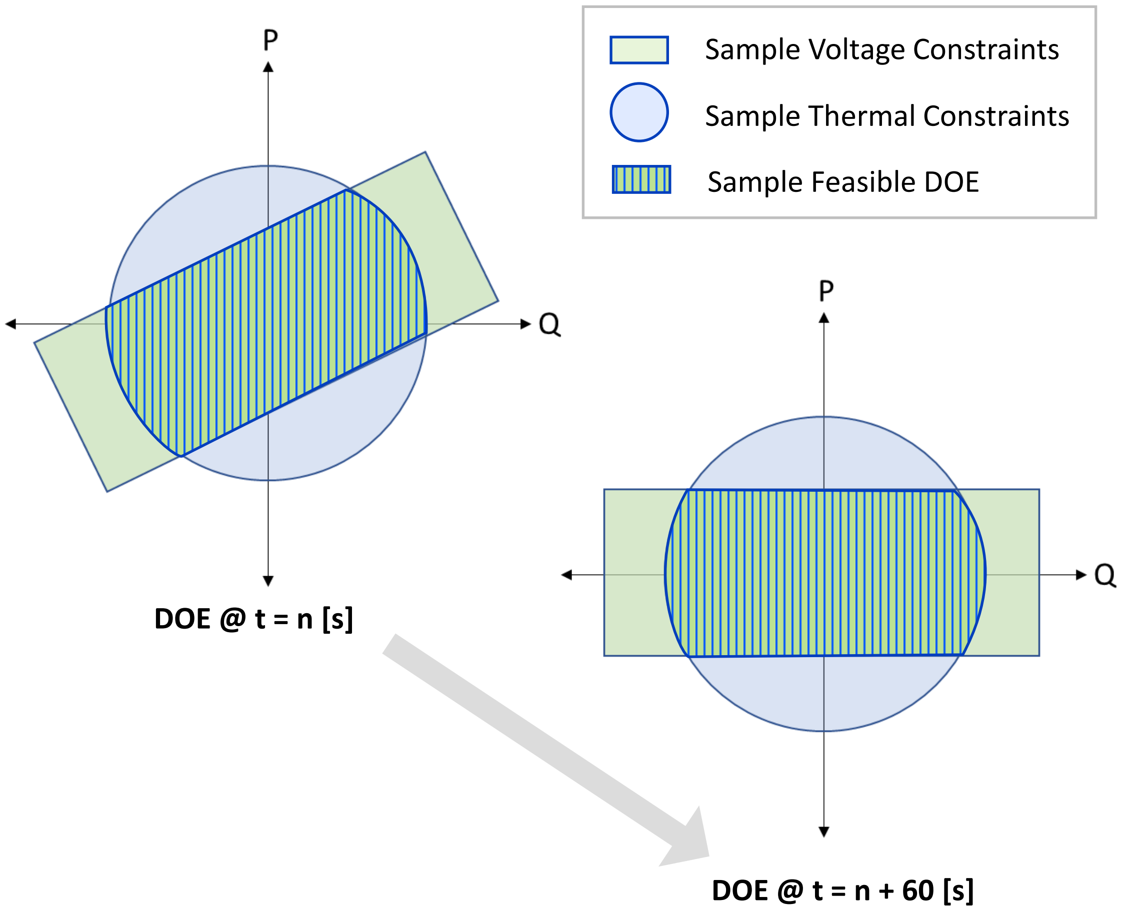
Information exchanged between utility networks, system operators, aggregators, and DERs typically consists of simple instances of the most common data types:

- Integers
- Floating-point
- Strings
- Booleans
- Date-Time
- Lists/Arrays

Many utility networks and system operators are beginning to require complex communications when approaching setting operational boundaries on DERs – such as deploying **Dynamic Operating Envelopes (DOEs)** for assets participating on their network.

These n-dimensional DOEs impose a series of operational constraints on assets at a series of fixed time intervals and include a variety of constraints.

Complex – Dynamic Operating Envelope Constraints



[Source: Blackhall, L. – On the Calculation and Use of Dynamic Operating Envelopes]

Protocols in DER-Utility Communications

Utility-DER Communication Protocols

Overview of Common and Contemporary Protocols

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Analogy from 1990s-2000s:

Protocol and language fragmentation of the early internet (each playing different roles):

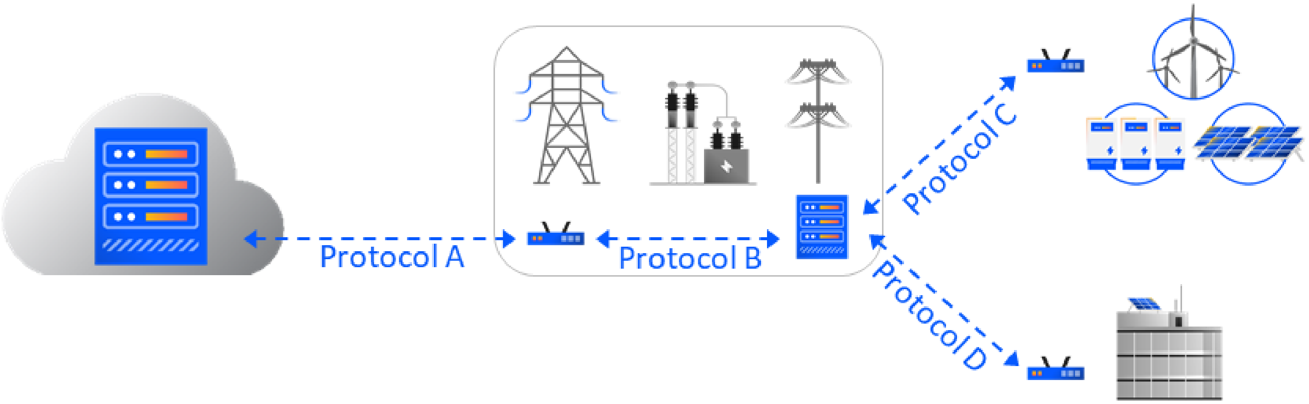
- TCP/IP
- AppleTalk
- FTP
- SMTP
- Http
- Java
- Flash

Different protocols are often "layered" together along an end-to-end communications chain in order for a command to have a desired output.

Communication occurring between devices requiring conversion between other protocols are carefully considered.

Different stakeholders utilize different communication protocols:

- System/Network operators
- Control software developers
- SCADA hardware providers
- Data logging/historian databases
- Asset Hardware manufacturers



Utility-DER Communication Protocols

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Overview of Common and Contemporary Protocols

Many protocols to cover within the scope of this discussion notable exclusions include:

- Modbus (Sunspec)
- DNP3
- ASHRAE BACnet
- Proprietary SCADA/EMS protocols
- Proprietary transactive energy / identity verification protocols

The strengths/weaknesses of these protocols are documented extensively online, and not all focus exclusively on Utility-DER communications

Focus of Discussion

- OpenADR 2.0
- IEC 61580
- IEEE 2030.5

OpenADR 2.0

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Origin

- Initially development by LBNL/CEC in 2002
- First commercial applications in CAISO in 2007 and official specification for DR programs in 2009
- Expansion into DERs, EVs, dynamic pricing, etc. beginning in early 2010s

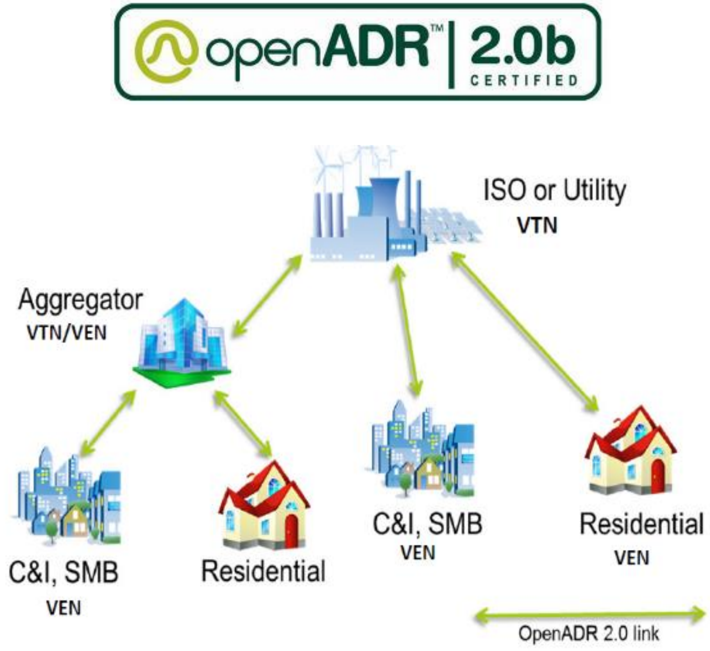
Common Use Cases

- Coordinating portfolios of DERs for participation in market programs such as demand response via internet
- Facilitating resource performance and availability reporting between aggregators and utilities / system operators
- Responding to real-time pricing events for market programs

[Source OpenADR Alliance]

Model Structure

- Structured into Virtual Top Nodes (VTNs) and Virtual End Nodes (VENs)
- **VTNs:**
  - Manage resource portfolio
  - Create/Transmit events
- **VENs:**
  - Receives event instruction
  - Dispatches DERs
- A single entity can perform both VTN and VEN functionalities – e.g. an aggregator receiving a signal from a TSO and dispatching downstream assets
- Relies upon aggregators or gateways to directly control generation / storage assets



[OpenADR Alliance]

Notable Adopters

- Austin Energy
- HECO
- NV Energy
- National Grid
- PG&E
- SCE
- SDG&E
- SMUD

IEC 61850

Origin

- Initially development by EPRI/UCA in 1989
- Standardization formalized in approximately 1995
- Driven by need to standardize communication between assets with object-based model

Common Use Cases

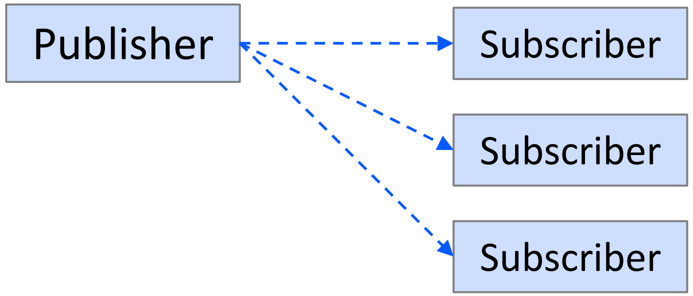
- Initially developed to enable fast control of substation equipment
- Reporting, logging, and retrieving status data from equipment containing processor-based controllers
- Capabilities to control assets beyond substation equipment gradually implemented over time

[Source: QualityLogic - Simpson, Kang, Mater]

Model Structure

- Object-oriented class model divided into:
  - **Devices** containing multiple nodal functions
  - **Nodes** performing specific functions on data
- A device (e.g. substation equipment) will have multiple nodes, and nodal functions are defined extensively within the IEC 61850 standard
- Supports multiple communication styles:
  - **Generic Object-Oriented Substation Event (GOOSE)**-based scheme allows for a single publisher/multiple subscriber commands
  - **Manufacturing Message Specification (MMS)** utilizes a client-server model where authorized clients request data from the server
- Control occurs over ethernet and TCP/IP

IEC



Publisher-Subscriber

Client-Server

IEEE 2030.5

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Origin

- Initially development by ZigBee Alliance in 2007
- Formally became IEEE standard in 2013
- Developed by a wide range of hardware manufacturers, utilities, and energy providers to develop a unified communication protocol across devices

Common Use Cases

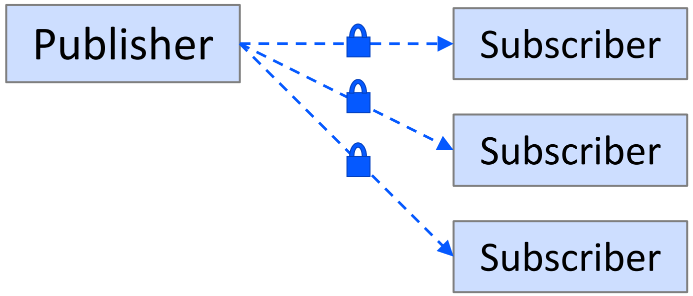
- Initially developed to facilitate integrated control of a wide range of utility assets, DERs, and C&I equipment
- Integrates control schemes for, market signals, system services, and direct device control
- Support for complex command functionality, such as dynamic operating envelopes (DOEs)

[Source: QualityLogic - Simpson, Kang, Mater]

Model Structure

- Data model derived from IEC 61850 and leverages similar classes
- Utilizes representational state transfer (REST) client-server architecture
- Expansive list of pre-defined functions for:
  - Utility network operations
  - Direct DER control
  - Energy market transactions
  - Aggregated resource portfolios
- Encrypted and approved access control list methodology with security certificates between parties
- Support for direct device control required for CA Rule 21 Smart Inverter
- Similar to IEC 61850, supports both publisher/subscriber and server-authorized client communication
- Control occurs over ethernet and TCP/IP

IEEE



Publisher-Subscriber

Client-Server

Side-by-Side Comparison

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	OpenADR 2.0	IEC 61850	IEEE 2030.5
Primary Use Case	Dispatching and related reporting portfolios of DER assets within a market	Fast communication for substation equipment	Providing control to a wide range of individual energy devices and portfolios in response to grid & market conditions
Model Structure	Top/Bottom nodes cascade commands	Object-oriented model of classes and nodes	Object-oriented model of classes and nodes
Communication Medium	Internet	Ethernet, TCP/IP	Internet
Target Users	T/DSPs, Aggregators	T/DSPs	T/DSPs, Aggregators, Generators, Asset owners/operators
Direct Asset Control	No	Yes	Yes
Primary Assets Supported	Portfolios of aggregated resources	Substation equipment with extensions for DERs	Individual DERs through portfolios/ large aggregations of assets
Embedded Market Participation Functionality	• Real-time pricing • Dispatched events (e.g. DR)	N/A; capabilities come from separate control source	• Real-time / DA market • Capacity Market Services • Ancillary Services • Dispatched events (e.g. DR)
Advanced Transactive Grid Features	Extensible to support some 2030.5 features,	N/A	• Dynamic Operating Envelopes • CA Rule 21 Compliant

[Source: QualityLogic - Simpson, Kang, Mater; OpenADR Alliance]

Brief Case Study: Horizon Power and PXiSE DERMS

Distributed Energy Resource Management System

HORIZON POWER

Horizon Power DERMS + Onslow Microgrid

Onslow Microgrid

Transition diesel-powered remote community to a highly-renewable 11MW microgrid with:

- → 8 1-MW natural gas-fueled generators
- → 1 1-MW diesel-fueled generator
- → 1 MW solar power generation (several hundred customer assets)
- → 2 MW/1.25 MWh battery storage
- → High-Speed Microgrid Controller

Customer Motivations

- → Providing reliability and stability across the utility's vast territory while enabling 4x increase in renewable hosting capacity for customers
- → Reducing annual fossil fuel consumption and costs by enabling peak renewable production of 90%+

Technical Objective

- → Deploy network-wide DERMS to coordinate 50,000 customer DERs with utility assets

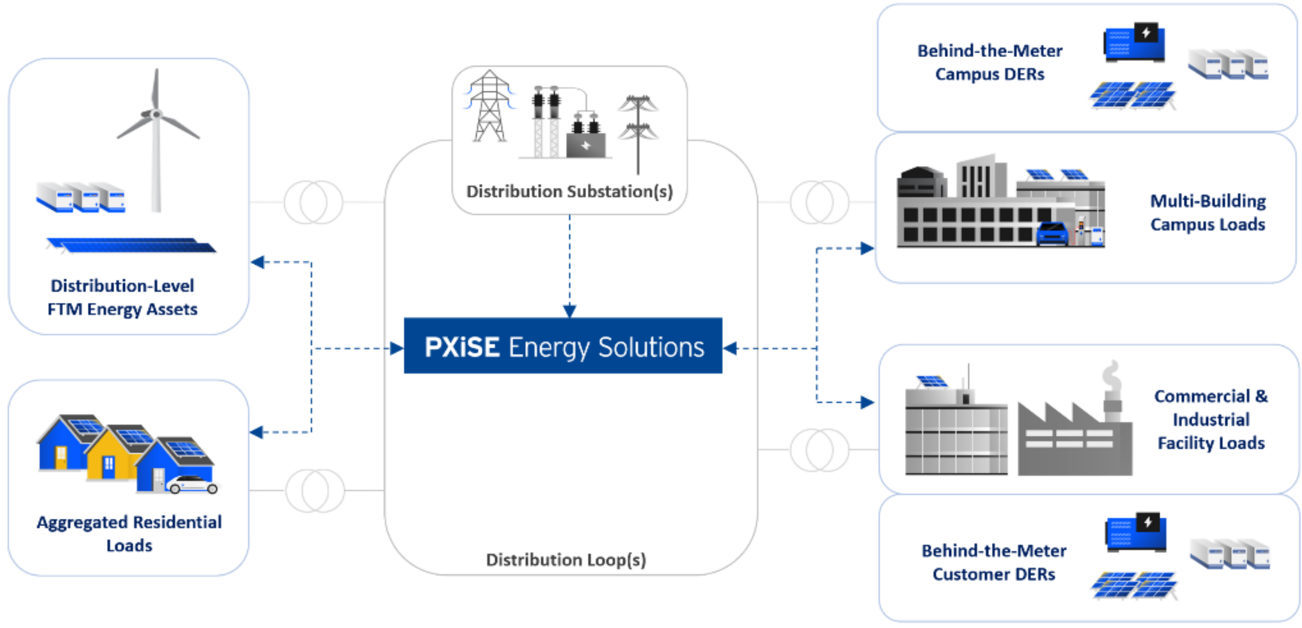
Read More: https://www.canarymedia.com/articles/a-renewable-and-battery-only-microgrid-the-holy-grail-of-clean-energy/

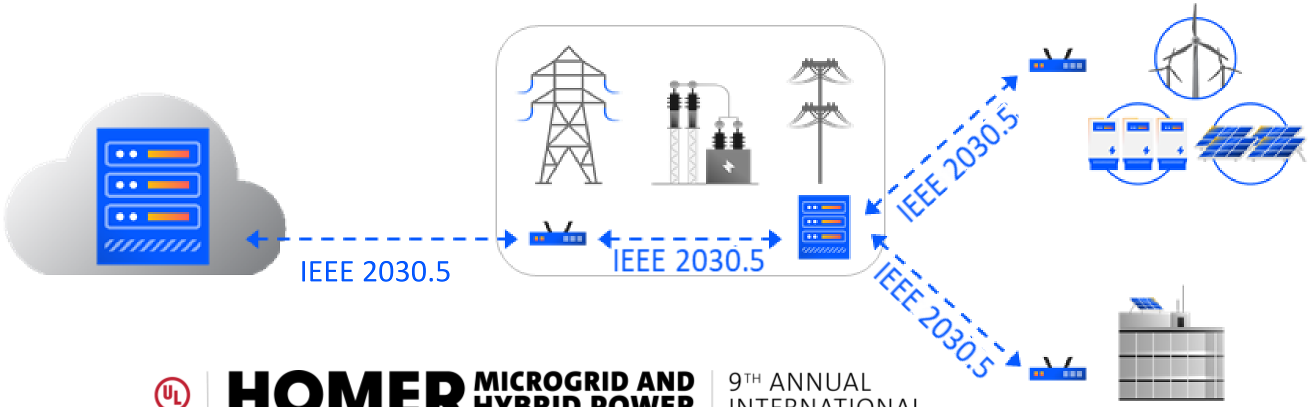
HORIZON POWER

Horizon Power + PXiSE DERMS

Deployed System Performance

- Acts as a supervisory controller to downstream high-speed control systems such as microgrids, large C&I facilities, and EV fleet charging systems
- Controlled hundreds of DERs across 250+ customer sites
- Remotely communicates with and controls DERs quickly and securely
- Mitigates intermittency and coordination challenges by optimizing the energy mix throughout the distribution circuit(s) controlled
- Flexibly integrates with distribution and transmission system network systems for streamlined control and market participation





References

[1] Simpson, Kang and Mater, *"IEC 61850 and IEEE 2030.5: A Comparison of 2 Key Standards for DER Integration - An update,"* QualityLogic.

[2] openADR Alliance, *"DER Control and How to Implement Smart Inverter Management with OpenADR".*

[3] openADR Alliance, *"How OpenADR can Compare with IEEE 2030.5 for California Rule 21".*

[4] L. Blackhall, *"On the Calculation and Use of Dynamic Operating Envelopes,"* Battery Storage and Grid Integration Program, Australian National University.