ELECTRIC POWER RESEARCH INSTITUTE

EPRI Smart Grid Information Sharing Webcast

OpenADR and Extending Functions for the Management of Distributed Energy Resources

October 2, 2013

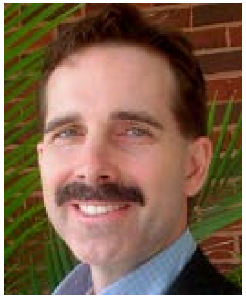
Speakers

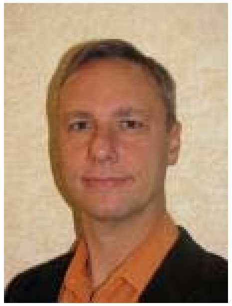
- Matt Wakefield
  Director, Information & Communication Technology, EPRI

- 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

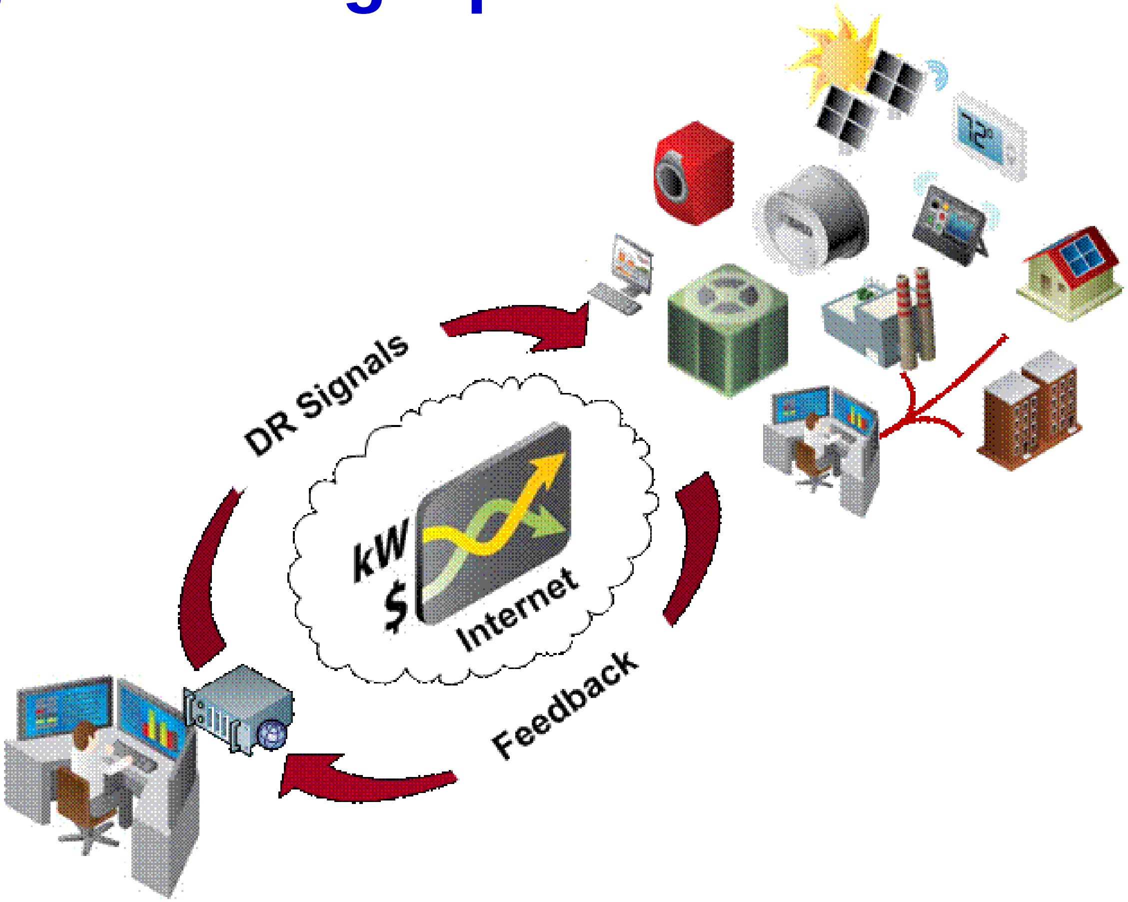




Agenda

- 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

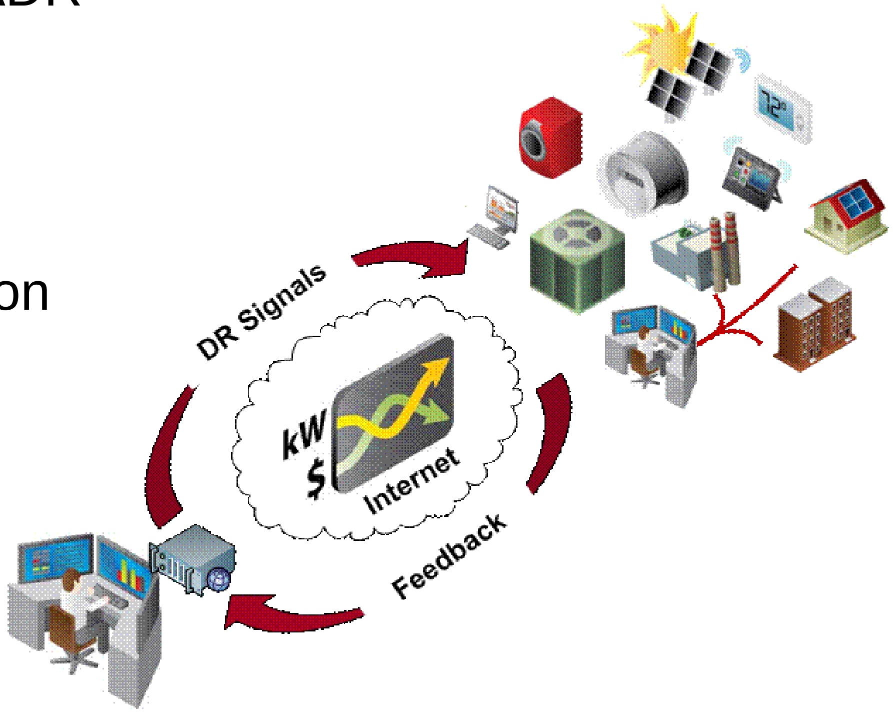


Being Leveraged by Utilities, ISO's and Aggregators around the World

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

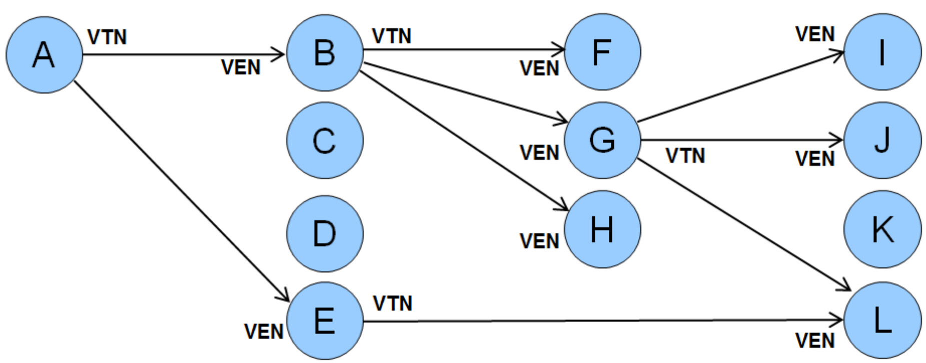


Emerging Opportunity – Using OpenADR for DER Management
The Architecture, Security, Standards & Comm's can apply to DER

Demand Response Signal Types in OpenADR 2.0b

Signal Types Apply to Loads

- Air Conditioning
- Water Heaters
- Pool Pumps
- Aggregators



Recursive Architecture:
VTN=Virtual Top Node, **VEN**=Virtual End Node

Signal_Types

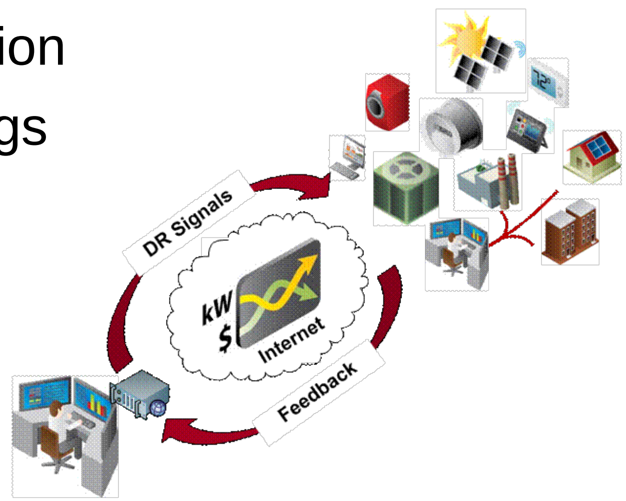
ELECTRICITY_, Price
PRICE, Price, Price
ELECTRICITY_, priceRelative
PRICE, PriceRelative
ELECTRICITY_, priceMultiplier
PRICE, PriceMultiple
ENERGY_PRICE, price
ENERGY_PRICE, priceRelative
ENERGY_PRICE, priceMultiplier
DEMAND_CHARG, price
DEMAND_CHARG, priceRelative
DEMAND_CHARG, priceMultiplier
BID_PRICE, 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:

- V2G, B2G, I2G, H2G, Storage & Renewable Integration, etc.
- Can we Simplify the "Grid" Interface?

Signal_Types

ELECTRICITY_, Price
PRICE, Price, Price
ELECTRICITY_, priceRelative
PRICE, PriceRelative
ELECTRICITY_, priceMultiplier
PRICE, PriceMultiple
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

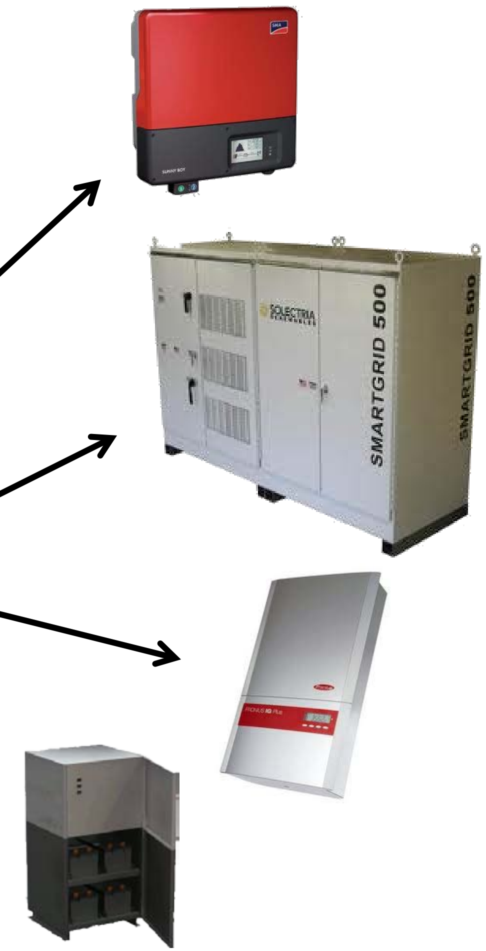
Focusing on Electrical Capabilities Simplifies the Architecture

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

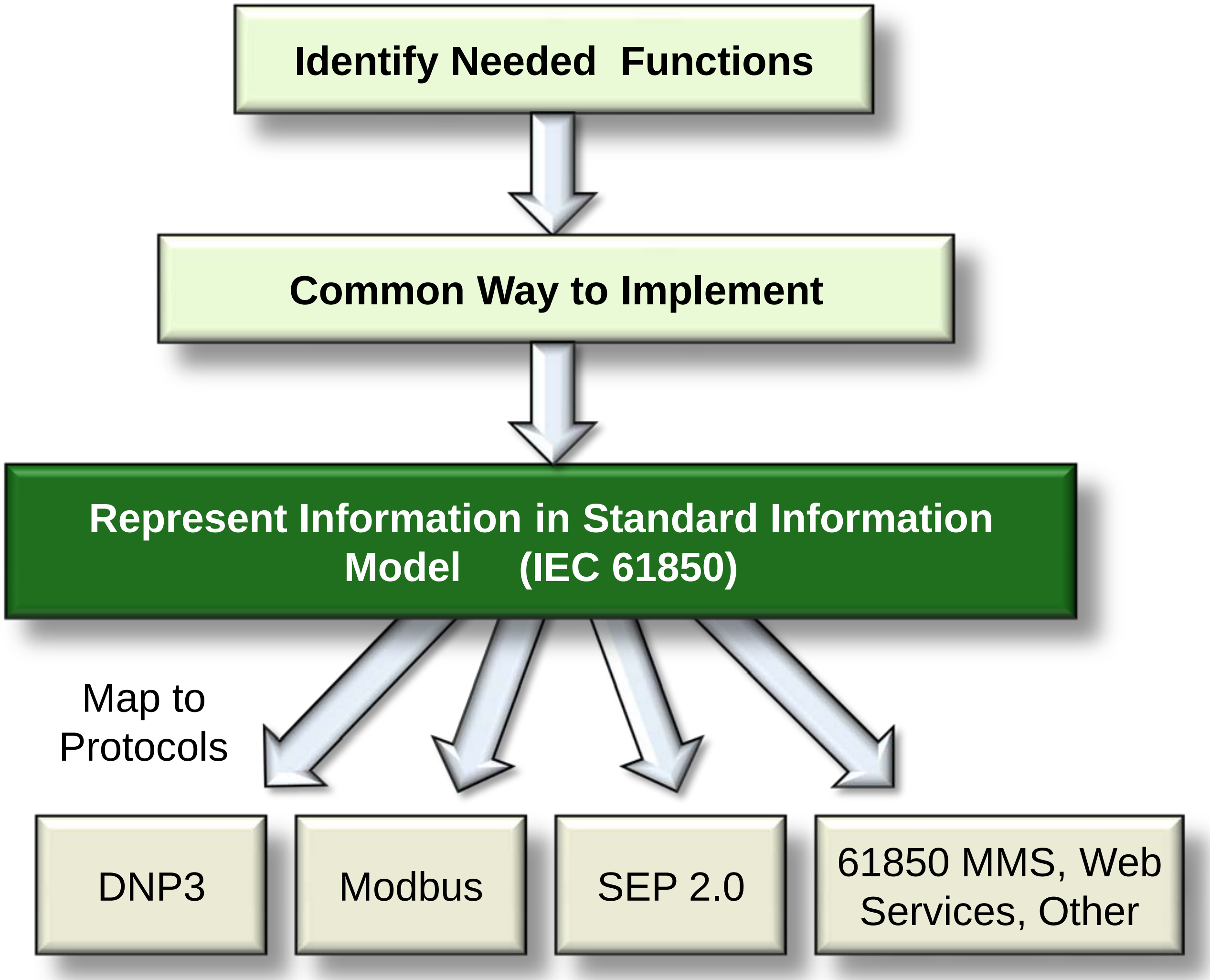
Collaborative Industry Project Formed in 2009

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



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

Standard Communication Protocol: DNP3 Mapping

Distributed Network Protocol

DNP Application Note AN2013-001

DNP3 Profile for Advanced Photovoltaic Generation and Storage

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

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Standards-Based Integration of Distributed PV and Storage

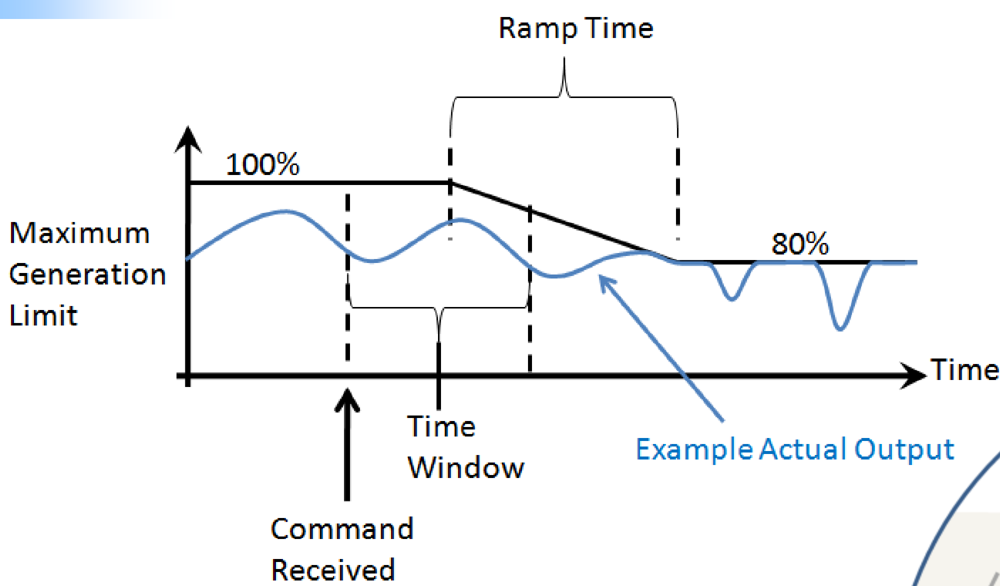
Phase 1 Functions:

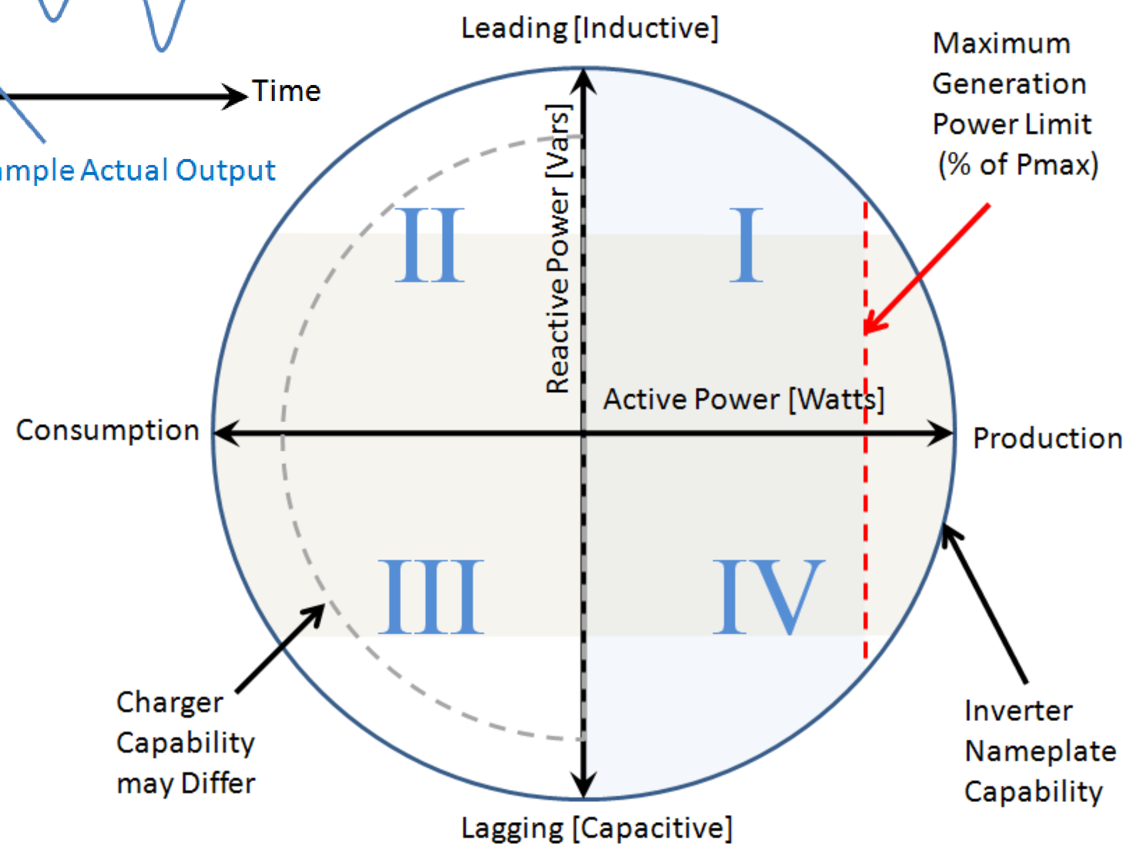
- Connect/Disconnect – Non Islanding
- Max Generation Level Control
- Autonomous Volt-VAR Management and PF
- Storage Management
- State/Status Monitoring
- Event Logging
- Time Adjustment

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

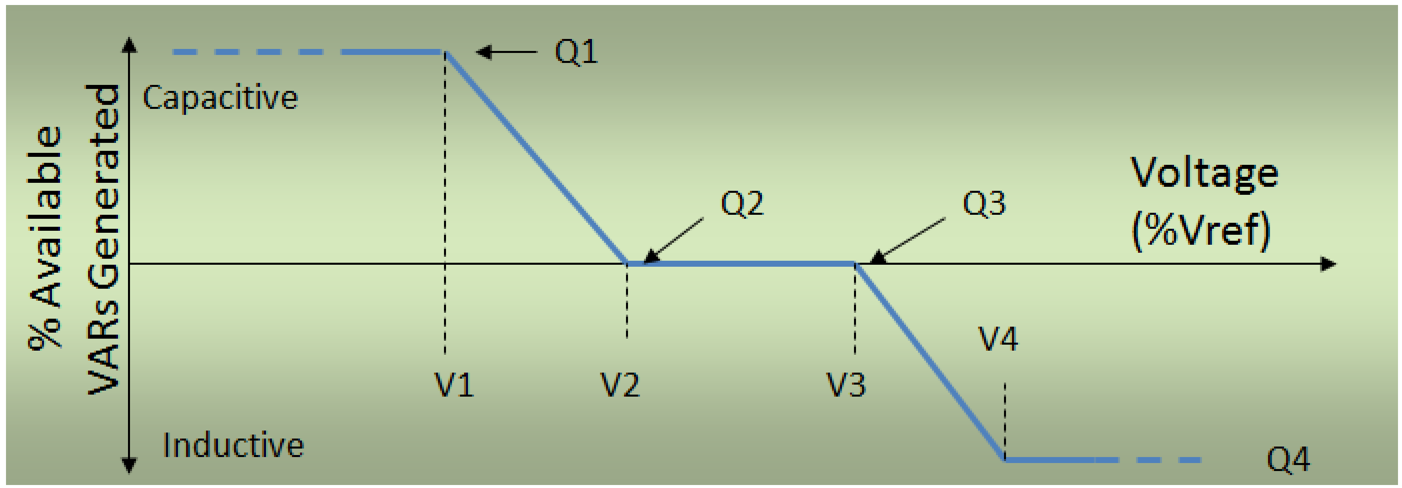




Volt-Var Function

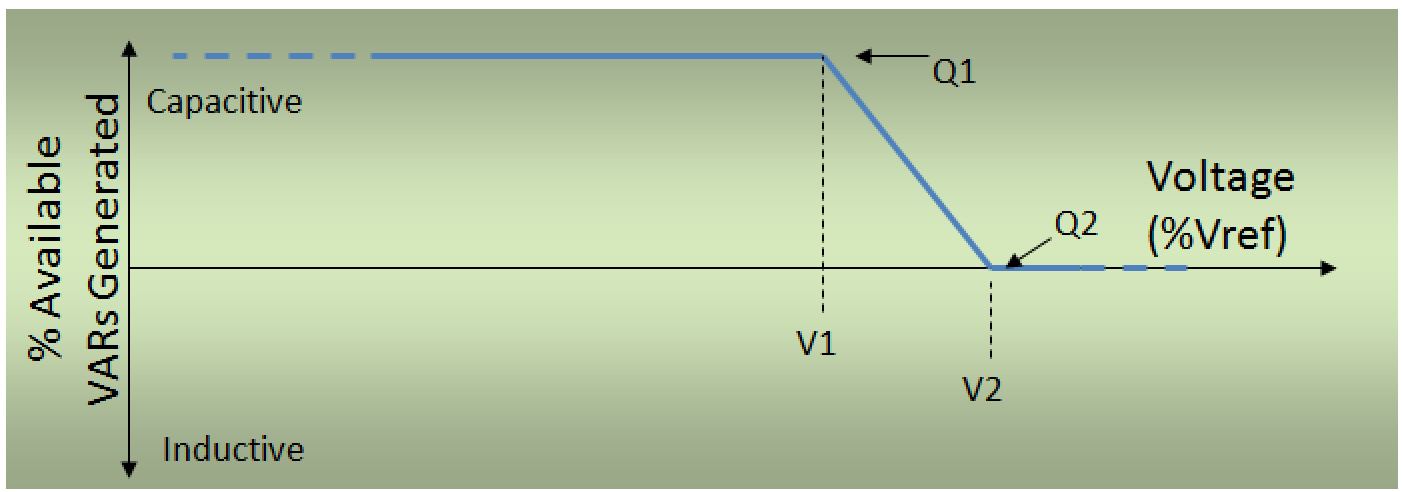
Utility-Defined Curve Shapes

Volt/Var Mode 1 – Normal Regulation

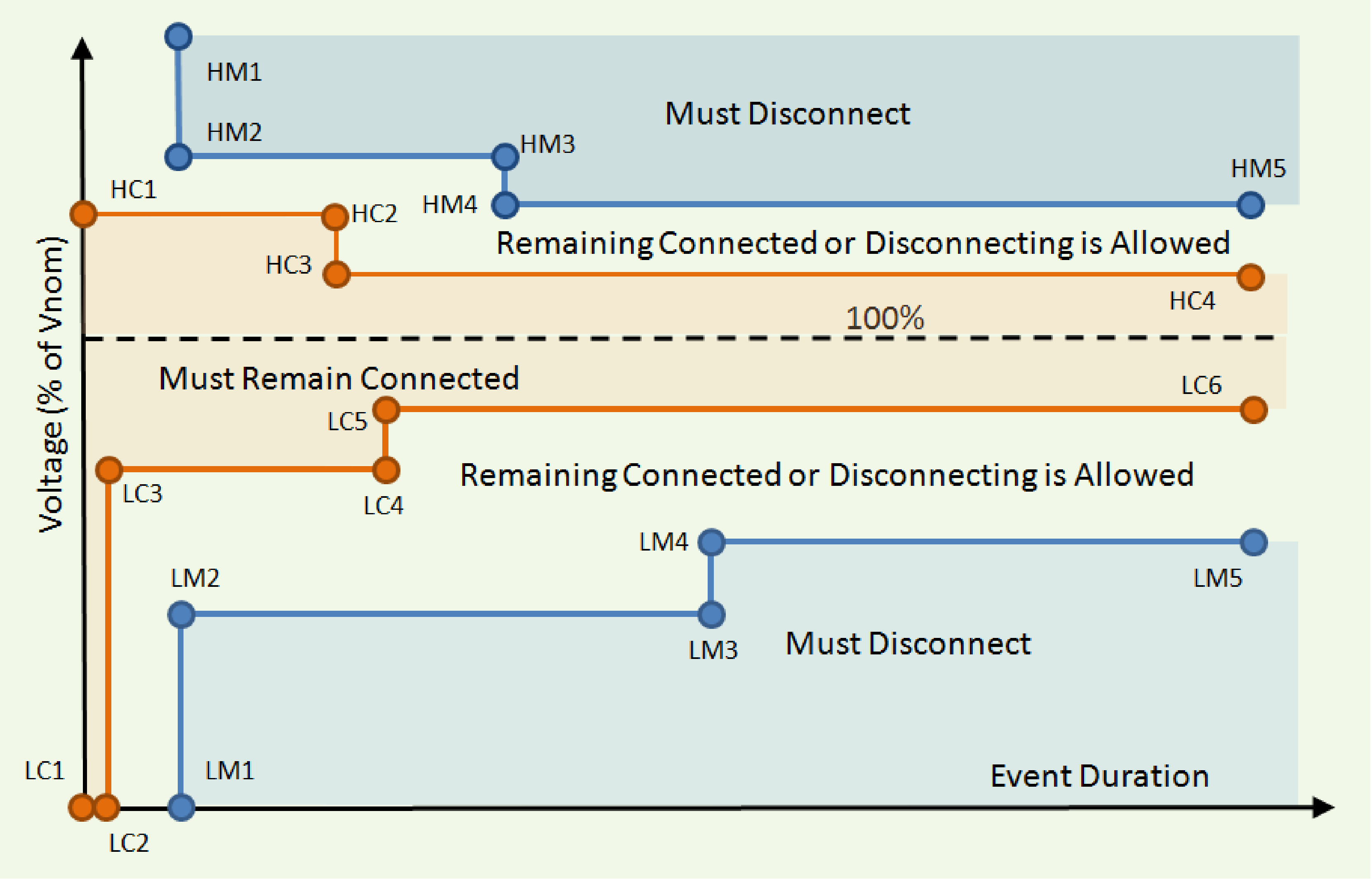


Simple Broadcast

Volt/Var Mode 2 – Transmission VAR Support



Configurable Voltage Event Ride-through



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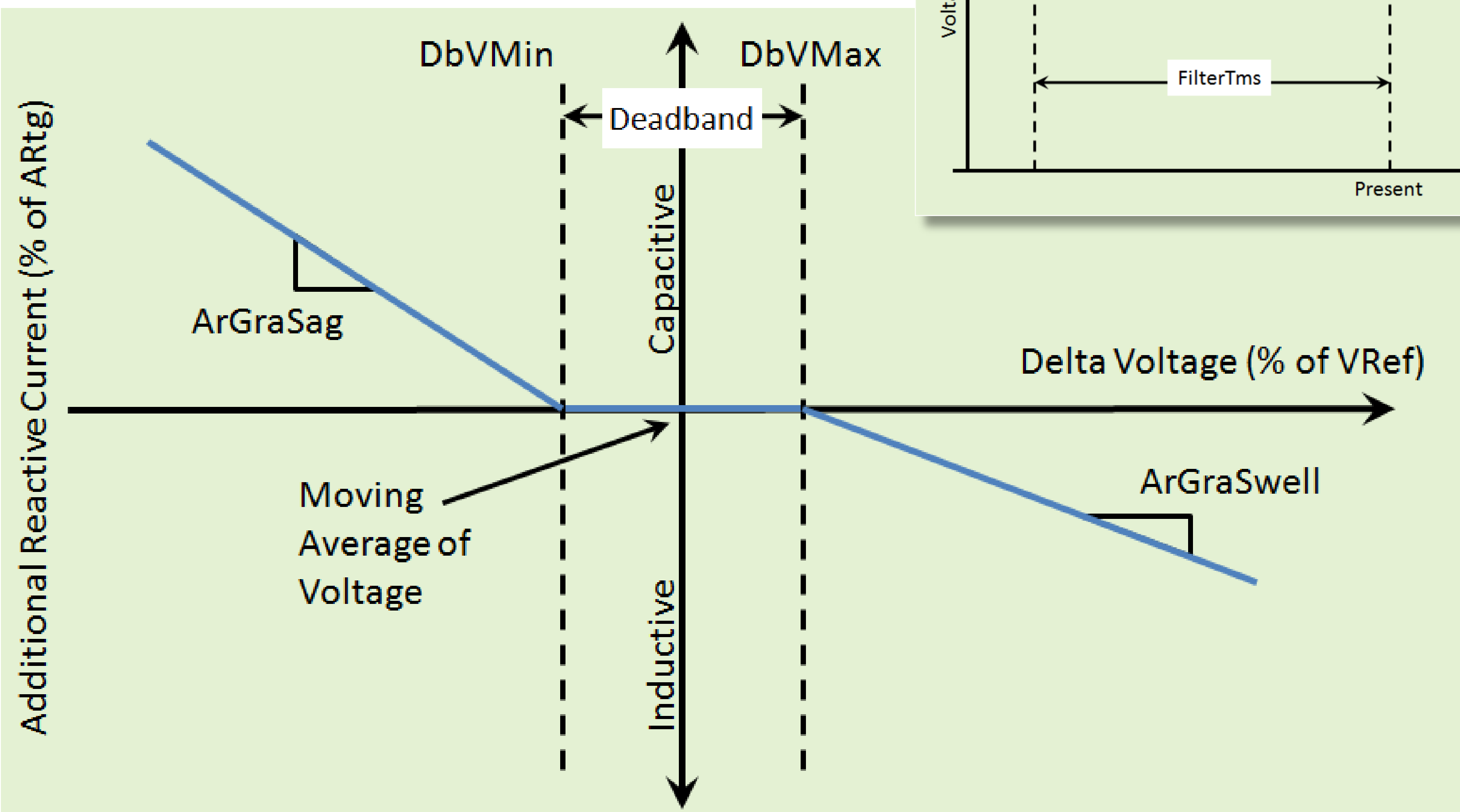
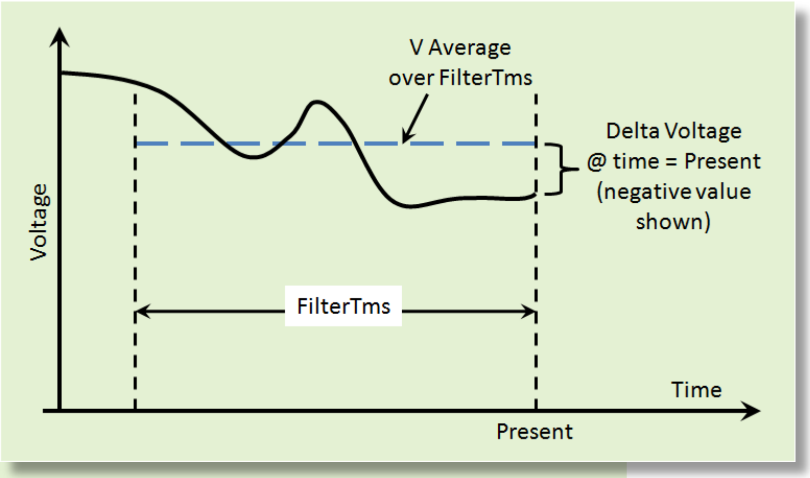
Dynamic Reactive Current





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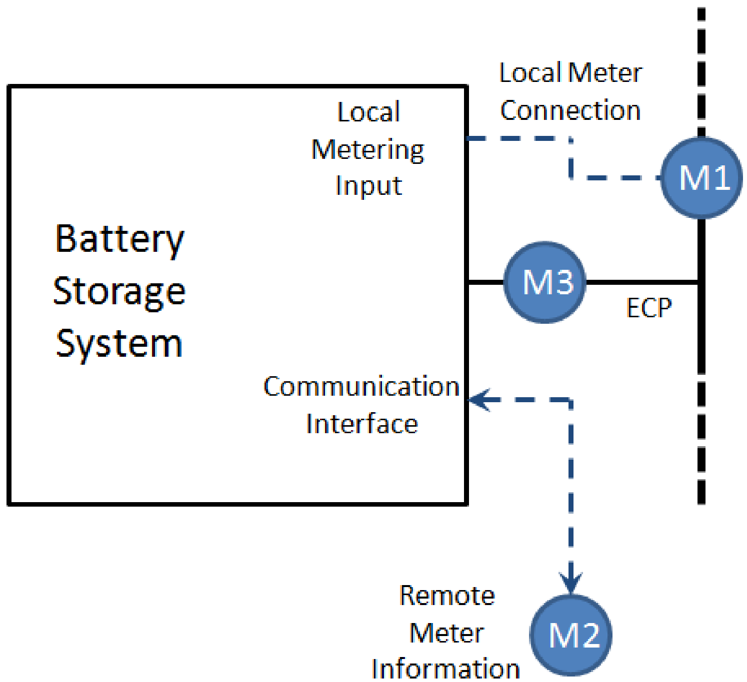
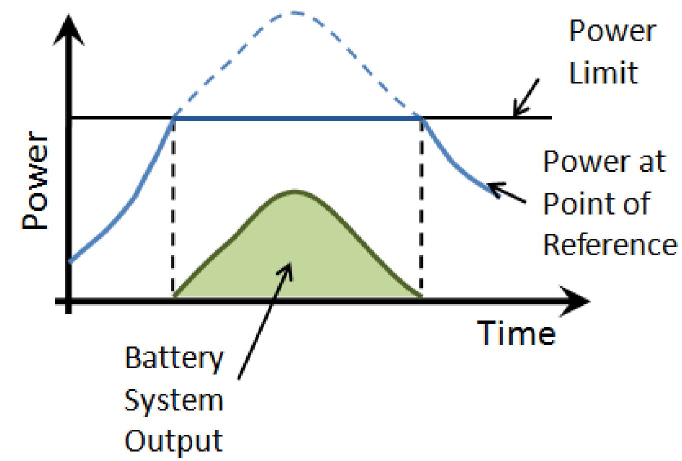
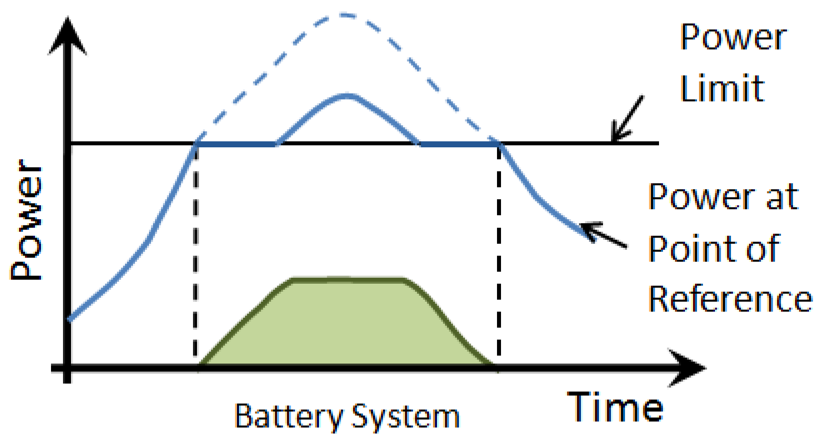
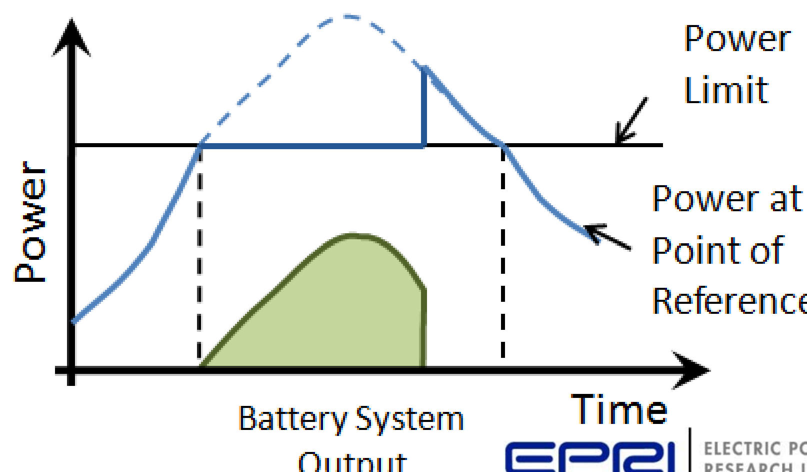
Peak Power Limiting (at point of reference)

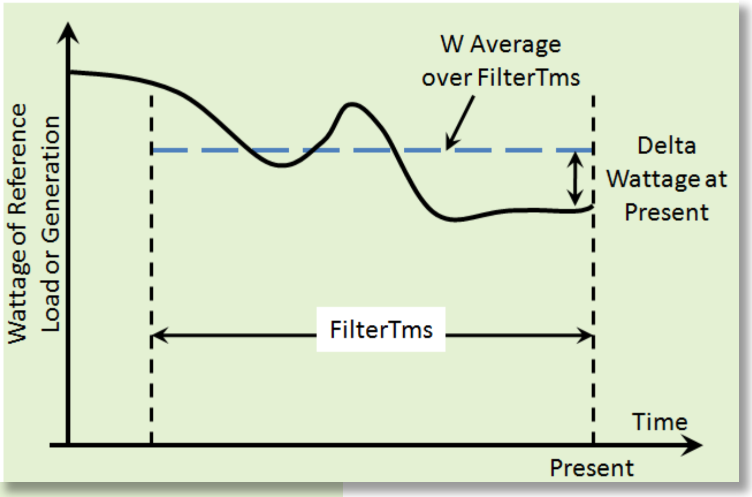


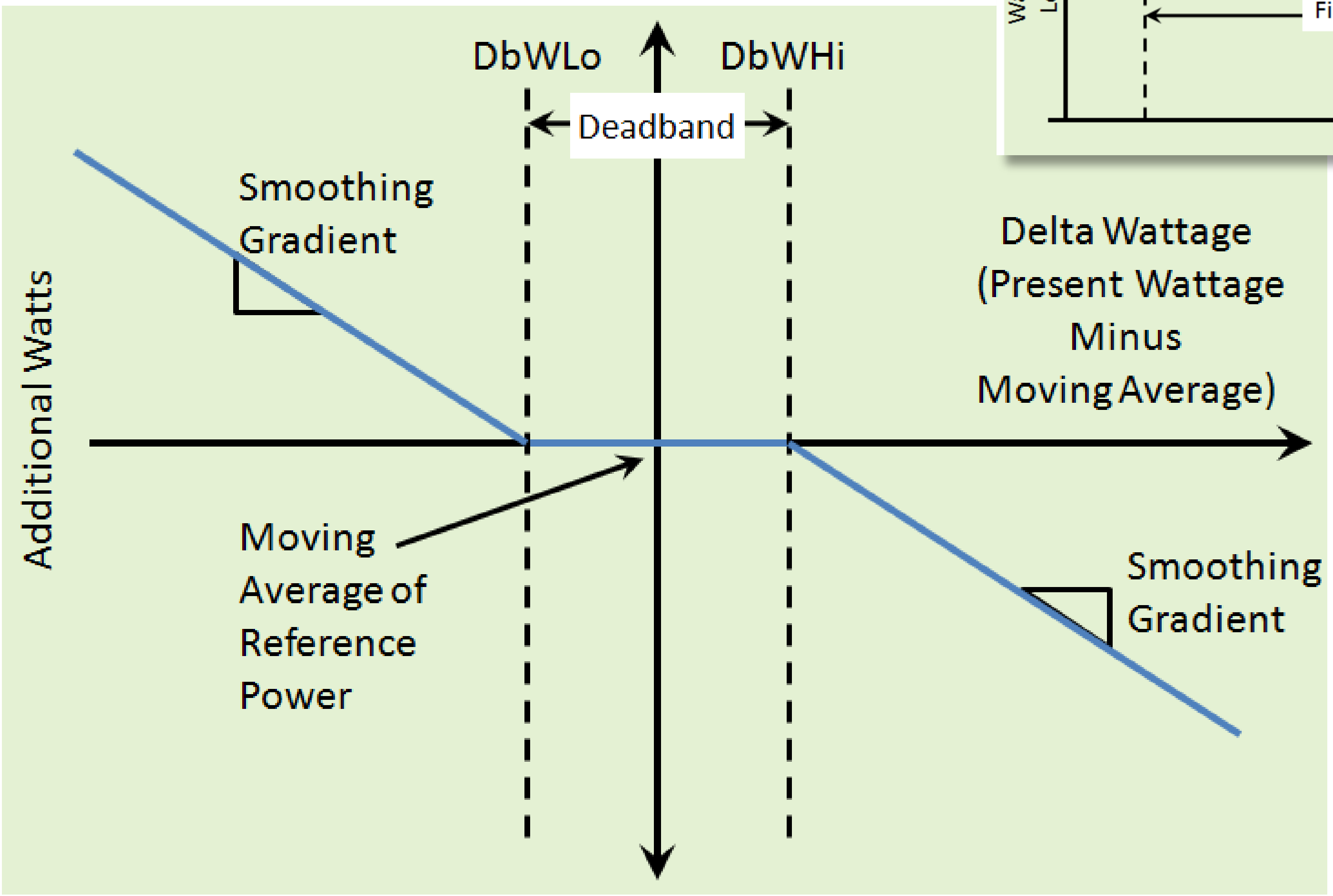




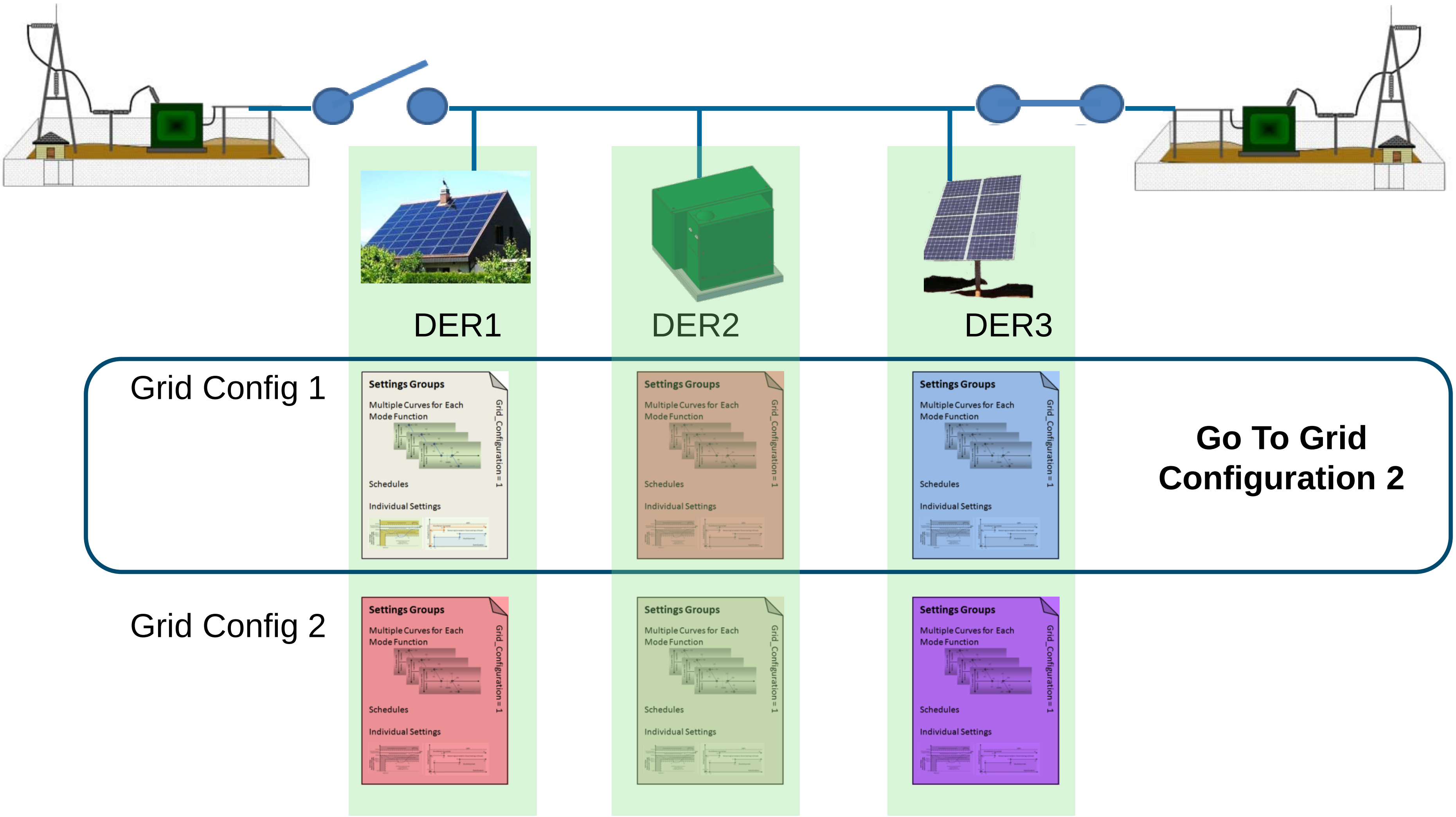


Power Smoothing





Multiple Grid Configurations



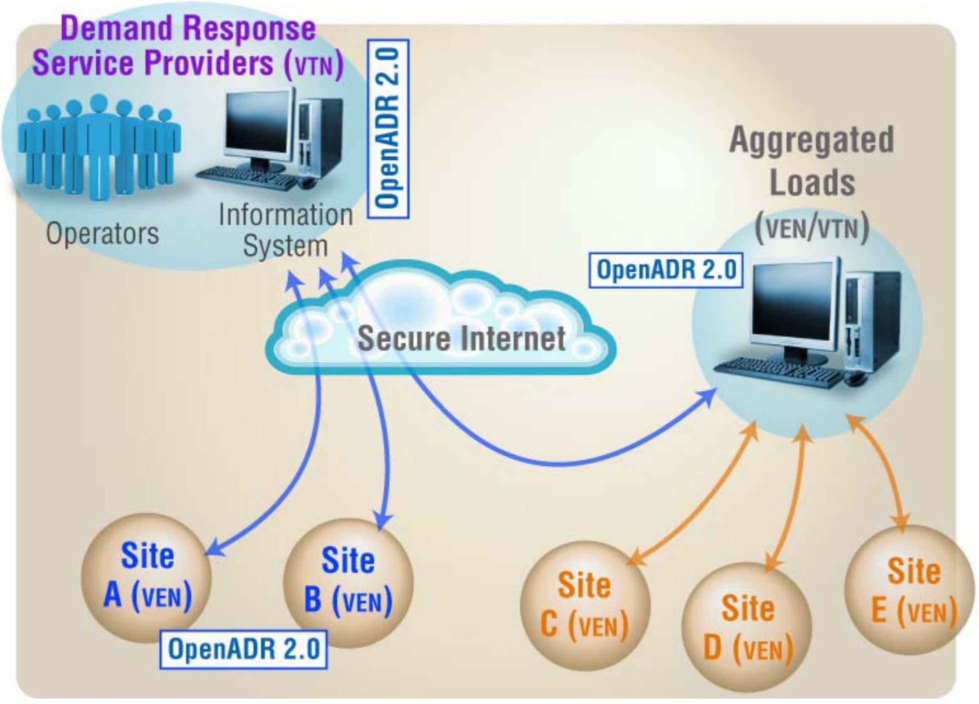
Enabling The Standard for Automated Demand Response

OpenADR Alliance

Rolf Bienert

Understanding OpenADR

- 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

DER management

- 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

DER management

- 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

Sponsor Members

Contributor Members

ACLARA
ALSTOM
BYUCKSAN POWER
candi
CISCO
comverge
Constellation Energy
The way energy works.
COOPER Power Systems
DAIKIN
ENERES
ENERGY RESOURCE SERVICE
Google
HITACHI
Inspire the Next
Ingersoll Rand
Inspiring Progress
Intertek
IPKeys
Johnson Controls
KEMA
LOCKHEED MARTIN
MITSUBISHI ELECTRIC
Changes for the Better
NTT
nuri TELECOM
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OMRON
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Powerit Solutions
QualityLogic
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KOREA ELECTROTECHNOLOGY
RESEARCH INSTITUTE

NVEnergy

Thank You!

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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

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.

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 Group		
Demand Response (DR)	**Microgrids**	**Electricity Reliability**
• Energy Technology & Systems Integration • Tariffs, Rate Design • Communications and Telemetry • Commercial, Industrial and Residential End uses, automation, and Controls • Open and Automated DR	• Optimization of Distributed Energy Resources • Distributed Energy Resources, Technologies, and Integration • V2G, Vehicle to Building (V2B), Microgrids • Distributed Energy Resources Modeling	• Real-Time Grid Reliability Management • Customers & Markets • Renewable Integration • Load as a Resource (LAAR) • Reliability Technology Issues & Needs Assessment
Core Competency: Technology Demonstrations, Pilots and Deployment, Markets, Regulations, Polices, Standards		

Grid Integration and Interoperability

Official OpenADR specification (v1.0) by LBNL/CEC*

Research initiated by LBNL/ CEC

OpenADR 1.0 Commercialization
(PG&E, SCE, and SDG&E)

Pilots and field trials
Developments, tests (Utilities)

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

2002 to 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013

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

EI 1.0 standards**
 - OpenADR profiles

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

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

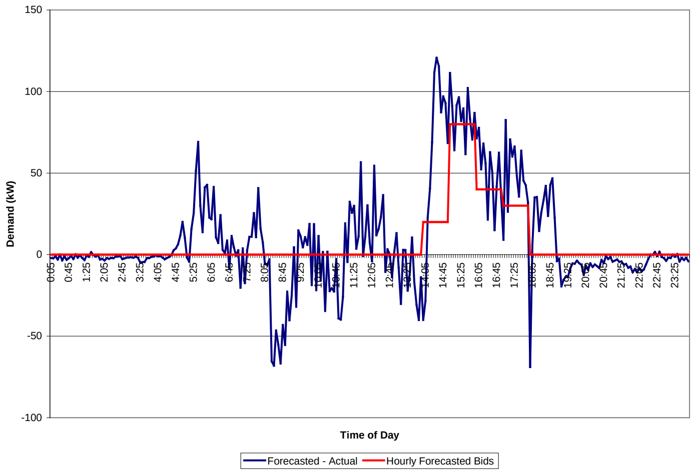
* **OpenADR v1.0:** http://openadr.lbl.gov/
** **OASIS EI 1.0 standards:** http://www.oasis-open.org/committees/download.php/45425/energyinterop-v1.0-cs01.zip
*** **OpenADR 2.0 Profile Specifications:** http://www.openadr.org/

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:

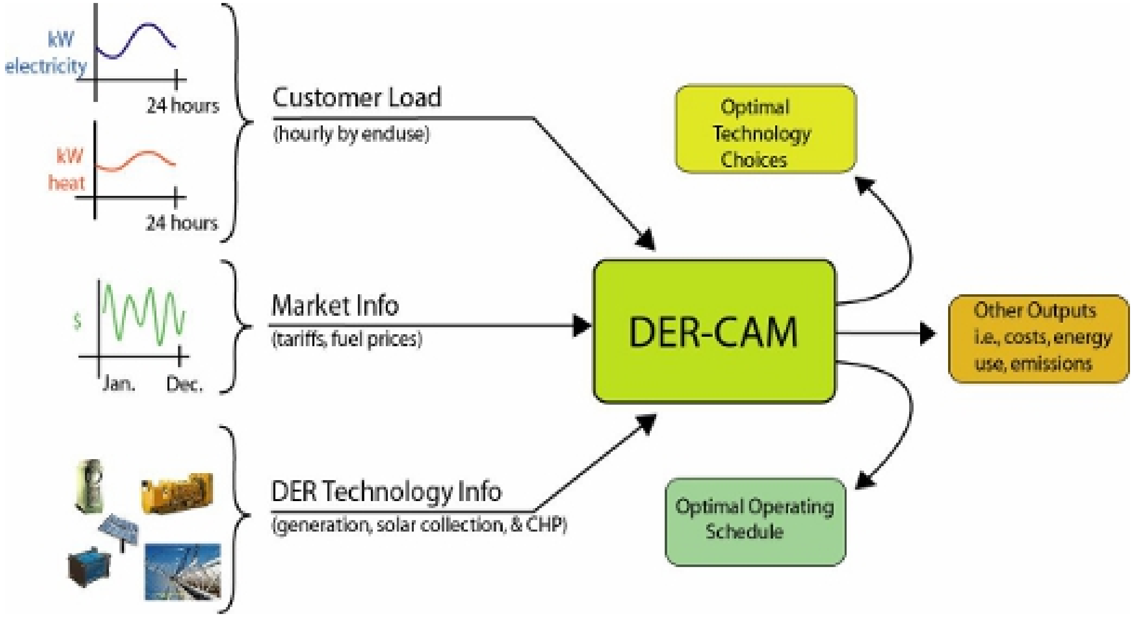
1. Load as a regulation resource: V2G demonstration
2. Load as spinning and non-spinning reserves: Participating Load Pilot
3. Price-responsive commercial buildings in New York to minimize operational costs.



Distributed Energy Resources and Microgrids

U.S. Department of Energy Microgrid Exchange Group:

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 t**o enable it to operate in both grid-connected or island-mode.



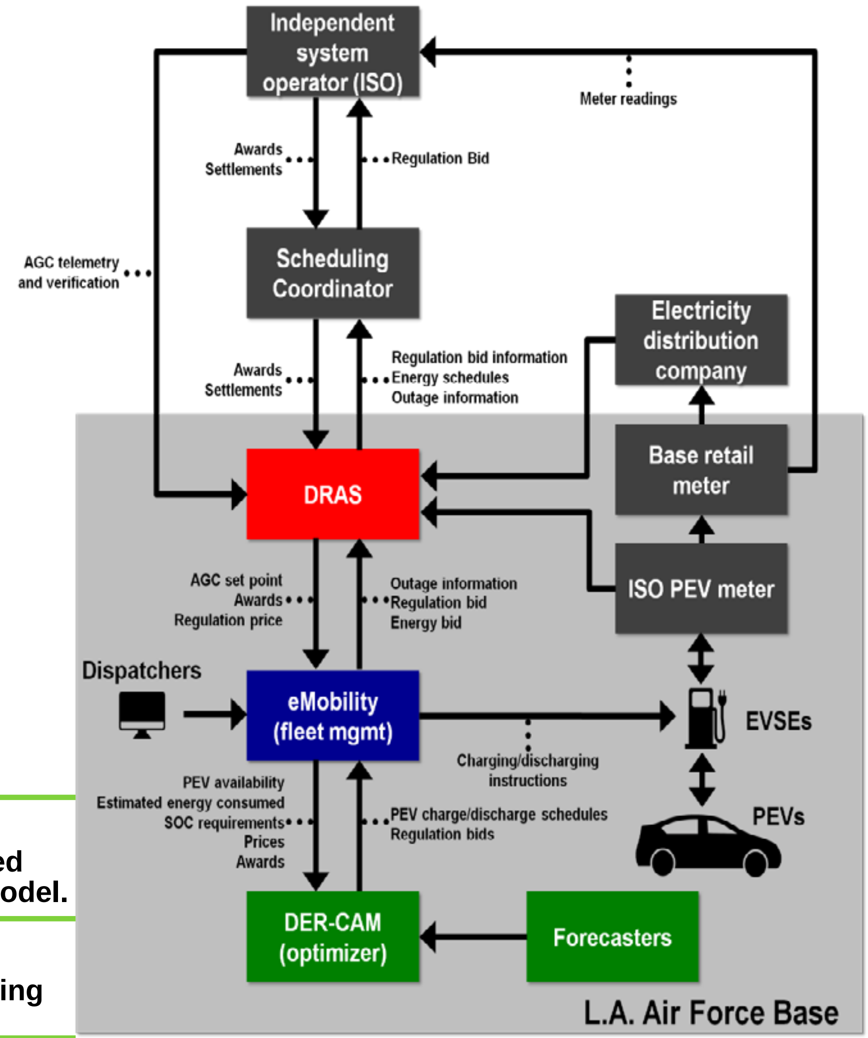
The Distributed Energy Resources Customer Adoption Model (DER-CAM) is an economic and environmental model of customer DER adoption.

Vehicle to Grid (V2G) Integration: LA Air force Base

V2G integration adds key capabilities to demonstrate V2G the full electric grid integration of all-electric fleets.

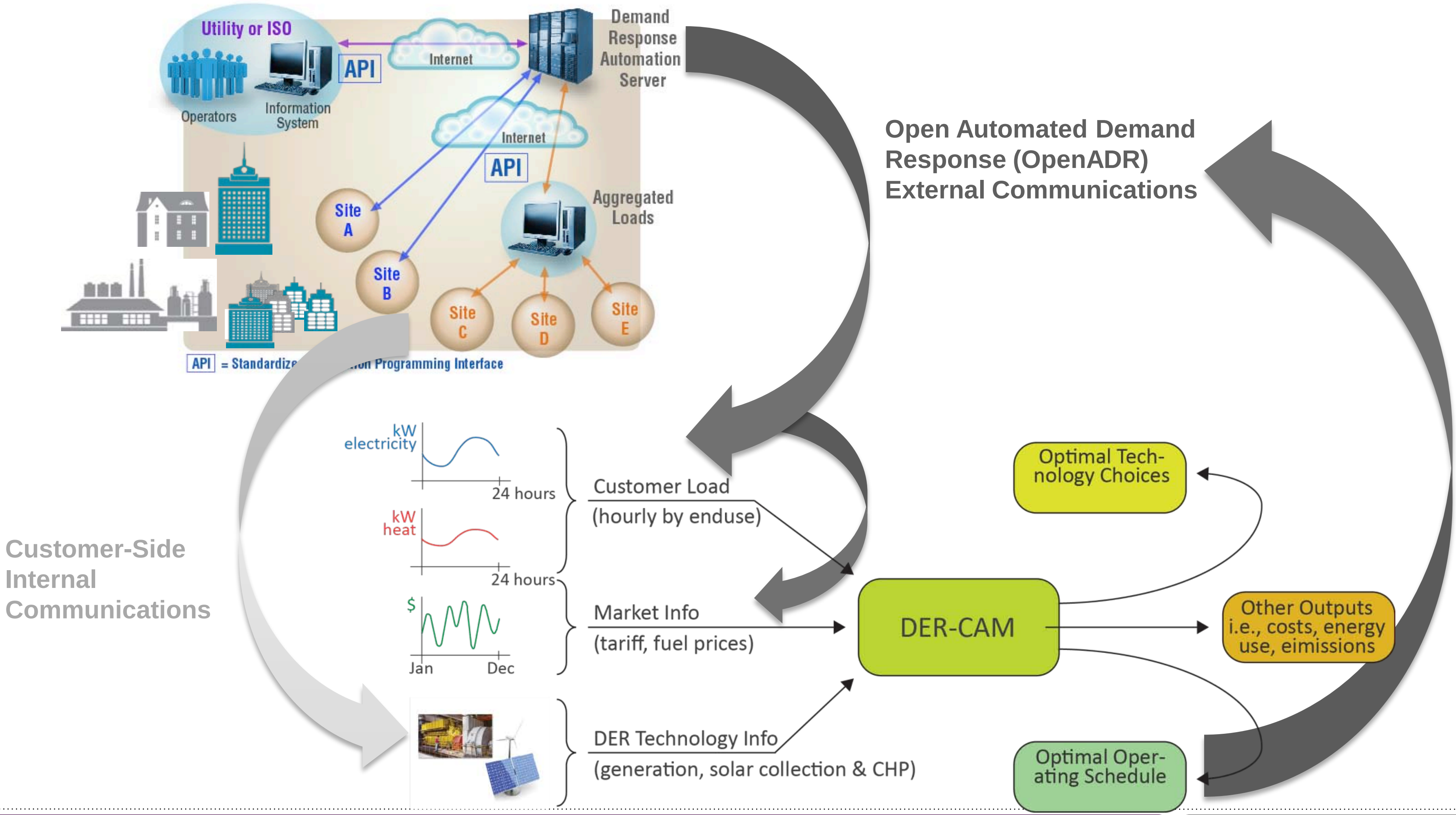
- Optimal charging and bidding into wholesale regulation markets of a fleet of 100% plug-in electric vehicle (PEV
- PEVs will be given additional fleet management capabilities and enabled for OpenADR
- Optimization to schedule charging and discharging of PEVs to minimize energy
  costs and maximize benefits 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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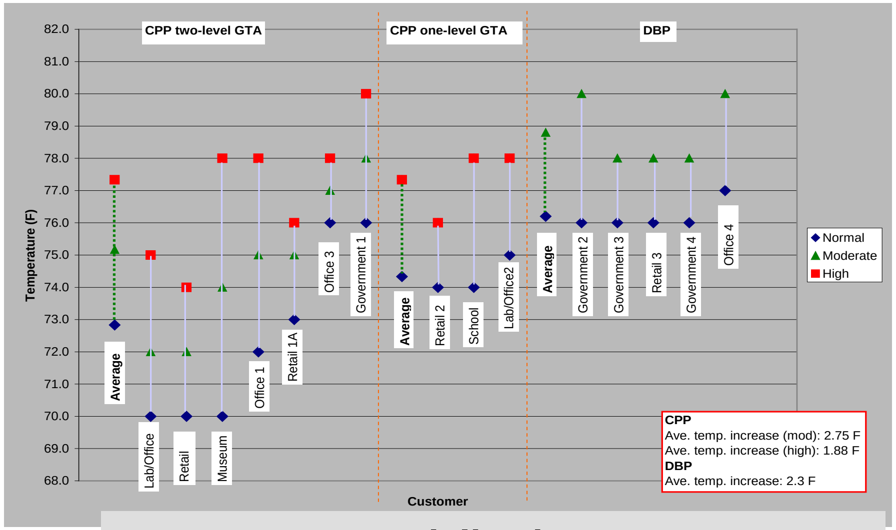
- Deputy Leader; The Grid Integration Group; Lawrence Berkeley National Laboratory
- Vice Chairman; The OpenADR Alliance
- GGhatikar@lbl.gov

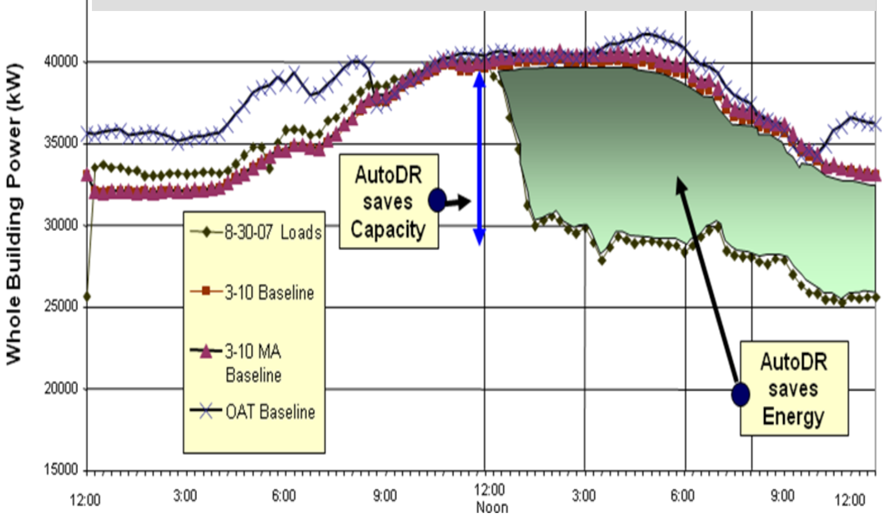
Web References:

- http://www.lbl.gov/
- http://gig.lbl.gov/
  - http://der.lbl.gov/
  - http://drrc.lbl.gov/
  - http://certs.lbl.gov
- http://www.openadr.org/

DR Control Strategies Evaluation



Commercialization Impact: PG&E Demand Bid Test Day (aggregated)



AutoDR into CA Codes

	Building use	HVAC: Global temp. adjustment	Duct static pres. Increase	SAT Increase	Fan VFD limit	CHW temp. Increase	Fan qty. reduction	Pre-cooling	Cooling valve limit	Boiler lockout	Slow recovery	Extended shed period	Lighting: Common area light dim	Office area light dim	Turn off light	Dimmable ballast	Bi-level switching	Other: Non-critical process shed
ACWD	Office, lab	X	X	X		X			X	X		X						
B of A	Office, data center		X	X	X	X			X									
Chabot	Museum	X						X										
2530 Arnold	Office	X									X							
50 Douglas	Office	X									X							
MDF	Detention facility	X																
Echelon	Hi-tech office	X	X	X			X						X	X	X	X		
Centerville	Junior Highschool	X						X										
Irvington	Highschool	X						X										
Gilead 300	Office			X														
Gilead 342	Office, Lab	X		X														
Gilead 357	Office, Lab	X		X														
IKEA EPaloAlto	Furniture retail	X																
IKEA Emeryville	Furniture retail	X																
IKEA WSacto	Furniture retail																	
Oracle Rocklin	Office	X	X															
Safeway Stockton	Supermarket																X	
Solectron	Office, Manufacture	X													X			
Svenhard's	Bakery																	X
Sybase	Hi-tech office														X			
Target Antioch	Retail	X					X											
Target Bakersfield	Retail	X					X											
Target Hayward	Retail	X					X						X				X	
Walmart Fresno	Retail	X															X	

Q&A / Discussion