EPRI Smart Grid Information Sharing Webcast

OpenADR and Extending Functions for the Management of Distributed Energy Resources

October 2, 2013
Speakers

• Matt Wakefield
  Director, Information & Communication Technology, EPRI

• Brian Seal
  Technical Executive, EPRI

• Rolf Beinert
  Technical Director, OpenADR Alliance

• Rish Ghatikar
  Deputy Leader, The Grid Integration Group, Lawrence Berkeley National Laboratory
  Vice Chairman, The OpenADR Alliance
Agenda

• Overview of OpenADR Functions and Possibility of Extending them for DER Management  Matt Wakefield

• Smart Inverters and OpenADR  Brian Seal

• Enabling the Standards for Automated Demand Response  Rolf Beinert

• Distributed Energy Resources and Smart Grid Technology Integration  Rish Ghatikar

• Discussion
Exploring Extending OpenADR Functions to DER

Being Leveraged by Utilities, ISO’s and Aggregators around the World
Auto DR Demonstration & Emerging Opportunities

EPRI 3 Year Demo – OpenADR 2.0

- Demonstrating Capabilities of OpenADR against Utility & ISO Requirements
- US, France, Japan
- Understanding Capabilities & Migration Paths for next generation DR
- Open Source Software Development
  - Server, Client & “C” Library

Emerging Opportunity – Using OpenADR for DER Management
The Architecture, Security, Standards & Comm’s can apply to DER
Signal Types Apply to Loads

- Air Conditioning
- Water Heaters
- Pool Pumps
- Aggregators

Recursive Architecture:

**VTN** = Virtual Top Node, **VEN** = Virtual End Node

**Signal Types**
- ELECTRICITY, Price
- PRICE, Price, Price
- ELECTRICITY, priceRelative
- PRICE, PriceRelative
- ELECTRICITY, priceMultiplier
- PRICE, PriceMultiplier
- ENERGY_PRICE, price
- ENERGY_PRICE, priceRelative
- ENERGY_PRICE, priceMultiplier
- DEMAND_CHARG, price
- DEMAND_CHARG, priceRelative
- DEMAND_CHARG, priceMultiplier
- BID_PRICE, price
- BID_LOAD, setpoint
- BID_ENERGY, setpoint
- CHARGE_STATE, energyXXX
- CHARGE_STATE, energyXXX
- CHARGE_STATE, None
- LOAD_DISPATCH, setpoint
- LOAD_DISPATCH, delta
- LOAD_DISPATCH, multiplier
- LOAD_DISPATCH, level,
- LOAD_CONTROL, x-LoadControlCapacity
- LOAD_CONTROL, x-LoadControlLevelOffset
- LOAD_CONTROL, LoadControlSetpoint
- LOAD_CONTROL, x-LoadControlPercentOffset

**Does it Matter what the Resource is?**
Leveraging OpenADR for Managing DER

Distributed Energy Resources (DER)
- Solid State Transformers
- Distributed Generation
- Commercial Buildings
- PhotoVoltaics (PV)
- Energy Storage
- Microgrids
- Cap Banks

Many Existing Efforts:
- Can we Simplify the “Grid” Interface?

Focusing on Electrical Capabilities **Simplifies** the Architecture
Types of Inverter Functions Standardized

EPRI Report  1026809

• Smart Volt-Var curves
• Individual device status / state monitoring
• Event logs and history monitoring
• Volt-watt curves
• Storage charge/discharge control and scheduling
• Connect/disconnect control
• Maximum generation limiting
• Load/generation smoothing
• Islanding configuration settings

These apply here, at the connection to the end device

What DER Standards/Management Efforts Can Be Leveraged?
Smart Inverters and OpenADR

Brian K. Seal

October 2nd, 2013
Collaborative Industry Project Formed in 2009

To identify a standards-based means for the fielding of inverters with a common set of advanced functions

More than 550 individuals engaged, representing:

- 50+ PV & Storage equipment providers
- 60+ utilities
- 12 National labs and research organizations
Smart Inverter Functions and Protocols

1. Identify Needed Functions
2. Common Way to Implement
3. Represent Information in Standard Information Model (IEC 61850)

Map to Protocols:
- DNP3
- Modbus
- SEP 2.0
- 61850 MMS, Web Services, Other
Standardized Functions, IEC Object Models

IEC 61850-90-7

IEC 61850 Object Models for Photovoltaic, Storage, and Other DER inverters

May be Mapped into Any Protocol
1 Introduction

This document describes a standard data point configuration, set of protocol services and settings – also known as a profile – for communicating with photovoltaic (PV) generation and storage systems using DNP3. The purpose of defining this profile is to make it easier to interconnect the DNP3 masters and outstations that are used to control such systems.

This document is an application note, meaning it does not specify any changes to the DNP3 standard at all; it merely describes how to use DNP3 for a particular purpose. It is, however, intended to be an interoperability standard for those wishing to build and specify PV generation and storage systems.

Although this document describes a DNP3 profile, it is designed based on the structured data models of
Standards-Based Integration of Distributed PV and Storage

Phase 1 Functions:
• Connect/Disconnect – Non Islanding
• Max Generation Level Control
• Autonomous Volt-VAR Management and PF
• Storage Management
• State/Status Monitoring
• Event Logging
• Time Adjustment

Phase 2 Functions:
• Voltage Sag Ride-Through
• Autonomous Watt-Voltage Management (transient and steady-state)
• Autonomous Watt-Frequency Management
• Dynamic Reactive Current
• Islanding
• Additions to State/Status Monitoring
• Others
Simple Max Generation Level Control

- Ramp Time
- Maximum Generation Limit
  - 100%
  - 80%
- Time Window
- Command Received
- Example Actual Output

Circle Diagram:
- Leading [Inductive]
- Maximum Generation Power Limit (% of Pmax)
- Reactive Power [Vars]
- Active Power [Watts]
- Consumption
- Production
- Lagging [Capacitive]
- Inverter Nameplate Capability
- Charger Capability may Differ

Quadrant I: Leading Power
Quadrant II: Reactive Power
Quadrant III: Lagging Power
Quadrant IV: Active Power
Volt-Var Function

Utility-Defined Curve Shapes

Volt/Var Mode 1 – Normal Regulation
Simple Broadcast

Volt/Var Mode 2 – Transmission VAR Support
Configurable Voltage Event Ride-through
Dynamic Reactive Current

Diagram showing the relationship between voltage and reactive current, with annotations for 
- Deadband
- DbVMin
- DbVMax
- Capacitive
- Inductive
- ArGraSag
- ArGraSwell
- Delta Voltage (% of VRef)
- Voltage
- FilterTms
- V Average over FilterTms
- Delta Voltage @ time = Present (negative value shown)

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Peak Power Limiting (at point of reference)
Power Smoothing

Diagram showing the concept of power smoothing with variables such as Delta Wattage (Present Wattage Minus Moving Average), Wattage of Reference Load or Generation, and Filter Time (FilterTms). The diagram illustrates the smoothing gradient and deadband.
Multiple Grid Configurations

Grid Config 1

Grid Config 2

Go To Grid Configuration 2
Enabling The Standard for Automated Demand Response

OpenADR Alliance

Rolf Bienert
Open Automated Demand Response (OpenADR) provides a non-proprietary, open standardized DR interface that allows electricity providers to communicate DR signals directly to existing customers using a common language and existing communications such as the Internet.

Source: LBNL
Architecture

- Web Service like logical request-response services
  - Event Service – Send and Acknowledge DR Events
  - Opt Service – Define temporary availability schedules
  - Report Service – Request and deliver reports
  - RegisterParty Service – VEN Registration, device information exchange

- Each service has a single common endpoint

- XML Payloads – Root element defines service operation

Excerpted from QualityLogic’s OpenADR Training Workshop © QualityLogic
General OpenADR 2.0 Aspects
- Provides information from program operator to resource and back
- Does not specify energy savings strategies at the resource side
- Resources can be customers, building, or other sources of energy and curtailment

Status of OpenADR 2.0 Profiles
- Completed 2.0a and 2.0b Profiles
- Gathering requirements for future version
OpenADR Alliance would like to work with additional DER stakeholders to define use cases.

Future specification could focus on these additional use cases.

Current specification can handle general DER interactions.
What is the OpenADR Alliance?

- Member-based organization comprised of a diverse set of industry stakeholders interested in fostering global OpenADR adoption
- Supports development, testing, and deployment of OpenADR technologies across a broad range of services (i.e. real time demand markets)
- Leverages Smart Grid-related standards efforts from NIST SGIP, OASIS, UCAIug, NAESB, and others
- Enables stakeholders to participate in automated DR, dynamic pricing, and electricity grid reliability
Contributor Members
Adopter Members

California ISO
Duke Energy
ERGON ENERGY
EDF R&D
Hawaiian Electric Company
ITRI Industrial Technology Research Institute
財団法人 資訊工業策進會 INSTITUTE FOR INFORMATION INDUSTRY
KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE
財団法人 エネルギー総合工学研究所
openADR ALLIANCE
NV Energy
Thank You!

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www.openadr.org
Distributed Energy Resources and Smart Grid Technology Integration

Rish Ghatikar
Deputy Leader; The Grid Integration Group, Lawrence Berkeley National Laboratory
Vice Chairman; The OpenADR Alliance
http://gig.lbl.gov
http://www.openadr.org
The Grid Integration Group (GIG) develops the technologies and tools to:

1. facilitate dynamic interaction between grid operators and energy consumers;
2. support the grid integration of intermittent renewable sources; and
3. foster the participation of distributed energy resources.

Grid Integration Objectives

Grid Integration of end-uses and electrical vehicle fleets represents a key efficiency and energy security objective for the Federal and State Agencies.

Core Competency: Technology Demonstrations, Pilots and Deployment, Markets, Regulations, Policies, Standards

### Grid Integration Group

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<th>Demand Response (DR)</th>
<th>Microgrids</th>
<th>Electricity Reliability</th>
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<td>• Energy Technology &amp; Systems Integration</td>
<td>• Optimization of Distributed Energy Resources</td>
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<td>• Tariffs, Rate Design</td>
<td>• Distributed Energy Resources, Technologies, and Integration</td>
<td>• Customers &amp; Markets</td>
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<td>• Communications and Telemetry</td>
<td>• V2G, Vehicle to Building (V2B), Microgrids</td>
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<td>• Commercial, Industrial and Residential End uses, automation, and Controls</td>
<td>• Distributed Energy Resources Modeling</td>
<td>• Load as a Resource (LAAR)</td>
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<td>• Open and Automated DR</td>
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<td>• Reliability Technology Issues &amp; Needs Assessment</td>
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THE GRID INTEGRATION GROUP
Grid Integration and Interoperability

Research initiated by LBNL/CEC

- OpenADR 1.0 Commercialization (PG&E, SCE, and SDG&E)
- Pilots and field trials
  - Developments, tests (Utilities)

2002 to 2006

1. OpenADR Standards Development
   - OASIS (EI TC), UCA, IEC
2. NIST Smart Grid, PAP 09

2006 to 2007

1. DR 2.0 Pilots and field trials
   - Wholesale markets, ancillary services
   - Dynamic pricing, renewable, EVs
   - International demonstrations
2. All end-uses and sectors

2007 to 2008

1. Adoption (100+ members)
2. Test/Certify (v2.0)***

2008 to 2009

1. OpenADR 2.0 specifications
   - International standards (IEC)
   - OpenADR 2.0 products/deployments
2. USGBC national pilots
3. Codes (CA T24)

2009 to 2010

1. EI 1.0 standards**
   - OpenADR profiles

2010 to 2013

- OpenADR v1.0: http://openadr.lbl.gov/
- OASIS EI 1.0 standards: http://www.oasis-open.org/committees/download.php/45425/energyinterop-v1.0-cs01.zip
- OpenADR 2.0 Profile Specifications: http://www.openadr.org/
Information Technology Demand-Side Integration

Develop and demonstrate strategies and technologies to transform, innovate and integrate systems, open communications, and distributed energy resources.

Fully integrated end-to-end systems demonstrations using demand-side assets for grid integration:

1. Load as a regulation resource: V2G demonstration
2. Load as spinning and non-spinning reserves: Participating Load Pilot
3. Price-responsive commercial buildings in New York to minimize operational costs.
A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.

The Distributed Energy Resources Customer Adoption Model (DER-CAM) is an economic and environmental model of customer DER adoption.
V2G integration adds key capabilities to demonstrate V2G the full electric grid integration of all-electric fleets.

- Optimal charging and bidding into wholesale regulation markets of a fleet of 100% plug-in electric vehicle (PEV)
- PEVs will be given additional fleet management capabilities and enabled for OpenADR
- Optimization to schedule charging and discharging of PEVs to minimize energy costs and maximize benefits from DR and ancillary services markets
- Integration of PEVs into energy system to examine their potential role in base microgrids

**Bosch’s eMobility**
Front end interface and databases for PEV fleet management and tools for charging services.

**Simulation/Modeling**
Optimal scheduling of the PEV fleet using Distributed Energy Resource Customer Adoption (DER-CAM) Model.

**OpenADR (DRAS)**
Participate in DR and Ancillary Services markets using the U.S. Smart Grid standard, OpenADR.
Integrating OpenADR and DER

Technologies to enable optimized cost and energy choices for DR within customer-side DER such as combined heat and power (CHP), storage, and renewables.
Contact

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- Deputy Leader; The Grid Integration Group; Lawrence Berkeley National Laboratory
- Vice Chairman; The OpenADR Alliance
- R.Ghatikar@lbl.gov

Web References:
- http://www.lbl.gov/
- http://gig.lbl.gov/
  - http://der.lbl.gov/
  - http://drrc.lbl.gov/
  - http://certs.lbl.gov
- http://www.openadr.org/
AutoDR into CA Codes

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Commercialization Impact: PG&E Demand Bid Test Day (aggregated)
Q&A / Discussion