OpenADR 1.0 System Requirements Specification

Version: *Draft v1.0*

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Document History

Revision History

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Revision Number	Revision Date	Revision By	Summary of Changes	Changes marked
0.1	4/13/2010	Bruce Bartell	Initial draft "shell" based on OpenADE SRS	N
0.2	4/20/2010	Bruce Bartell	Updated through sections 3.2.1	N
0.2	4/30/2010	Bruce Bartell	Updated through sections 3.2.2	N
0.3	5/1/2010	Ed Koch	Scope update and comments for F2F	N
0.4	5/7/2010	Bruce Bartell	Incorporate feedback from OSG Quarterly	N
0.4	5/14/2010	Bruce Bartell	Added Integration Service Messages based on Entity, Priorities.	N
0.4	5/18/2010	Bruce Bartell	Added attributes & definitions for Priority 1 messages	N
0.5	6/11/2010	Bruce Bartell	Attributes & definitions for priorities 2,3. Revised process model to match current PAP09 Retail. Moved open items to issues/open items log.	N
0.5	6/23/2010	Bruce Bartell	Incorporated comments for Open Items log. Corrected some items in data requirements.	N
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0.6	07/06/2010	Bruce Bartell for Ed Koch.	Revised some OpenADR Comm. Spec. mappings.	N
0.6	07/09/2010	Bruce Bartell	Incorporated comments that had a resolution ad of 7/9/2010	Y
1.0	07/15/2010	Bruce Bartell	Revised messages based on notes from NAESB Phase 2 meeting.	Y
1.0	07/16/2010	Bruce Bartell	Moved Issues list to Comments document.	Y

Open Items and Issues Log

Last updated: June 23, 2010

As open items and issues are addressed in new versions of this document, they are removed from this list.

Item No.	Date	Provided By	Summary of the Issue	Status / Disposition

Contents

70 # List of Figures

1 Introduction

The Open Smart Grid Open Automated Demand Response (OpenADR)[1] is an industry-led initiative under the Open Smart Grid (OpenSG) subcommittee within the UCA International Users Group (UCAIug). The OpenADR Task Force defines systems requirements, policies and principles, best practices, and services, required for business and data requirements for standardizing control and pricing signals for Demand Response (DR) and Distributed Energy Resources (DER) as part of the Smart Grid implementation[2]. OpenADR, as an open user group forum, is developing a set of utility-ratified requirements and specifications for utilities and 3rd Parties to adopt and implement. The end-state of this effort will contribute to the development of open and interoperable Demand Response solutions.

This will be achieved by defining and making the following OpenADR related items available to the market:

- Common business processes and functional requirements
- Common architecture principles and patterns
- Common information requirements and model
- Common integration services (functional & informational)

1.1 Purpose

The purpose of this document is to provide both the functional and technical guidance and requirements needed to serve as the "rules of engagement" for messaging and data exchange to achieve interoperability. This would lead to open and interoperable components that can be delivered with different vendor products and/or solutions within the scope of OpenADR. The functional requirements will be driven by business processes and the technical requirements will be driven by desired architectural principles and best practices.

[1] The OpenADR Task Force of the Open Smart Grid Users Group acknowledges the work coordinated by the Demand Response Research Center and funded by the California Energy Commission (Energy Commission), Public Interest Energy Research (PIER) Program in development of the *Open Automated Demand Response Communications Specification*, also known as OpenADR or Open Auto-DR. For the purposes of this document the specification will be cited using the full title. The term OpenADR SRS or SRS refers to the *OpenSG OpenADR System Requirements Specification*.

[2] *Requirements Specifications for Wholesale Standard DR Signals - for NIST PAP09, Requirements Specifications for Retail Standard DR Signals - for NIST PAP09*

1.2 Scope

The SRS focuses on the requirements to support the interactions and exchange of information for the purposes of Demand Response (DR) and includes the exchanges of DR related information between various entities dealing with the Utilities, such as Independent System Operators (ISO's), Aggregators, Energy Service Providers and end use customers. The scope of OpenADR SRS includes standardizing dispatch, control and pricing signals for DR and Distributed Energy Resources (DER) as part of the Smart Grid implementation as defined in Section 1.4 External Considerations and References.

Demand Response is defined as the temporary modification of customer energy usage for a defined duration which is triggered by some condition on the grid such as reliability or market conditions. These DR events result in the exchange of "DR signals" between service providers such as Utilities, ISO's, Aggregators, ESP's, etc. and their customers. The information in the DR signals causes modifications to the end users load profiles. The requirements in the SRS are from the perspective of the enterprise systems of the service providers that are publishing the DR signals to their customers (i.e. Utility). This is in contrast to the customer's systems or perspective which is covered in other efforts such as OpenHAN and SEP. The thing that all the various efforts have in common is the need to exchange the DR related information in some standardized form. Furthermore this SRS does not cover many of the administrative aspects of managing a DR program such as measurement and verification and settlement. The SRS is focused on only those aspects of DR management that is required to facilitate the exchange of DR signals with their customers.

The SRS defines the logical components and business functions in order to identify the interfaces that must be specified to enable interoperability across different implementations, for many utilities to many 3rd Parties. It includes architectural aspects and specific requirements. The inputs include OpenADR use cases, as well as industry best practices and standards, including information models and other specifications.

1.2.1 Scope of This Release

OpenADR SRS 1.0 addresses the following functional areas:

- Direct Load Control Signals
- Dispatching of Load Profiles
- DR Related Pricing Signals
- DER applications (Limited to the context of grid-connected DR and to those DER devices that can affect load levels on the grid. Excludes injection of power and micro-grids)
- Yes, but limited to those DER devices that can affectd load levels on the grid.)
- DR Program Management (Limited to data required to support DR Signals)
    - Program and Customer Registration

- DR Resource Registration

1.2.2 Scope of Subsequent Releases

- Utility internal systems integration for DR purposes
- DR Bidding
  - DR Offer to Supply (Retail Offers)
  - DR Bid to Buy
- Forecasting

The OpenADR SRS does not include the following items that are typically a part of solution architecture. Some of them are or have been addressed by other parts of the OpenSG initiative. Others will need to be dealt with specifically for each implementation.

- Network and hardware infrastructure architecture
- Operational architecture
- Testing methodology and architecture
- Internal application architecture

1.3 Acronyms and Abbreviations

This subsection provides a list of all acronyms and abbreviations required to properly interpret the OpenSG OpenADR System Requirements Specification.

Acronym	Name
ADE	Automatic Data Exchange
ADR	Automated Demand Response
AMI	Advanced Metering Infrastructure
CIM	IEC TC57 Common Information Model
DLC	Direct Load Control
DR	Demand Response
EMS	Energy Management System
ESP	Energy Service Provider
ESI	Energy System Interface; Energy Services Interface
HAN	Home Area Network
IETF	Internet Engineering Task Force
IHD	In-Home Display
ISO	Independent System Operator
IT	Information Technology

M&V	Measurement and Verification
NERC	North American Electric Reliability Corporation
PHEV	Plug-In Hybrid Electric Vehicle
RTO	Regional Transmission Organization
RTP	Real Time Pricing
SDO	Standards Development Organization
SEP 2.0	Smart Energy Profile
SLA	Service Level Agreement
SRS	System Requirements Specification
TOGAF	The Open Group Architecture Framework

1.4 External Considerations and References

The work of the OpenADR SRS is dependent upon the requirements defined in the following sources:

- Open ADR Functional Requirements and Use Case Document (OpenSG)
- Requirements Specifications for Wholesale Standard DR Signals - for NIST PAP09
- Requirements Specifications for Retail Standard DR Signals - for NIST PAP09
- OPEN AUTOMATED DEMAND RESPONSE COMMUNICATIONS SPECIFICATION - Public Interest Energy Research (PIER), California Energy Commission
- Requirements Specifications for Common Electricity Product and Pricing Definition - for NIST PAP03
- Requirements Specifications for Common Scheduling Mechanism for Energy Transactions - for NIST PAP04
- ZigBee Smart Energy Profile™ 2.0 Technical Requirements Document
- Smart Energy Profile Specification ZigBee Profile: 0x0109 Revision 15
- Energy Information Standards (EIS) Alliance Customer Domain Use Cases
- Energy Information Standards (EIS) Alliance Customer Domain Energy Services Interface (ESI) Requirements
- Energy Interoperation Version 1.0 - © OASIS® 2010
- Smart Grid Communication Standards for Demand Response Data Requirements – (IRC) ISO/RTO Council for PAP09
- Transactional Energy Market Information Exchange (TeMIX) An Information Model for Energy Transactions in the Smart Grid - By Edward G. Cazalet, PhD on behalf of the OASIS Energy Market Information Exchange Technical Committee

The work of OpenADR SRS is dependent upon the best practices available from the following entities and standards organizations:

- IETF Internet Suite - Internet Standards, including the following
  - [RFC-793] IETF Transmission Control Protocol (TCP)
  - [RFC-791] IETF Internet Protocol (IP)
  - [RFC-2616] Hypertext Transfer Protocol -- HTTP/1.1
- [IEC-61968] IEC TC57 Working Group 14 (IEC 61968) (Common Information Model)
- [ASAP-SG-3P] Security Profile for Third Party Access (ASAP-SG)
- W3C XML, XML Schema related standards
- OASIS Web Services related standards

1.4.1 RFC 2119 Keyword interpretation

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119.

1.5 Document Overview

TOGAF 9.0 defines four architecture domains that are commonly accepted as subsets of overall enterprise architecture, all of which TOGAF is designed to support, see Figure :

- **Architecture Vision** defines overall architecture guiding principles, goals and objectives and desired traits.
- The **Business Architecture** defines the business strategy, governance, organization, and key business processes.
- The **Information Systems Architecture**, including the following.
    - The **Data Architecture** describes the structure of an organization's logical and physical data assets and data management resources.
    - The **Application Architecture** provides a blueprint for the individual application systems to be deployed, their interactions, and their relationships to the core business processes of the organization.
- The **Technology Architecture** describes the logical software and hardware capabilities that are required to support the deployment of business, data, and application services. This includes IT infrastructure, middleware, networks, communications, processing, standards, etc.

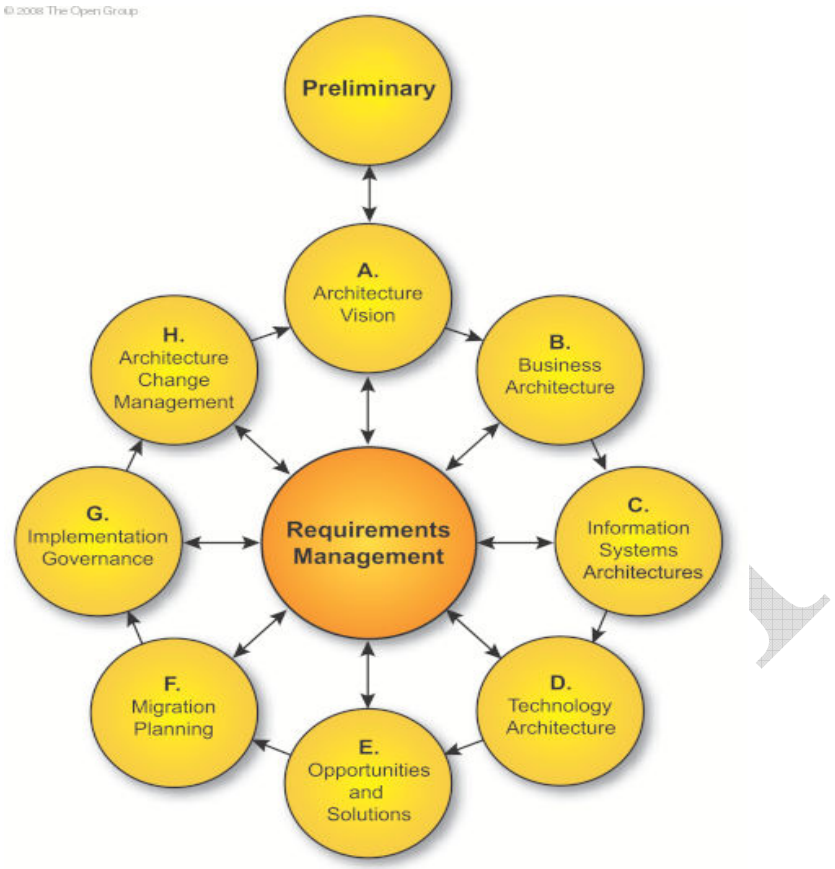

Figure 1. The Open Group Architecture Framework (TOGAF) architecture development cycle.

As such, the document will be structured as follows:

Section 2 describes the overall Architecture Vision for the system, including Guiding Principles, Architectural Considerations, and the OpenADR Reference Model, all relevant to providing a consistent framework within which the four architecture components can be developed.

Section 3 provides details on the following:

1. **Business Architecture:** This will refer to work products produced by the Use Case and Service Definition Teams of OpenADR, which includes the list of use cases and integration requirements and business services at the functional level.
2. **Data Architecture:** This provides the technical level requirements relative to how the OpenADR data should be modeled and represented consistently across all integration services to ensure semantic interoperability.
3. **Application Architecture:** This provides the technical level requirements relative to how applications are modeled as logical components, and what services each logical component may provide or consume. This should be an instantiation of the business services identified within the Business Architecture.
4. **Technology Architecture**: This provides the technical level requirements relative to how services will interact with each other to support end-to-end AMI business processes.

Section 4 contains the Appendices, which includes terms and definitions, logical components list, integration requirements list, and integration services view.

2 Architecture Vision

The Architecture Vision articulates the Architectural Goals and Principles that enables the business goals and addresses the stakeholder concerns and objectives. As stated in the Introduction, the goal is the development of open and interoperable Demand Response solutions.

Demand Response systems consist of the hardware, software and associated system and data management applications that create a communications network between end systems at customer premises (including meters, gateways, and other equipment) and diverse business and operational systems of utilities and third parties, see Figure 2.

The Demand Response system components are defined as part of the Systems Architecture later in this document. The components in Figure 2 show the controlling components the Utility Enterprise and Operational Systems that communicate with the Assets and Resources of the Customer through public or private networks.

Although not shown in the diagram below the architecture does not preclude the use of intermediaries such as aggregators or third party control companies that may receive DR signals on behalf of the end user facilities. This is discussed in more detail in section 2.1 Architectural Goals and Guiding Principles where the concepts of a Resource Energy Controller and Virtual End Node are introduced.

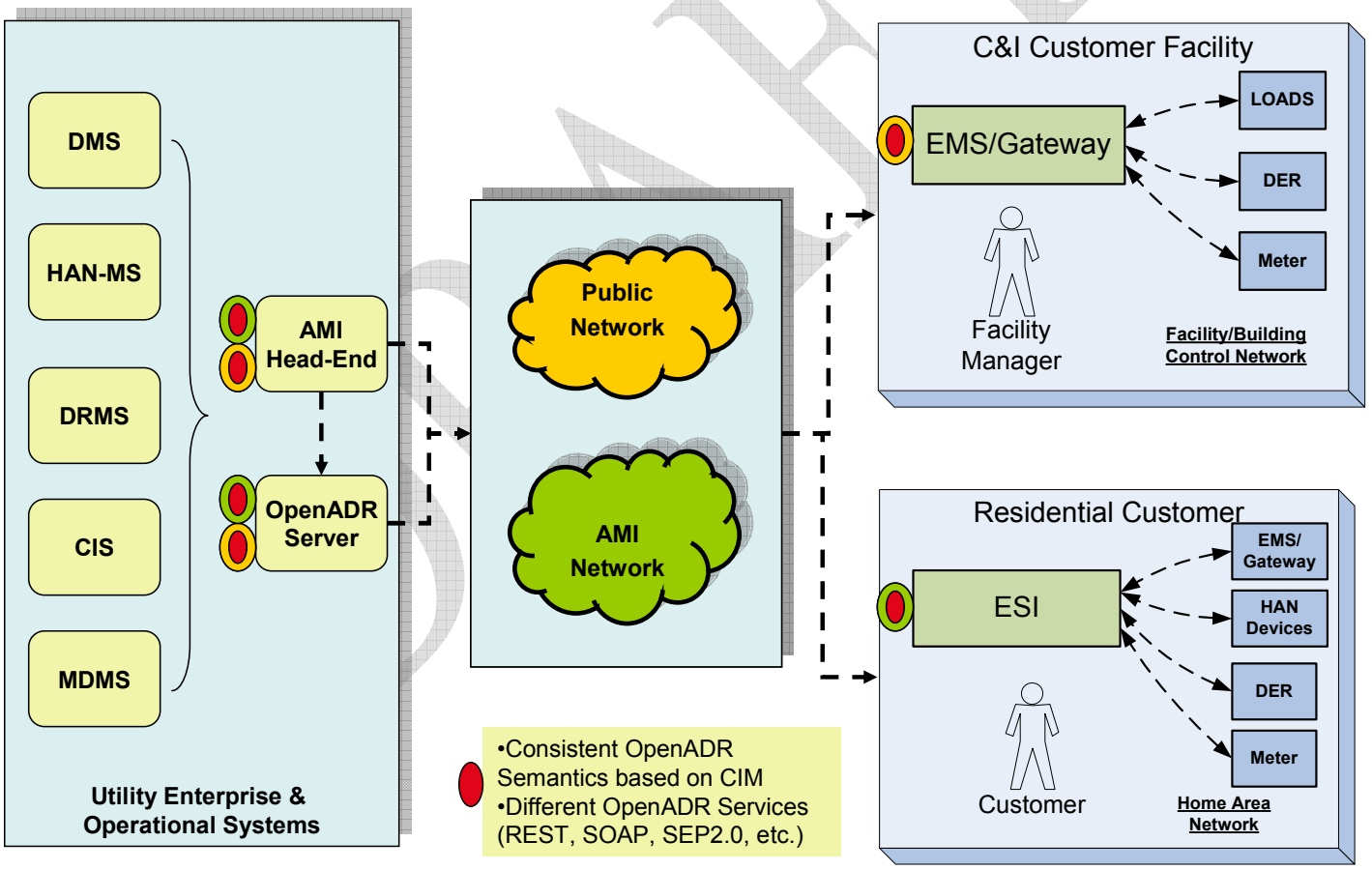

Figure 2. OpenADR SRS component diagram showing the actors and components.

Components	Description / Key Business Functions
Energy Management System	A system that helps a customer to manage their energy usage within a facility.
Energy Service Interface	Energy System Interface; Energy Services Interface

Components	Description / Key Business Functions
	Provides communications, security and, often, coordination functions that enable secure interactions between relevant Home Area Network Devices and the Utility. Permits applications such as remote load control, monitoring and control of distributed generation, in home display of customer usage, reading of additional meters (e.g. water, gas, renewables, PEVs), and integration with building management systems. Also provides auditing/logging functions that record transactions to and from Home Area Networking Devices. The ESI is assumed to have at least two interfaces: one which provides connectivity to the Home Area Network, and one which provided connectivity to the utility. (ZigBee Smart Energy Profile™ 2.0 Technical Requirements Document)
Distribution Management System	A system that manages the distribution network operations.
HAN Management System	A system that allows utilities to send messages (such as pricing, billing, usage or alarms) to customer display devices (IHDs). Manages the enrollment of devices in specific home area networks, management the enrollment of those devices in programs, manages the de-enrollment in programs and from the HAN
Demand Response Management	A system that manages the demand response programs from utility point of view. Includes load control, integration with DMS, and DR program management. Uses historical and externally input data to make predictions and what-if analysis for DR purposes
Customer Information System	A system that manages customer interaction, billing and issues resolution.

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2.1 Architectural Goals and Guiding Principles

Architecture guiding principles are rules of engagement designed to ensure that all aspects of the implementation fit within a well-defined framework. These principles, discussed and agreed upon with all stakeholders of OpenADR, are used to drive the architectural approach and patterns to be implemented. These principles should not be taken lightly as they imply what and how the overall goals of OpenADR will be met. Each of the principles has a level of effort and cost implications for utilities and 3rd Parties looking to adopt this specification. Adherence to these principles can be adjusted for specific cases driven by time and budget constraints. These exceptions should be approved by all stakeholders and must be documented.

- Exchanges of data cross enterprise boundaries
    - Industry best practices must be followed
    - The most interoperable and widely supported technologies should be used to ensure adoption regardless of development and deployment platforms used
    - The technologies chosen shall be well specified, with active communities and tools and/or frameworks available. For example, WS-I, or RESTful in conjunction with AtomPub, OData or GData.
    - Technologies chosen shall be compatible and interoperable with technologies specified for access on premise or HAN resources.
    - Security and privacy of customer information is of utmost importance, since transfers must support the secure use of public networks, and sensitive customer information may be exchanged across enterprise boundaries.
- Recommendations must promote and enable interoperability
    - Many utilities need to be interoperable with many 3rd Parties, so there are significant efficiency savings possible by defining a common interface for the OpenADR message exchanges. Therefore, recommendations must be specific and prescriptive, actionable and testable
- Must meet the goals of several different types of stakeholders
    - Requires an open process to allow discussion and negotiation of the recommendation
- Forwards and backwards version compatibility is needed
    - Existing implementations must remain operational when either side adds future extensions

2.2 Architectural Considerations

OpenADR as a system needs to be architected with requirements that cover the entire spectrum of business, technical, and market needs. The following list of architectural attributes will be used as guidelines for OpenADR systems requirements development.

- System quality attributes discernable at runtime
    - Performance - Services SHALL provide and consume data in a timely manner as defined by the requirements.
    - Security –

284 - Parties involved in any DR event SHALL be authenticated and authorized;
285 - Command/message exchanged between parties involved in any DR event SHALL be
286 secure from end to end.
287 - Results of the DR event execution SHALL be auditable.
288 - Authorization – Protected resources SHALL be authorized individually by the user(s) associated
289 with those resources.
290 - Availability – Services SHALL be highly available as defined by the requirements.
291 - Functionality – SHALL meet the functional needs of customers and regulators
292 - Usability – SHALL require only commonly available tools and technologies
293 - Scalability – SHALL be able to add additional servers to meet performance
294 - System quality attributes requiring assessment for evaluation
295 - Modifiability – SHALL allow additions without affecting existing systems
296 - Portability – SHALL be possible to implement on a variety of platforms
297 - Reusability – SHALL use standard industry object representations
298 - Integrability – SHALL be possible to map to a variety of other interfaces
299 - Testability – SHALL be possible to perform testing using a variety of methods
300 - Business Qualities
301 - Cost – SHALL not be cost-prohibitive
302 - Projected life time of the system – SHALL allow growth
303 - Qualities directly related to the architecture
304 - Conceptual integrity – Semantics of defined elements SHALL be consistent across objects that
305 use those elements
306 - Correctness and completeness - Is aligned with common application architectures and addresses
307 all considerations required for interoperability.

308 Note that desired, minimum and maximum levels for performance, availability, functionality, acceptable use, and
309 other characteristics will likely be specified and negotiated in Service Level Agreements (SLAs) between DR
310 Signal consumers and providers. Regulators may also require certain service levels. Each side will likely have
311 some number of terms required for use of their services. This is not part of the standardization effort, just a note to
312 prepare for these agreements.

3 OpenADR Systems Architecture

3.1 OpenADR Business Architecture View

The key stakeholders to be addressed by the business architecture are shown in the figure below. The stakeholders all perform business roles and represent a subset of the Actors from the use cases which fill business roles in the OpenADR business processes, as described in the *DR Functional Requirements and Use Case Document*.

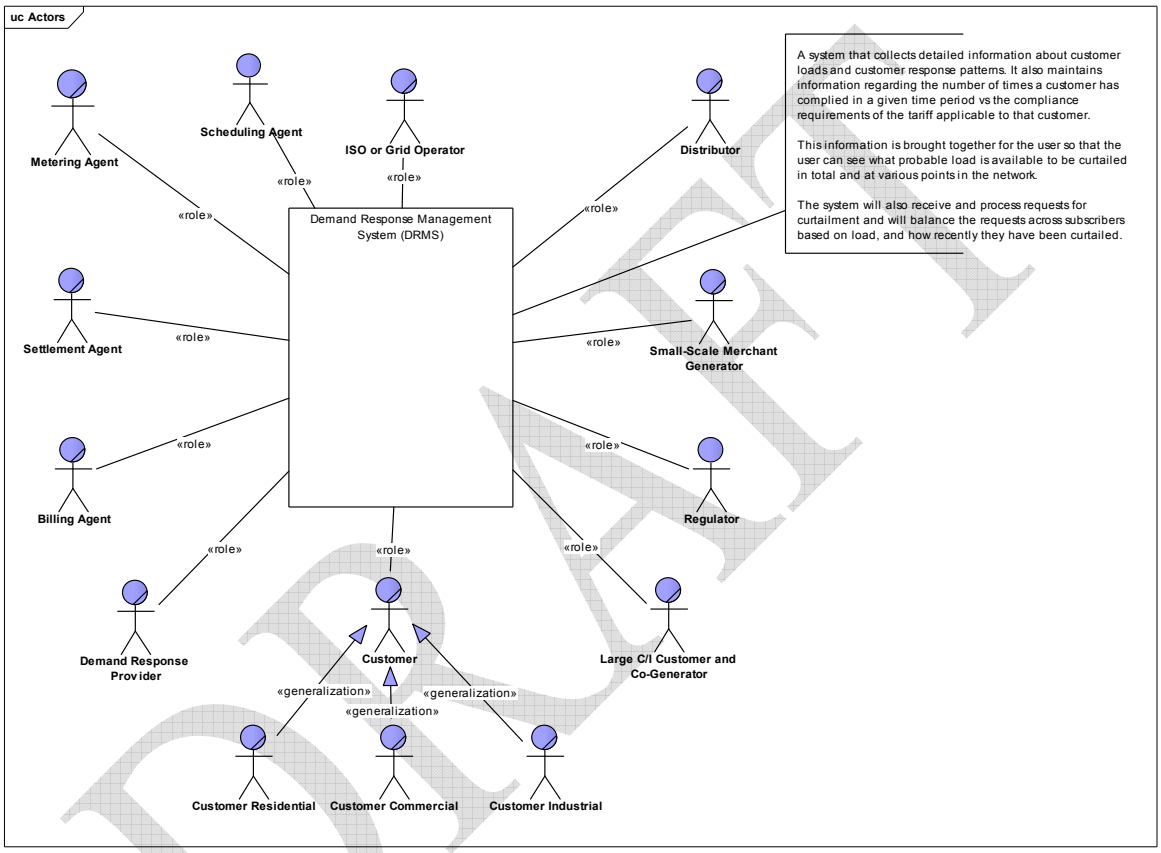


Figure 3. OpenADR Stakeholders Overview

The primary business flows include DR Program Administration, Bidding, and Execution as shown in the following diagram. The swim lanes represent business roles and the blocks within the swim lanes correspond to a business process carried out by that business role. Business roles are related to the Actors identified earlier; however, in some cases multiple different Actors may carry out the same business role. For example, an ISO/RTO, Utility Distribution Company (UDC), Load Serving Entity, or DR Aggregator can all perform the business role of Service Provider. The business processes shown are those that involve the exchange of information between business roles.

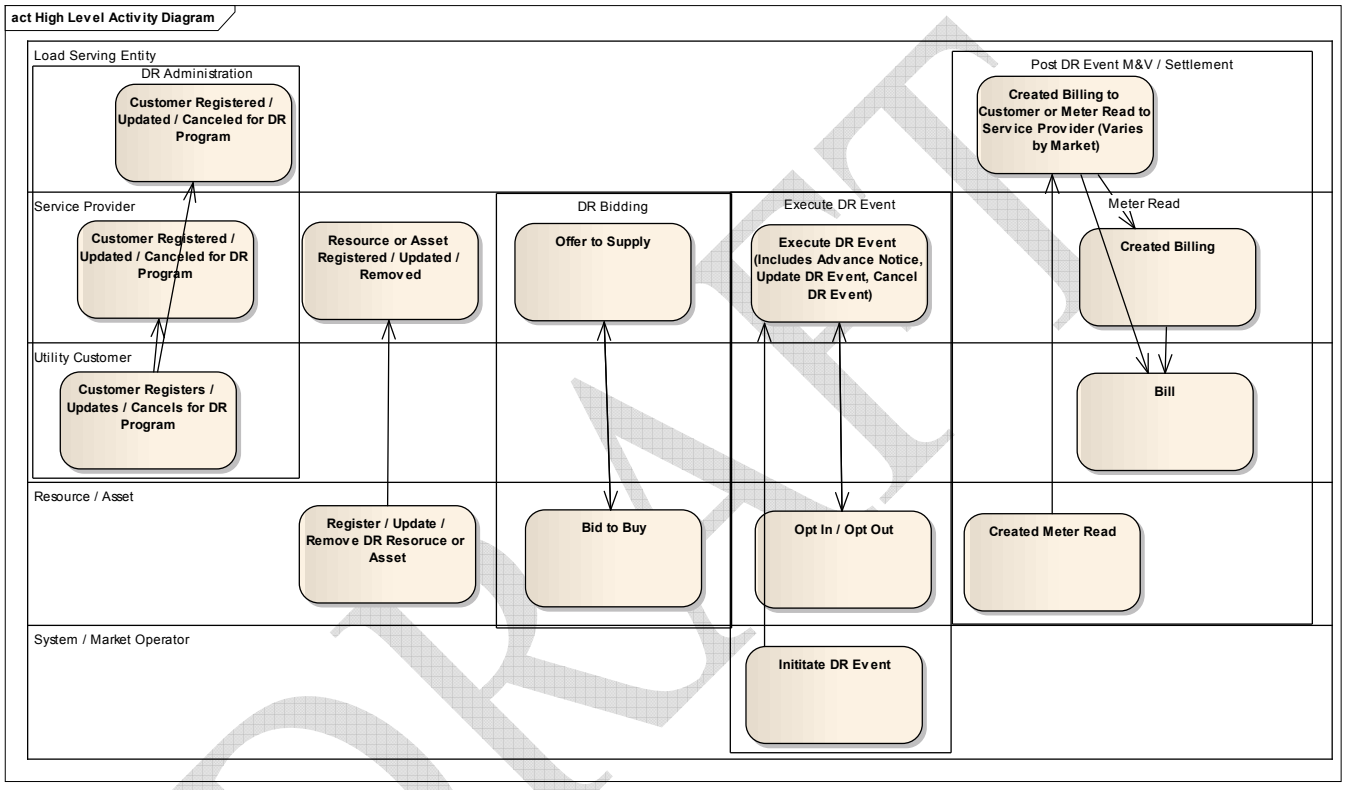


Figure 4. Overview of Business Process Flows

The Business Roles used in the Business Process Flow shown in Figure 4 are summarized from the Use Cases and represent activities performed at the business level. Section 3.2.2 Functional Requirements – Integration Services maps these business roles into integration roles as described in that section.

The Demand Response process flow is broken into four phases: DR Administration, DR Bidding, Execute DR Event, and Post DR Event Measurement and Verification / Settlement. The DR Execution processes includes DR Program types of Direct Load Control, Dynamic Price Based / Real Time Pricing, and Notification (Objectives) Based.

340 **Following is a table listing all major Business Roles that will provide some functions to support ADR**
341 **business processes.**

Business Role	Description / Key Business Functions	Map to NIST	Map to LBNL
Load Serving Entity	A role which carries the responsibility of serving end-users and selling electric energy to end-users. (PAP09 Retail dated 2/11/2010 v 1.5) The entity that is responsible for serving the Electricity Customers Electricity needs. An LSE may also perform the role of DR Aggregator. (Base Use Case)	Load Serving Entity	
Electricity Consumer	The end users of electricity. May also generate, store, and manage the use of energy. Traditionally, three customer types are discussed, each with its own domain: home, commercial/building, and industrial.	Utility Customer	Participant
Service Provider	A role which carries the responsibility of coordinating resources to deliver electricity products and services to a market or distribution operator. (Requirements Specifications for Retail Standard DR Signals - for NIST PAP09 dated 5/13/2010) The Business Role of Service Provider as used in the PAP09 Retail Use Cases is also referred to as a DR Aggregator. See "Aggregators and Curtailment Service Providers" below.	Service Provider	
DR Asset	An energy resource that is capable of shedding load in response to Demand Response Events, Electricity Price Signals or other system events (e.g. under frequency detection). Examples of Demand Response Assets are: Smart Appliances, entire buildings that are under the control of an Energy Management System, Electric Vehicles. (PAP09 Retail dated 2/11/2010 v 1.5)		
DR Resource	A DR resource is a virtual representation of one or more DR assets. It is similar to a DR Asset in that it is capable of shedding load in response to a triggering event. Unlike a DR Asset, which is autonomous, a DR Resource may consist of multiple DR Assets that have been aggregated to form a larger capacity or energy resource. An apartment building with multiple electricity consumers, each one having one or more DR Assets may be considered one large DR Resource by aggregating the total load shedding capacity of all the DR Assets in the apartment building and representing the sum total of this capacity as one DR Resource. A DR Resource may also consist of different types of Assets (e.g., a wind Turbine and an electric motor that work in combination to meet DR program obligations).		DRAS Client

Business Role	Description / Key Business Functions	Map to NIST	Map to LBNL
	(PAP09 Retail dated 2/11/2010 v 1.5)		
System and Market Operator	A System Operator is a Balancing Authority, Transmission Operator, or Reliability Coordinator whose responsibility is to monitor and control an electric system in real time (based on NERC definition). The System Operator is responsible for initiating Demand Response Events (e.g., Advance Notifications, Deployment, and Release/Recall instructions). The Market Operator manages the bulk electricity market and produces prices for various products. ISO New England and PJM Interconnection are examples of Market and System Operators that perform this function. (PAP09 Retail dated 2/11/2010 v 1.5)		

Aggregators and Curtailment Service Providers

The terminology used regarding Aggregators and Service Providers is summarized in "*Framework for Integrated Demand Response (DR) and Distributed Energy Resources (DER) Models*":

> In the organized markets (wholesale electricity markets), generally the end use customer does not participate directly in the market. An intermediary aggregates these end use customers and presents this aggregated capability to reduce consumption to the organized market. The Federal Energy Regulatory Commission (FERC) refers to these entities as Aggregators of Retail Customers (ARC), and these entities are also called curtailment service providers (CSP) or Demand Response provides (DRP) in the wholesale market place. Local distribution companies (LDC) may also aggregate retail customers for Demand Response and present these curtailments to the wholesale market. The ARC, CPS, DRP and LDC are wholesale market participants and may provide various services to the wholesale market based on the specific market rules.

For the purposes of this specification, the term DR Aggregator is synonymous with an ARC or CSP.

3.2 Integration Requirements Specification

3.2.1 Functional Requirements – Business Processes

The business processes that have been developed as part of OpenADR are listed as follows. Note that the requirements documents summarized in section 1.4 External Considerations and References contain the details of each business process (use case).

The following requirements are identified based the use cases defined in *Requirements Specifications for Retail Standard DR Signals - for NIST PAP09.*

- Administrate Customer for DR (Limited to data required to support DR Signals)
  - Register / Enroll Customer for DR Program
  - Remove Customer from DR Program
- Administrate DR Resource (Limited to data required to support DR Signals)
  - Administrate Distribution DR Resource
  - Update DR Resource
  - Register DR Resource
- Administrate DR Asset (Direct Load Control)
  - Register DR Asset
  - Update DR Asset
  - Remove DR Asset
- DR Bidding
  - DR Bid to Supply (Retail Offers)
  - DR Bid to Buy
- Execute DR Event
  - Notify DR Event
    - Advanced Notification for DR
    - Update a DR Event
    - Cancel a DR Event
    - DR Resource Confirmation
  - Dispatch DR Objectives

- DR Direct Load Control
  - Monitor DR Event (DR Resource)
  - Monitor DR Event (DR Asset)
- DR Real Time Pricing (RTP)

- Operational Coordination
  - Post DR Event Management (out of scope, handled by other groups: AMI-ENT and M&V Settlement Standards)
  - Post DR Event M&V / Settlement (No Open Retail)
  - Post DR Event M&V / Settlement (Open Retail)

3.2.2 Functional Requirements – Integration Services

3.2.2.1 Logical Components

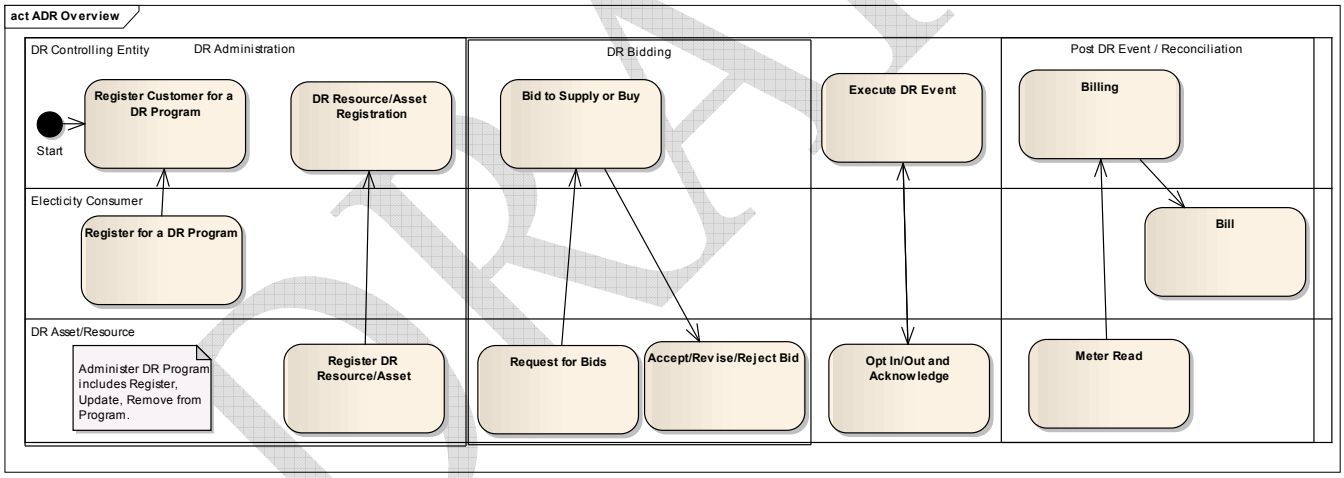
Logical Components are used in this document to organize interfaces (integration services) for OpenADR. These logical components represent IT systems which exchange information to carry out the business processes and implement the use cases identified earlier. They may be mapped to specific physical components for a particular implementation. The Logical Components in some cases consolidate multiple Business Roles/Actors to represent entities which perform a common integration role in exchanging information. For example, a DR Controlling Entity is a generalized actor class which represents all the different entities that may need to manage and interact with wholesale and/or retail DR resources. It represents actors such as an ISO/RTO, Distribution Company, Load Serving Entity, and DR Aggregator.

Following is a table listing all major logical components that will provide some functions to support ADR business processes. All services will be organized accordingly.

Logical Components	Description / Key Business Functions	Map to NIST	Map to LBNL
Electricity Consumer	The end users of electricity. May also generate, store, and manage the use of energy. Traditionally, three customer types are discussed, each with its own domain: home, commercial/building, and industrial.	Utility Customer	Participant
DR Asset Owner	The entity that is responsible for the DR Resource or Asset in the retail market.		
DR Controlling Entity	This is a generalized actor class and represents all the different entities that may need to manage and interact with wholesale and/or retail DR resources. It includes the following actors: ISO/RTO, Distribution Company, Load Serving Entity, DR Aggregator. (PAP09 Retail dated 2/11/2010 v 1.5)		DRAS - Demand Response Automation Server
DR Asset	An energy resource that is capable of shedding load in response to Demand Response Events, Electricity Price Signals or other system events (e.g. under frequency detection). Examples of Demand Response Assets are: Smart Appliances, entire buildings that are under the control of an Energy Management System, Electric Vehicles. (PAP09 Retail dated 2/11/2010 v 1.5)		
DR Resource	A DR resource is a virtual representation of one or more DR assets. It is similar to a DR Asset in that it is capable of shedding load in response to a triggering event. Unlike a DR Asset, which is autonomous, a DR Resource may consist of multiple DR Assets that have been aggregated to form a larger capacity or energy resource. An apartment building with multiple electricity consumers, each one having one or more DR Assets may be considered one large DR Resource by aggregating the total load shedding capacity of all the DR Assets in the apartment building and		

Logical Components	Description / Key Business Functions	Map to NIST	Map to LBNL
	representing the sum total of this capacity as one DR Resource. A DR Resource may also consist of different types of Assets (e.g., a wind Turbine and an electric motor that work in combination to meet DR program obligations). (PAP09 Retail dated 2/11/2010 v 1.5)		
System and Market Operator	A System Operator is a Balancing Authority, Transmission Operator, or Reliability Coordinator whose responsibility is to monitor and control an electric system in real time (based on NERC definition). The System Operator is responsible for initiating Demand Response Events (e.g., Advance Notifications, Deployment, and Release/Recall instructions). The Market Operator manages the bulk electricity market and produces prices for various products. ISO New England and PJM Interconnection are examples of Market and System Operators that perform this function. (PAP09 Retail dated 2/11/2010 v 1.5)		

405 The following figure represents the Business Process Flows consolidated using the Logical Components.



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407 **Figure 5. Overview of Business Process Flows Using Logical Components.**

The following diagram shows the logical components involved in data exchanges. The exchanges are identified at a high level in order to show the major types of functions carried out.

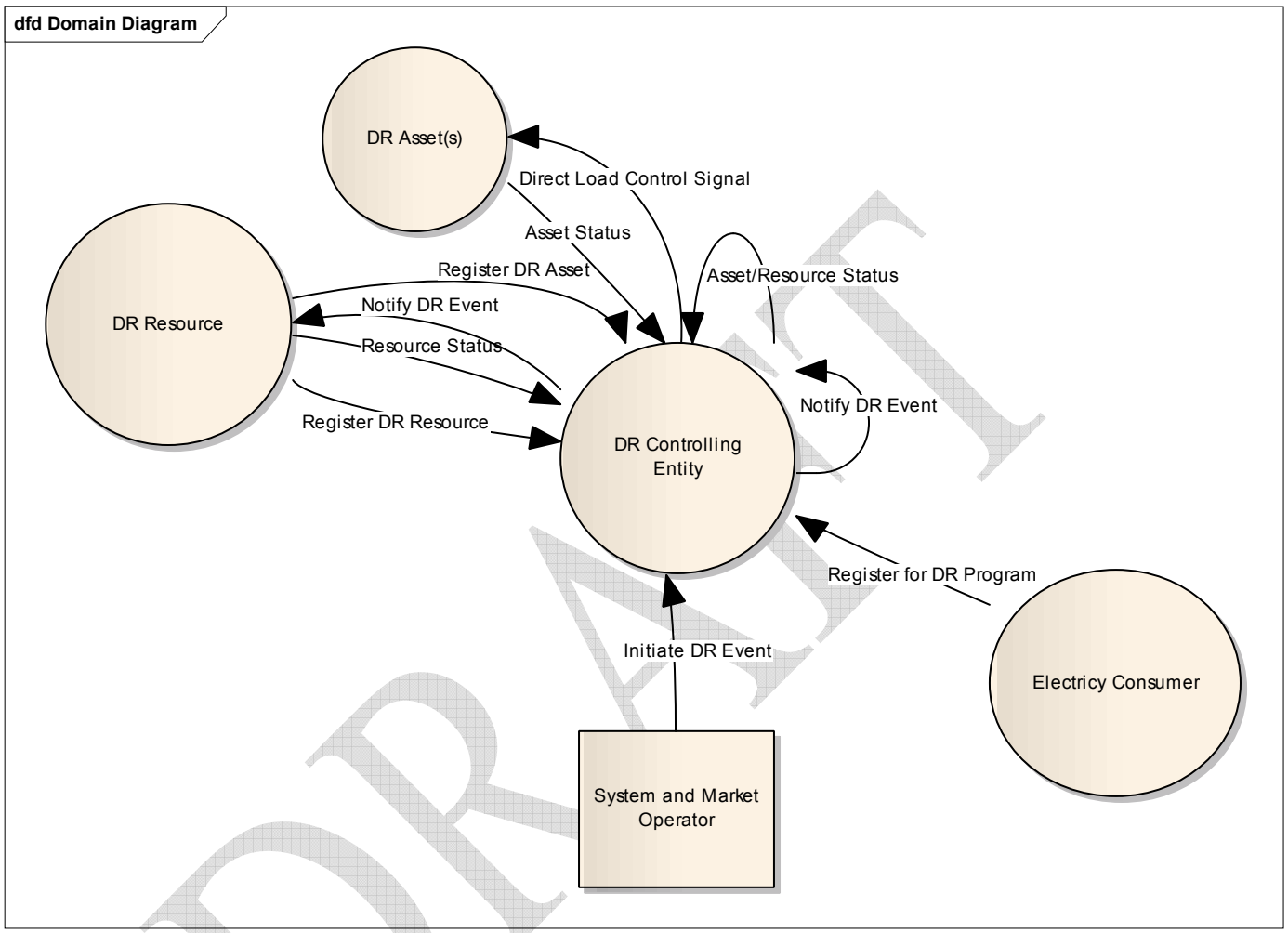

Figure 6. Overview diagram of Logical Components

Note that a DR Controlling Entity may represent a single Actor, such as a Utility Distribution Company in the business role of a Load Serving Entity. However, a DR Controlling Entity may also represent a hierarchy of entities, such as an ISO/RTO dispatching DR instructions to a Transmission Operator, who in turn sends the dispatch instructions on to a UDC, who sends instructions to a DR Aggregator, who then directs a specific DR Resource to execute the instruction. This can be modeled as a recursive relationship with DR Controlling Entity which represents each of these Actors in an integration role. The goal is to minimize the number of different logical components and hence the number of different services and message payloads that need to be defined through reuse of the standard services and payload definitions.

This concept is elaborated more extensively in a recent EPRI report titled *Concepts to Enable Advancement of Distributed Energy Resources.* This approach is made possible as we shift from designing *control* systems which issue direct load controls to system viewed as a grid resource which "has the ability to handle to handle a situation

in an effective manner"[3], where the "how" of the response is replaced by a description of the situation requiring a change in energy consumption, leaving it to the final DR Resource to know how to control DR Assets to effect the desired change in energy use. The concept put forward by the EPRI report is called the REC-VEN concept, where the REC (Resource Energy Controller) determines when and why to send specific grid messages to the resources it manages, which are represented as a VEN (Virtual End Node). A VEN can in turn also function as a REC to another VEN which is lower down in the control hierarchy.

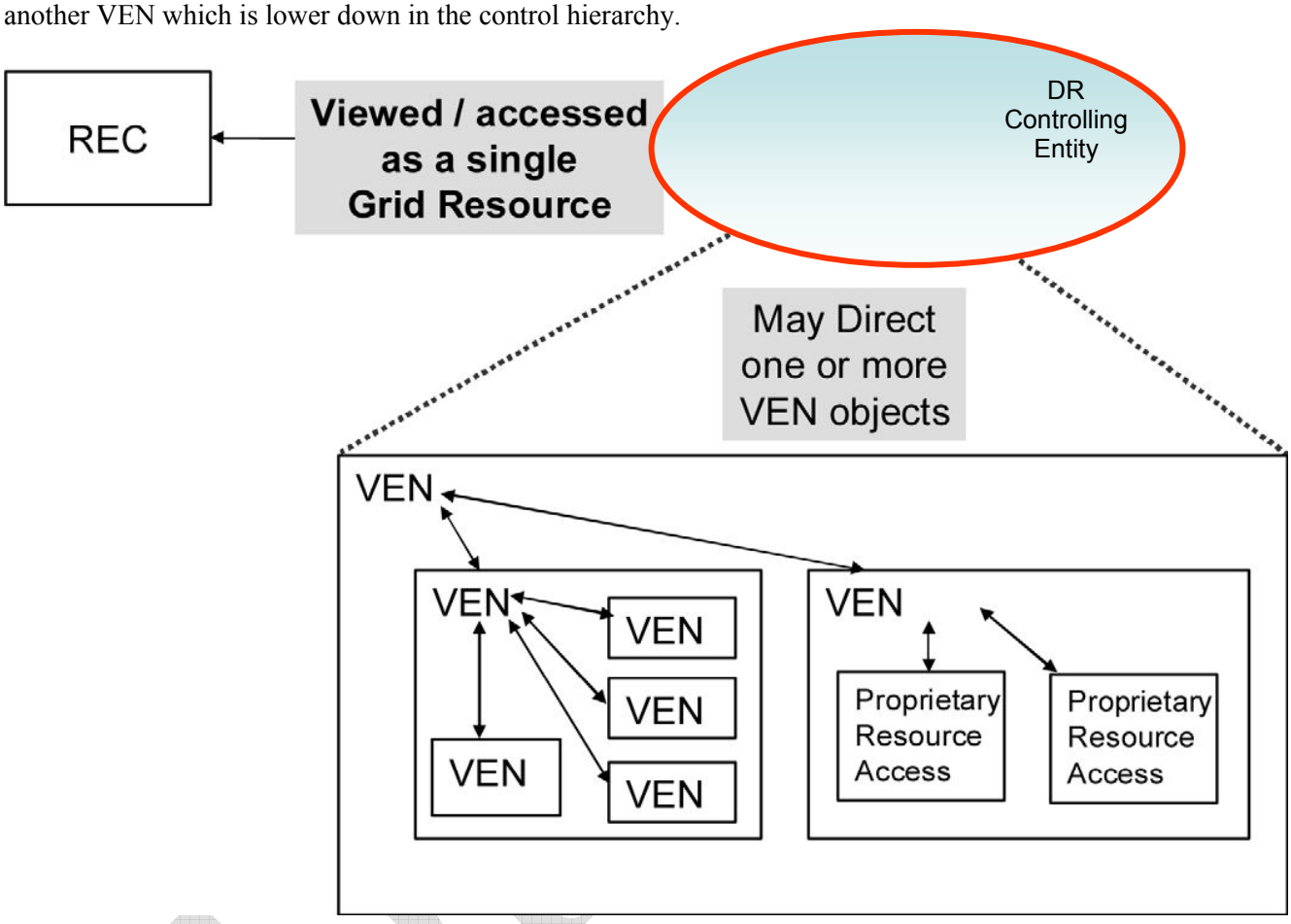

Figure 7. REC-VEN Operations, adapted from: *Concepts to Enable Advancement of Distributed Energy Resources: White Paper on DER*. EPRI, Palo Alto, CA : 2010. 1020432

In the diagram above, the DR Controlling Entity can be thought of as a VEN-REC object, thus representing all the entities in series from the System and Market Operator to the DR Resource. This is modeled by adding a recursive relation to a DR Controlling Entities, so that the DR Controlling Entity in the diagram represents one or more entities. This approach ensures a scalable architecture for all future Smart Grid developments.

[3] Concepts to Enable Advancement of Distributed Energy Resources: White Paper on DER. EPRI, Palo Alto, CA : 2010. 1020432

3.2.2.2 Integration Services

The following Integration Services were derived from the Use Cases, Business Processes, and Functional Specifications documents defined earlier (Section 3.2.1) and represent the services needed to carry out the necessary data exchanges between logical components. The data required for the data exchange is defined in Section 3.4.1 Data Architecture View.

Specific Service Operations and Resource Patterns are defined as part of the OpenADR Service Definition document and the associated artifacts. The operations are defined based on the methods defined in Section 3.4 OpenADR Data Architecture View.

A detailed list of individual messages in Use Case Context is provided in Section 4.2.

Use Case Scenario	Service Name	Provider	Functional Description of the Service	Priority
Administrate Customer for DR	DR Customer Agreement	DR Controlling Entity	Customer is Registered for, Updated or Removed from a DR Program.	3
Administrate DR Resource	DR Resource	DR Resource Owner	DR Resource is registered and associated with a DR Program and Customer. The Resource is updated and/or removed from DR Program.	2
Administrate DR Asset	DR Asset	DR Asset Owner	DR Asset is registered and associated with a DR Resource. The Resource is updated and/or removed from DR Program.	2
Execute DR Event	Notify DR Event	DR Controlling Entity	DR Event information is sent to participants prior to the DR Event start based on defined intervals and is Updated, and/or Canceled.	1
Execute DR Event	DR Event	DR Controlling Entity	DR Event is a polymorphic message type that supports Direct Load Control, DR Instructions (Objectives), Price Schedule	1
Execute DR Event – Operational Coordination	Forecast Demand	DR Controlling Entity	Multiple levels of aggregated DR Demand and Telemetry data is provided for the purpose of coordinating a DR Event and to provide checks against circuit limits.	6
Execute DR - Event Monitoring / Confirmation	Asset / Resource Status (State)	DR Resource or Asset	The DR Resource or Asset (in the event of DLC) provides status for opt in / out or other state that impacts Demand Response. The Status message may be as a confirmation reply to a DR Signal or as an update resulting from a state/status change or in response to a Get message.	1
Post DR Event – M&V / Settlement	Meter Read & Billing		The process and messages used for settlement of a DR event are the same as defined in the ***Utility AMI AMI-ENT System Requirements Specification***, Utility AMI-ENT Task Force. The meter read interval is determined by the interval of DR Event participation.	4
DR Bidding				5

3.2.3 Technical Requirements – Integration Services

Integration services that are well defined, understood and managed are the linchpin of an open and interoperable implementation between the utility enterprise and other business entities. Following is a list of guiding principles for integration services design:

- Common protocol and business semantics SHALL be used to achieve loose coupling of end-point service (directly or indirectly)
- Services SHALL be representative of a unique unit of work and reusable across business functions.
- Services SHALL be reusable across common practices of utilities.
- Service design SHALL be driven by business requirements and reflected in the architecture.
- Service design SHALL be governed with a common approach and framework to achieve conceptual integrity.
- Service level agreement should be defined to support key architecture qualities: security, reliability, performance, availability, scalability, data quality, information fidelity, etc.

3.3 OpenADR Application Architecture View

1. Audit information SHOULD be maintained, so that a report could be produced containing details (who, what, when, etc.) about authorizations, transfers, and other significant events.
2. OpenADR Application Architecture SHALL provide measures that protect and defend information and information systems by ensuring their availability, integrity, authentication, confidentiality, and non-repudiation.

3.4 OpenADR Data Architecture View

Based on OpenADR use cases, the following data objects have been identified. The OpenADR services SHALL implement methods to make requests related to these objects.

- DR Customer Enrollment
  - Register Customer for DR Program
  - Update Customer for DR Program
  - Remove Customer from DR Program
- DR Asset (End Device)
  - Register Asset for DR Program
  - Update Asset for DR Program
  - Remove Asset from DR Program
- DR Resource (Device Group)
  - Register Resource for DR Program
  - Update Resource for DR Program
  - Remove Resource from DR Program
- Notify Demand Response Event
  - Advance Notification
  - Update Event
  - Cancel Event
- Demand Response Event
  - Types:
    - Direct Load Control Signal
    - Demand Response Instructions / Objectives (DR Dispatch)
    - Price Signal / Schedule
  - Updates
  - Cancel
- Forecast Demand (out of scope)
- Asset / Resource Status (Monitor Demand Response Event)
  - Response to Signal
  - Get Status/State
  - Continuous Response

3.4.1 Temporal Model of a DR Event

An Event consists of the time periods, deadlines, and transitions during which Demand Resources perform. A DR Event Schedule a Notification Period, Active Event Period, Ramp Period and Recovery Period. The Ramp Period is considered part of the Active Event Period. A DR Event can be partitioned into a continuous block of consecutive time periods called intervals. Events can also be open-ended. i.e. a Start Time without duration or end-time.

An instance of DR instructions represents a specific type of instruction that was defined specifically for the DR program and is effective for a specific interval or open-ended. Each type of instruction may have a schedule of values that are valid across the entire period for which the DR event is active. Therefore, a single type of instruction may have multiple values, each of which are valid during a different time period during the event.

The Temporal Model of a DR Event is shown in Figure 8 below (Based upon OpenADR model).

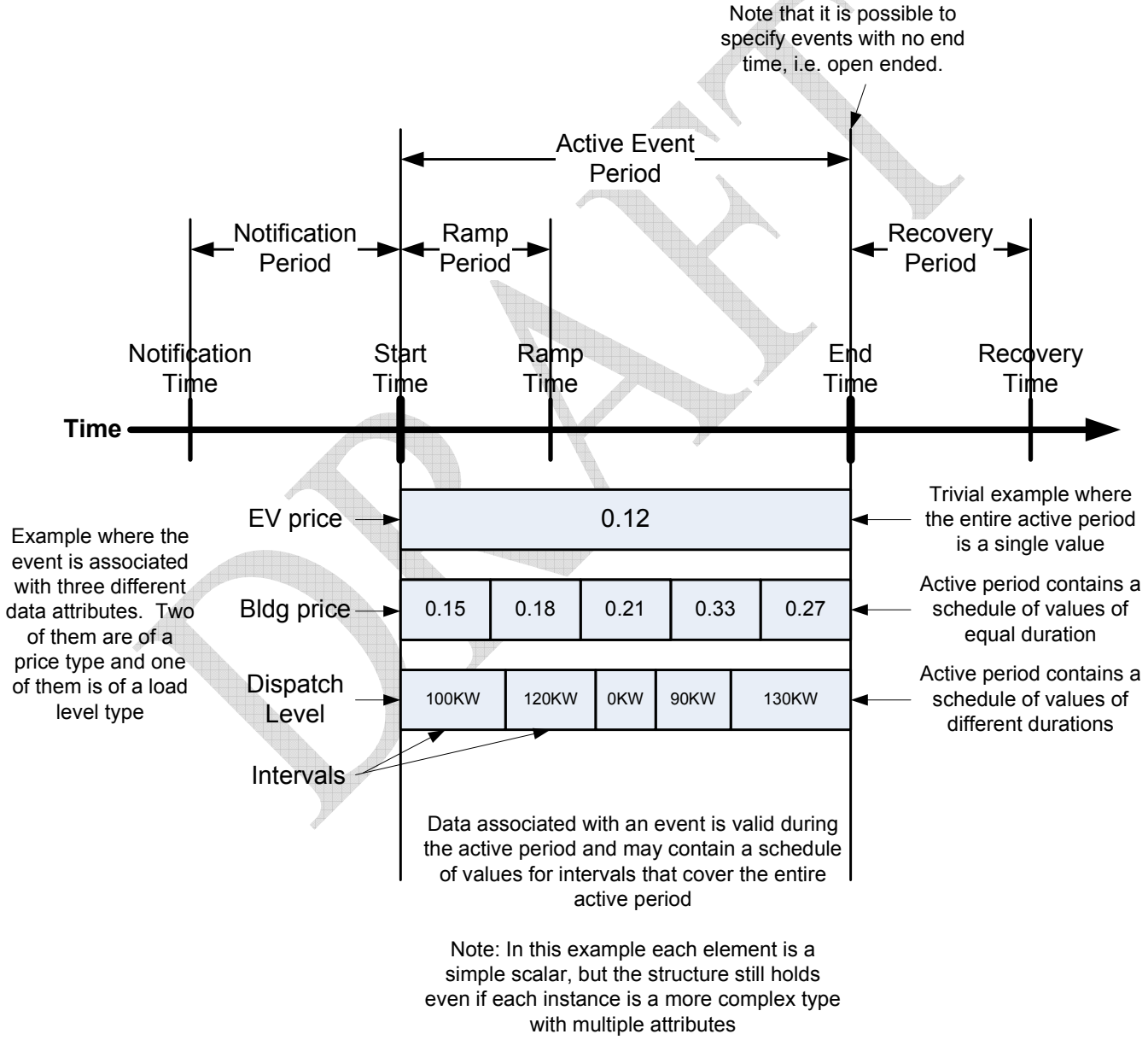

Figure 8. Temporal Model of a DR Event and its Associated Data

3.4.2 DR Event - Data Requirements

A DR Event data object is used to initiate a DR Dispatch types of Price Plus, Objectives, and Direct Load Control. An Event consists of the time periods, deadlines, and transitions during which Demand Resources perform. (PAP09 Wholesale)		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[4]**	**Map to SEP 2.0 TRD**
	All DR Events				
DR Program Name	An identifier of the program for which a DR event was issued.	DR Program Name	Program Name	EventState.programName	DR event name
Service Provider ID	An identifier for the Service Provider issuing the DR event.	Service Provider ID	(System Operator)	EventState.drasName	
Event ID	An identifier for the DR event that was created when the DR event was first issued.	Event ID	Event ID	EventState.eventIdentifier	DR event ID
Event Modification Number	A modification number for the DR event. This is used to indicate if the DR Event has been modified by the Utility. Each time it is modified, this number is incremented.	Event Modification Number	n/a	EventState.eventModNumber	
Test Event Flag	This attribute signifies whether this is a test event or not. Test events may be issued by the Utility/ISO like other DR Events.	Test Event Flag	Deployment Type=test or Audit	EventState.testEvent	
Simple Signal Levels	Used as an alternate and simplified representation of the DR signal, whether it be price based or a dispatch. Takes on a small number of finite levels such as NORMAL, MODERATE, and HIGH, SPECIAL		n/a	EventState.simpleDRModeData.OperationModeValue EventState.simpleDRModeData.OperationModeSchedule	
	All Price Plus Information Dispatches				

[4] Abbreviation for *OPEN AUTOMATED DEMAND RESPONSE COMMUNICATIONS SPECIFICATION*

A DR Event data object is used to initiate a DR Dispatch types of Price Plus, Objectives, and Direct Load Control. An Event consists of the time periods, deadlines, and transitions during which Demand Resources perform. (PAP09 Wholesale)		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[4]**	**Map to SEP 2.0 TRD**
DR Dispatch Type (for Price Plus)	Identifies the type of the DR Price Plus Dispatch. PRICE_ABSOLUTE - Price number PRICE_RELATIVE - Change in price PRICE_MULTIPLE - Multiple of current price	Instruction Type	n/a Retail only for now	EventState.drEventData.eventInfoInstances.eventInfoTypeID EventState.DrEventData.eventInfoInstances.eventInfoName	
	All Price Plus Information Intervals				
Currency	Identifier used to interpret the price element. MUST follow ISO 4217 standard.	Currency			
Price	Expressed in decimal notation with a precision up to 6 decimal places. Prices MAY be either positive or negative. Single or multiple valued price (e.g., for energy, demand, etc.)	Price		EventState.DrEventData.eventInfoInstances.eventInfoValues.value	
Unit-of-Measure	Indicates the unit of measure for which the price pertains. MUST be complaint with the International System of Units as defined by NIST SP 330, ref: http://physics.nist.gov/Pubs/SP330/sp330.pdf Examples of NIST compliant units of measure include: kWh MWh	Unit-of-Measure	type of attribute	EventState.DrEventData.eventInfoInstances.eventInfoTypeID	
Duration	The amount of time for which this price is valid, commencing at the Effective-Date-Time specified. A value of zero means price is valid until next price broadcast override. Specified in decimal notation where integers represent minutes and decimals represent fractions of minutes.	Duration	Uses Start and End Times		

A DR Event data object is used to initiate a DR Dispatch types of Price Plus, Objectives, and Direct Load Control. An Event consists of the time periods, deadlines, and transitions during which Demand Resources perform. (PAP09 Wholesale)		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[4]**	**Map to SEP 2.0 TRD**
Effective-Date-Time	The date and time which the price is in effect. In ISO 8601 standard format. The date and time interval which the price is in effect.	Effective-Date-Time	Start Time	EventState.drEventData.startTime/endTime/notificationTime EventState.DrEventData.eventInfoInstances.eventInfoValues.timeOffset	
Location Identifier	An identifier used to indicate an area which this price is in effect. A value of "null" indicates that the price is in effect for all areas.	Location			

A DR Event data object is used to initiate a DR Dispatch types of Price Plus, Objectives, and Direct Load Control. An Event consists of the time periods, deadlines, and transitions during which Demand Resources perform. (PAP09 Wholesale)		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[4]**	**Map to SEP 2.0 TRD**
Location-type	A value used to interpret the value contained in the Location element. Examples of Location-type include: Address Zone GPS Coordinates Grid Location / USNG Electrical Node Zip-code	Location-type	Address1 Address2 City Facility State/Province Facility Zip/Postal Code Facility Country GPS Coordinates Weather Station Zone ID Zone (from CIM) Electrical Node ID Electrical Node Name Electrical Node Type PNode PNode ID Competitive Choice Area		
Product Type	Identifies the type of product to which this price pertains. Contains an enumeration of various products that may be offered. Extensibility MUST be supported in order to accommodate multiple jurisdictions and markets. Product types include the following: energy, regulation, spinning reserve.	Product-Identifier	Program ID & Program Name		

A DR Event data object is used to initiate a DR Dispatch types of Price Plus, Objectives, and Direct Load Control. An Event consists of the time periods, deadlines, and transitions during which Demand Resources perform. (PAP09 Wholesale)		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[4]**	**Map to SEP 2.0 TRD**
	All DR Objective Dispatches				
DR Dispatch Type (for Objectives)	Identifies the type of DR Objectives: • LOAD_LEVEL • LOAD_AMOUNT • LOAD_PERCENTAGE	Dispatch Instructions	Deployment MegaWatts	EventState.DrEventData.eventInfoInstances.eventInfoTypeID EventState.DrEventData.eventInfoInstances.eventInfoName	
	All DR Objective Intervals				
Interval Start Time	Start time of the dispatch interval.	Event Schedule	Event Day Event Start Time Event End Time	EventState.drEventData.startTime EventState.drEventData.eventInfoInstances.eventInfoValues.timeOffset	
Interval Duration	Period of time the Control Command is in effect.		Use Start/End		
	All DR Load Level Objective Intervals				
Load Level Value	Value of the load level to be achieved based on a set of enumerated values. (i.e. moderate, high, etc)	Dispatch Instructions	n/a	EventState.drEventData.eventInfoInstances.eventInfoValues.value	
	All Load Amount Level Objective Intervals				
Load Amount Value	Fixed amount of load to shed in kW.	Dispatch Instructions	Energy Schedule or Ancillary Service Product Schedule	EventState.drEventData.eventInfoInstances.eventInfoValues.value	

A DR Event data object is used to initiate a DR Dispatch types of Price Plus, Objectives, and Direct Load Control. An Event consists of the time periods, deadlines, and transitions during which Demand Resources perform. (PAP09 Wholesale)		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[4]**	**Map to SEP 2.0 TRD**
	All Load Percentage Objective Intervals	Dispatch Instructions			
Load Percent Value	Percentage of load to shed.	Dispatch Instructions	Deployment MegWatts as percentage.	EventState.drEventData.eventInfoInstances.eventInfoValues.value	Average Load Adjustment Percentage (expressed as signed integer, e.g -10 is 10% reduction from average load)
	All Direct Load Control Dispatches Direct Load Control is a Dispatch type that requests an Asset to be in a specific state.				
DR Dispatch Type	Identifies the objective type as Direct Load Control.	DR Dispatch Type	n/a		
DR Asset ID	An identifier of the DR Asset for which the control is intended.	DR Asset ID	n/a	EventState.drasClientID	HAN Device ID
Status Check	A signal to require the DR resource status to be sent back.	Status Check	n/a		SEP 2.0 Req[DRLC-3] No specific data requirement
	All Direct Load Control Intervals		n/a		

A DR Event data object is used to initiate a DR Dispatch types of Price Plus, Objectives, and Direct Load Control. An Event consists of the time periods, deadlines, and transitions during which Demand Resources perform. (PAP09 Wholesale)		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[4]**	**Map to SEP 2.0 TRD**
Direct Load Control Type	The type of DR Direct Load Control Command: e.g. Set Point Open/Close Heating Temperature -offset/setpoint Cooling Temperature -offset/setpoint Load adjustment offset	DR Control Command			Heating Temperature (offset/ setpoint), Cooling Temperature (offset/ Setpoint), Load adjustment offset
Direct Load Control Value	Value associated with the Direct Load Control Type.	DR Control Command			
Interval Start Time	Start time of the dispatch interval.	Event Schedule		EventState.drEventData.startTime/endTime/notificationTime EventState.drEventData.eventInfoInstances.eventInfoValues.timeOffset	DR event start date/time
Interval Duration	Period of time the Control Command is in effect.				DR event duration
Duty cycle	"Duty Cycle (optional): Defines the maximum On state duty cycle as a percentage of time. Example, if the value is 80, the device would be in an "on state" for 80% of the time for the duration of the event. Range of the value is 0 to 100. A value of 0xFF indicates the field is not used."[5]				Duty cycle

[5] *Smart Energy Profile Specification ZigBee Profile: 0x0109 Revision 15*, December 1, 2008

A DR Event data object is used to initiate a DR Dispatch types of Price Plus, Objectives, and Direct Load Control. An Event consists of the time periods, deadlines, and transitions during which Demand Resources perform. (PAP09 Wholesale)		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[4]**	**Map to SEP 2.0 TRD**
Event control	Event Control options for randomized start or end times: 1= Randomize Start time, 0=Randomized Start not Applied 1= Randomize End time, 0=Randomized End not Applied. 5				Event control
Criticality Level	This field defines the level of criticality of this event. The action taken by load control devices for an event can be solely based on this value, or combination with other Load Control Event fields supported by this device. For example, additional fields such as Average Load Adjustment Percentage, Duty Cycle, Cooling Temperature Offset, Heating Temperature Offset, Cooling Temperature Set Point or Heating Temperature Set Point can be used in combination with the Criticality level. **Criticality Level Level Description Participation** 0 Reserved 1 Green Voluntary 2 1 Voluntary 3 2 Voluntary 4 3 Voluntary 5 4 Voluntary 6 5 Voluntary 7 Emergency Mandatory 8 Planned Outage Mandatory 9 Service Disconnect Mandatory 0x0A to 0x0F Utility Defined Utility Defined 5				Criticality Level

A DR Event data object is used to initiate a DR Dispatch types of Price Plus, Objectives, and Direct Load Control. An Event consists of the time periods, deadlines, and transitions during which Demand Resources perform. (PAP09 Wholesale)		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[4]**	**Map to SEP 2.0 TRD**
Device Class	Bit encoded field representing the Device Class to apply the current Load Control Event. 0 HVAC compressor or furnace 1 Strip Heaters/Baseboard Heaters 2 Water Heater 3 Pool Pump/Spa/Jacuzzi 4 Smart Appliances 5 Irrigation Pump 6 Managed Commercial & Industrial (C&I) loads 7 Simple misc. (Residential On/Off) loads 8 Exterior Lighting 9 Interior Lighting 10 Electric Vehicle 11 Generation Systems 12 to 15 Reserved Footnote: [5]				Device Class

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3.4.3 Notify DR Event - Data Requirements

Notify DR Event is an advance notification of a DR Event on a day-ahead or hour-ahead basis. Advance notification-based DR is used for economic purposes and reliability events when the system operator expects a contingency or operating condition (e.g., congestion or planned outage) on the distribution or the transmission grid that requires a reduction (or an increase) on the load at a given location.		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[6]**	**Map to SEP 2.0 TRD**
	Notify DR Event includes all of the elements of Event with the following additional elements.				
Event Status	Gives the current status of an upcoming or active event.		n/a	EventState.simpleDRModeData.EventStatus FAR, NEAR, ACTIVE	
Event Modification Number .	This is Modification number of the DR event. It is used to indicate that the DR Event has been modified by the Utility. Each time a DR Event is modified, this number is incremented.	Event Modification Number	Event Status	EventStateventModNumber	
Modification reason code	The reason the event was modified.	Modification reason code			
Cancellation reason code	The reason the event is being cancelled.	Cancellation reason code	n/a		DR event cancel control
(Cancel) Effective date/time	The date and time a cancellation takes effect.	(Cancel) Effective date/time	n/a		Cancel effective date/time
Baseline Dates	Dates of days used to calculate the Energy Baseline		Baseline Dates		
Baseline Exclusion Dates	Dates of days Excluded from the calculation of the Energy Baseline		Baseline Exclusion Dates		
Energy Baseline Value	Calculated Energy Baseline		Energy Baseline Value		

[6] Abbreviation for *OPEN AUTOMATED DEMAND RESPONSE COMMUNICATIONS SPECIFICATION*

Notify DR Event is an advance notification of a DR Event on a day-ahead or hour-ahead basis. Advance notification-based DR is used for economic purposes and reliability events when the system operator expects a contingency or operating condition (e.g., congestion or planned outage) on the distribution or the transmission grid that requires a reduction (or an increase) on the load at a given location.		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[6]**	**Map to SEP 2.0 TRD**
Energy Baseline Timestamp	Timestamp of Energy Baseline		Energy Baseline Timestamp		
Reporting Interval	Interval size required for Reporting		Reporting Interval		

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3.4.4 Asset / Resource Status (State) – Data Requirements

Asset/Resource Status (State) data object is sent by a DR Resource to a DR Controlling Entity in response to receipt of a DR Event or a Notify DR Event. It is be used as an acknowledgement of the receipt of the DR signal, but it may also contain various information used to signify how the DR Resource will respond to the DR Signal.		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[7]**	**Map to SEP 2.0 TRD**
DR Resource ID	The identifier of the DR Resource.	DR Resource ID			
Exception Conditions	This is used to report that the load controller may not behave as commanded because of a variety of conditions including: • Faults in device • Customer override.	Exception Conditions			
Load Control State	The state of the load, which includes both commanded states and user settings. This may include a schedule of future states if a particular control algorithm for the load controller is being executed.	Load Control State			Req[DRLC-3] No specific data requirement
Operational Constraints	Constraints on how the load may be controlled. This may include limits on the state of the load controller as well as schedules upon those constraints.	Operational Constraints			
DR Assets Characteristics	The expected response characteristics of each DR Asset that is part of the DR Resource. These may be needed for aggregated DR Assets and may be as simple as whether a DR Asset is participating or its actual load profile. For each DR Asset, the following should be given: • Location of Asset, either geographic or grid location • Asset schedule of participating Asset load profile (schedule).	DR Assets Characteristics			
DR Resource Load Profile Response	The load profile response characterization of the DR Resource in response to getting the DR signal.	DR Resource Load Profile Response			
Notification Received Acknowledgement	This is an acknowledgement of the receipt of a DR notification or dispatch. It should include any necessary provisions for non-repudiation.	Notification Received Acknowledgement		EventStateConfirmation	

[7] Abbreviation for *OPEN AUTOMATED DEMAND RESPONSE COMMUNICATIONS SPECIFICATION*

Asset/Resource Status (State) data object is sent by a DR Resource to a DR Controlling Entity in response to receipt of a DR Event or a Notify DR Event. It is be used as an acknowledgement of the receipt of the DR signal, but it may also contain various information used to signify how the DR Resource will respond to the DR Signal.		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[7]**	**Map to SEP 2.0 TRD**
Opt in/out	This is used to temporarily opt in/out of DR Events and to override the normal operational constraints. The opt-in/out can be specified using the following criteria: • All events in a program indefinitely • Specific DR Event • All events in a specific time period. In addition, there may be a schedule associated with the opt in/out state.	Opt in/out		EventStateConfirmation.OptInState Also separate service for OptOutState	Req[DRLC-1] No specific data requirement

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3.4.5 DR Resource – Data Requirements

A DR Resource is used during the enrollment process. A DR Resource as a logical entity is a group of Assets that represents a dispatchable entity.		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[8]**	**Map to SEP 2.0 TRD**
DR Resource Identifier	This identifies the DR Resource that is being registered.	DR Resource Identifier	Resource ID		
DR Resource Enrollment (Registration) Transaction Type	This indicates the type of report being issued by the Asset or Resource Owner. This is an enumerated value containing one of the following: • REGISTRATION (to register a new asset/resource) • CHANGE (refers to permanent changes) • RETIREMENT.	Report-type			
Resource Type	Type of Resource. Valid types are: load reduction, generation, combination.		Resource Type- DR from load reduction, generation, combination		
Controlling Entity Identifier	Identifier of the entity that is responsible for the Demand Response	Customer Identifier	Service Provider ID	participantID	
The following attributes are used for a DR Resource to enroll in a DR Program.					
DR Program Identifier	This identifies the DR program in which a DR Resource is participating.	DR Program Identifier	Program ID	program	
DR Resource Qualification	This shows the qualification of a DR resource for certain type(s) of DR programs	DR Resource Qualification	Identified above (to be moved down to this section)		

[8] Abbreviation for *OPEN AUTOMATED DEMAND RESPONSE COMMUNICATIONS SPECIFICATION*

A DR Resource is used during the enrollment process. A DR Resource as a logical entity is a group of Assets that represents a dispatchable entity.		Map To			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[8]**	**Map to SEP 2.0 TRD**
DR Resource Operational Constraints	These are constraints that define the amount load that can be made available during a DR event and includes the following: • Minimum load • Maximum load. • Maximum-Duration • Minimum-Duration	DR Resource Operational Constraints; Maximum-Duration Minimum-Duration	Limits: Limit Value Limit Type Physical Min Gen Min Gen MW Ramp Rate Type Ramp Rate Segment Ramp Rate Direction (offer parameter section 8)	programConstraint. maxEventDuration	
DR Resource Schedule Constraints	These are a set of constraints that specify when the DR Resource will be available. It may contain such information as: • Time of day schedule constraints • Black out dates • Maximum consecutive days of participation • Maximum duration of DR event participation • Minimum duration of DR event participation • Max number of times per day the DR Resource may be called • Minimum advanced notification necessary. Provide details if DR asset or DR resource is in any other DR programs (wholesale and retail)	DR Resource Schedule Constraints	Operational Contraints: OC Type OC Value OC Interval	programConstraint	
Effective-Start-Date-Time	The start date and time which an asset/resource is available.	Effective-Start-Date-Time	Effective Enrollment Date	programConstraint	

A DR Resource is used during the enrollment process. A DR Resource as a logical entity is a group of Assets that represents a dispatchable entity.		Map To			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[8]**	**Map to SEP 2.0 TRD**
Program Enrollment Status	Status of the Program Enrollment for the Facility or Resource		Program Enrollment Status: Accepted, Approved, Denied, Withdrawn		
Location	An identifier to indicate the location of the asset/resource.	Location		locationInformation	
Location-type	A value used to interpret the value contained in the Location element. Examples of Location-type include: Address Zone GPS Coordinates Grid Location / USNG Electrical Node Zip-code	Location-type	PAP09 Wholesale (Mandatory) Address1 Address2 City Facility State/Province Facility Zip/Postal Code Facility Country GPS Coordinates Weather Station Zone ID Zone (from CIM) Electrical Node ID Electrical Node Name Electrical Node Type PNode PNode ID		

A DR Resource is used during the enrollment process. A DR Resource as a logical entity is a group of Assets that represents a dispatchable entity.		Map To			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[8]**	**Map to SEP 2.0 TRD**
Response-time	The amount of time before an asset/resource is capable of meeting its full performance, in response to a request by a Service Provider to shed load, expressed as minutes in decimal format.	Response-time			
Available-Capacity	The total amount of power (megawatts) available from the asset/resource, expressed in integer format representing the amount of kilowatts available.	Available-Capacity	Nominal capacity (decimal) Qualifiied Capacity Value Capacity Type & Description		
Monthly-Capacity-Availability	The average capacity available for interruption by month for the period defined by the effective start/end date, expressed in Megawatts with appropriate precision.	Monthly-Capacity-Availability			
Temporary Opt-Out	This is used to temporarily opt out of DR Events and to override the normal operational constraints. The opt-out can be specified using the following criteria: • All events in a program indefinitely • Specific DR Event • All events in a specific time period. • Other triggered programs for which an asset or DR resource is already called upon (reduce double counting of available capacity)	Temporary Opt-Out	No equivalent	OptOutState	
Resource Type	Type of Resource. Valid types are: load reduction, generation, combination.		Resource Type- DR from load reduction, generation, combination		
Resource Qualification Test Date	Date the Resource demonstrated its ability to deliver a product or service		Resource Qualification Test Date		
Requalification Test Date	Date the Resource will retest its ability to deliver a product or service		Requalification Test Date		
Removal Effective Date/time	Date/time when the DR resource is no longer available. Date of Termination of Enrollment	Removal Effective Date/time	Enrollment End Date		

3.4.6 DR Asset – Data Requirements

The DR Asset object is used during the enrollment process. A DR Asset as a logical entity has a reportable interval level of consumption. Examples include a site that has its own meter, a neighborhood of homes that has a net meter, or an estimate of consumption of an aggregation of retail customers.		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[9]**	**Map to SEP 2.0 TRD**
DR Asset Identifier	The unique identifier and name of the DR Assets.	DR Asset Identifier	No equivalent concept of DR Asset	EventState.drasClientID	
Report-type	This indicates the type of report being issued by the Asset or Resource Owner. This is an enumerated value containing one of the following: • REGISTRATION (to register a new asset/resource) • CHANGE (refers to permanent changes) • RETIREMENT.	Report-type			
DR Asset group ID	Grouping of Assets that can respond to the same DR Signal within a DR Resource. (See DR Resource Specification)	DR Asset group ID			
Asset Operator	The business entity that operates the DR assets	Asset Operator			
Asset Owner	The business entity that owns the DR assets	Asset Owner			
Location-type	A value used to interpret the value contained in the Location element. Examples of Location-type include: Address Zone GPS Coordinates Grid Location / USNG Electrical Node Zip-code	Location-type			
Asset Physical Location	The location of where the DR assets reside	Asset Physical Location		locationInformation	
Authorized Asset Servicers	The authorized service providers of the operation and maintenance of DR assets	Authorized Asset Servicers			
Date of Registration and Last Update	Date of which the DR Assets registered for DR purpose.	Date of Registration and Last Update			

[9] Abbreviation for *OPEN AUTOMATED DEMAND RESPONSE COMMUNICATIONS SPECIFICATION*

The DR Asset object is used during the enrollment process. A DR Asset as a logical entity has a reportable interval level of consumption. Examples include a site that has its own meter, a neighborhood of homes that has a net meter, or an estimate of consumption of an aggregation of retail customers.		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[9]**	**Map to SEP 2.0 TRD**
State of Registration Process	The state/status of the registration process of the DR assets.	State of Registration Process			
DR Asset Administrator	• System and Operator • Distribution Utility • Load Serving Entity • Service Providers	DR Asset Administrator			
DR Asset Availability and Status	Run Status, Set point, Override status, etc.	DR Asset Availability and Status			
DR Asset Physical Capabilities	Ramp Up/Down Rate, Maximum Capacity	DR Asset Physical Capabilities			
DR Asset Product	Manufacturer, Model, Version, Date of Manufacturer	DR Asset Product			
DR Asset Type	(DG, renewable, storage, curtailable or interruptible load)	DR Asset Type			
DR Resources	The identifier of DR resources that the DR Assets belong to.	DR Resources			
Authorized Asset Servicers	The authorized service providers of the operation and maintenance of DR assets	Authorized Asset Servicers			
Contractual Agreements	Contractual agreement under which the DR assets could be removed.	Contractual Agreements			
Third Party Participation	The identification of third parties involved in the removal of DR assets.	Third Party Participation			

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3.4.7 Demand Response Customer Enrollment – Data Requirements

Demand Response customer enrollment is used to register a customer for a DR Program.		**Map To**			
Data Element	**Description**	**PAP09 Retail**	**PAP09 Wholesale**	**OADRCS[10]**	**Map to SEP 2.0 TRD**
Demand Response Program Identifier	Identifier assigned to the Program	DR Program Identifier	Program ID	UtilityProgram.name	
Customer Identifier	This is a customer identifier (e.g., account number) that signifies the owner of the DR Resource to the Utility.	Customer Identifier		participantID	

[10] Abbreviation for *OPEN AUTOMATED DEMAND RESPONSE COMMUNICATIONS SPECIFICATION*

3.5 OpenADR Technical Architecture View

Given a large variety of integration technologies that exist in the market place and in the utility enterprises, it would be up to each utility to implement the OpenADR systems requirements specification that fit with their chosen technology infrastructure and architecture goals. However, regardless of the technologies, the following architectural issues are important and needs to be addressed when it comes to achieving interoperability.

3.5.1 Networking Standards

1. OpenADR services SHALL be provided via TCP/IP (internet) networks. (See [RFC-1122])
2. OpenADR services SHALL be exposed primarily using the HTTPS protocol. (See [RFC-1123])
3. OpenADR services MAY support Secure FTP. Since OpenADR requires HTTPS, FTP is only an option if both parties implement and agree to use FTP. *(Note that requiring support is in discussion.)*

3.5.2 Security Standards

A major component of OpenADR is ensuring that protected resources, including data, can and will be secured to prevent unauthorized access. To ensure that data is not provided to unauthorized parties, the constraints and controls documented in [ASAP-SG-3P] are to be complied with for OpenADR installations.

Using the terminology specified in the ASAP-SG Third Party Data Access document, the customer is the Resource Owner, the Data Service Provider is the Resource Custodian. (The 3rd Party is still called the Third Party)

3.5.3 Service / Resource Patterns

Service and/or resource naming standards are important to achieve a level of "plug & play" at the run time environment. It implies the semantics of the service and its operations.

The OpenADR services naming convention has the following rules:

- **Information Object –** Collection of entities (classes and attributes) to describe an object in a business context.
- **Service / Resource Name –** Service naming convention follows the information object in a business process for an interface definition.
- **Service Patterns -**These patterns are used for Web services naming convention.
    - **Send –** to provide (send) information (business object) for public (enterprise) consumption. To be invoked by the system of record for the business object and only when the state of the business objects has been changed.
    - **Receive –** to consume (receive) information (business object).
    - **Request –** to request another party to perform a specific service
    - **Execute –** to run a service provided to the public, which may include a state change request or a query request.
    - **Reply** – to reply with the result of the execution of a service (by the Execute service)

- **Show** – to provide (show) information (business object) for public (enterprise) consumption, when the state of the business object is not changed, by the system of record or other system that has a copy of the same business object.
- **Retrieve –** to request specific data of a business object to be provided.
- **Publish –** to provide (send) information (business object) for public (enterprise) consumption. To be invoked by the system of record for the business object and only when state of a business object has changed.
- **Subscribe –** to consume (receive) information (business object) from an external source.

- **Operation Name –** Operation name indicates a specific action that will be performed to the Information Object. Here is a list of operation naming patterns utilizing IEC 61989 verbs (See IEC61968-1 Specification for details):
  - The following verbs are used for service/operation provided by the master system that owns the Information Object to entertain the request for the specified action implied by the verb.
    - **Create**
    - **Change**
    - **Cancel**
    - **Close**
    - **Delete**
  - The following verbs are used for service/operation provided by systems that are interested in receiving the Information Object as the result of the specified action implied by the verb. This can be invoked by the master system or an intermediary to supply the Information Object.
    - **Created**
    - **Changed**
    - **Closed**
    - **Canceled**
    - **Deleted**
  - The following verbs are used for query type services provided by the master system of the Information Object.
    - **Get**
    - **Show**
  - The following verbs may be used within OpenADR.
    - **Subscribe**
    - **Unsubscribe**

3.6 Governance

Governance defines the rules by which parties participating in interoperability (integration, or data exchange) efforts can change the interfaces and components providing and consuming them, in order to maintain efficient operation. For OpenADR, governance includes guidelines recommended for addition or extension of standard interfaces, as well as modifications to or extensions to become part of the standard.

1. Changes shall be made to be backwards compatible (optional additions only), to allow existing implementations to continue to operate.
2. Participants are encouraged to submit extensions to the working group as business requirements, with additional recommendations as necessary, to be discussed, ratified, and added to periodic updates.

4 Appendices

4.1 Terms and Definitions

This subsection provides the definitions of all terms required to properly interpret the OpenSG OpenADR SRS.

Term	Definition
Advanced Metering Infrastructure (AMI)	The infrastructure built around advanced metering allowing the utility and consumer to communicate in real time with respect to energy consumption. Based on the information collected, the utility is able to obtain an accurate reading of demands, while consumers are able to modify their usage to save energy.
Aggregator	Intermediary that manages a collection or "aggregation" of Demand Response by Utility Customers. Also known as Curtailment Service Provider.
Curtailment Service Provider	See Aggregator.
Demand Response	Demand Response is defined as the temporary modification of customer energy usage for a defined duration which is triggered by some condition on the grid such as reliability or market conditions.
Demand Response Program	A Demand Response Program is a program that is created to provide incentive to customers to reduce or shift demand.
Demand Response Provider (DRP)	An entity or role with the responsibility to coordinate demand resources to deliver demand response services. A DRP includes entities that have acquired curtailment rights from electricity consumers, and manage the aggregation of capacity that is curtailable as an eligible energy or capacity resource for participating in Demand Response programs. (PAP09 Retail dated 2/11/2010 v 1.5)
IEC	The International Electrotechnical Commission (IEC). The IEC TC57 maintains an electric utility focused information model called CIM (Common information model).
IEC 61968	International standards for Energy Distribution Managements Systems, respectively, specify a Common Information Model (CIM) for utility data exchange, Applications Programming Interfaces (API) for application integration (GID), and XML messaging standards.
Logical Data Model	A representation of an organization's data based upon entities and attributes of those entities. A logical data model is often a logical representation of a business' integration or business requirements.
SLA	Service Level Agreement: the part of a service contract where the level of the services are agreed upon between two systems.

4.2 Integration Services – Detailed Messages by Use Case

The list of Integration Services defined in section 3.2.2.2 was derived from the sequence interaction defined in the supporting Use Cases. This subsection is a detailed list of each interaction / message in the context of the supporting Use Case.

The source of the requirement is defined in the "Requirements Source" column. Since the Service names are based the PAP09 Retail and OpenADR Use Case documents, only the remaining requirements sources are cited individually.

Each service is assigned a priority within the current release or defined for a future release as defined in the "Priority/Release" column.

Use Case Scenario	Service Name	Provider	Functional Description of the Service	Priority/ Release	Requirements Source
Create DR Program	Created DR Program	DR Controlling Entity	DR Program is created and published.		OADRCS[11] 7.1.3 Program Services
Update DR Program	Updated DR Program	DR Controlling Entity	DR Program is updated and updates published.		OADRCS 7.1.3
Cancel DR Program	Cancelled DR Program	DR Controlling Entity	DR Program is terminated and notice published.		OADRCS 7.1.3
Register Customer for DR Program	Register Customer for a DR Program	DR Controlling Entity	Register a Customer for a DR Program. Customer registers with DR Controlling Entity (Utility or DRP).		OADRCS 7.1.3
Update Customer for DR Program	Update Customer for a DR Program	DR Controlling Entity	Updates to Customer registration information are provided for Utility or DRP.		OADRCS 7.1.3
Remove Customer from DR Program	Cancel Customer for DR Program	DR Controlling Entity	Customer notifies Utility or DRP of cancellation/removal from DR program. (Contingent on contractual obligations)		OADRCS 7.1.3
Register DR Resource	Register DR Resource	DR Controlling Entity	The Resource is registered and associated with a Customer and DR Program		
Remove DR Resource	Remove DR Resource	DR Controlling Entity	The Resource is removed from DR Program.		
Register DR Asset	Register DR Asset	DR Controlling Entity	The Asset is registered and associated with a Customer and DR Program		
Update DR Asset	Update DR Asset	DR Controlling Entity	The Asset is updated.		
Remove DR Asset	Remove DR Asset	DR Controlling Entity	The Asset is removed from DR Program		
DR Bidding			Process currently out of scope	Phase II	OADRCS 7.1.2
DR Event Advance Notification	Notify DR Event	DR Controlling Entity	DR Controlling Entity provides the advance notification of a DR Event to a DR Resource to provide scheduled Operation Mode and Event		OADRCS 7.1.1

[11] Abbreviation for *OPEN AUTOMATED DEMAND RESPONSE COMMUNICATIONS SPECIFICATION*

Use Case Scenario	Service Name	Provider	Functional Description of the Service	Priority/ Release	Requirements Source
			Information		
DR Event Advance Notification	Confirm DR Resource for Event	DR Resource	DR Resource opts in/out for DR Event. Response to DR Event Advance Notification and Update DR Event.		OADRCS 7.1.1
Update DR Event	Update DR Event	DR Controlling Entity	Update of Event Notice for Resource.		OADRCS 7.1.1
Cancel DR Event	Cancel DR Event	DR Controlling Entity	Cancellation notice from DR Controlling Entity to DR Resource.		OADRCS 7.1.1
DR Broadcast Message (Price Plus)	Broadcast DR Message	DR Controlling Entity	DR Broadcast Message to DR Resource for Pricing Information. (May include other attributes of Energy Delivery)		
Dispatch DR Instructions (Retail)	Dispatch DR Instruction	DR Controlling Entity	DR Controlling Entity provides specific objectives to the DR Resource.		
Dispatch DR Instructions (Retail)	Confirm DR Resource	DR Resource	DR Resource Confirms DR Instruction (with opt in/out) Non-repudiation required.		OADRCS 7.3.1
DR Direct Load Control (Retail)	Created Direct Load Control	DR Controlling Entity	Direct interactions between the DR Service Provider and a specific DR Asset for the purposes of putting that asset into a specific load control state (e.g., to turn it on or off). In this case, the DR Asset is a DR Resource with only one DR Asset, and thus, the interaction is directly with the DR Asset.		SEP2TRD[12] 10.4
Monitor DR Event (DR Resource)	Monitor DR Event (DR Resource)	DR Resource	Response from DR Resource to DR Controlling Entity used to monitor a DR Resource's behavior. It may be executed as a result of the DR Resource receiving a DR signal or it may be conducted continuously.		SEP2TRD 10.4
Monitor DR Event (DR Asset)	Publish DR Asset Status	DR Asset	Response from DR Asset to DR Controlling Entity used to monitor a DR Asset's behavior. It may be executed as a result of the DR Asset receiving a DR signal or it may be conducted continuously.		SEP2TRD 10.4
DR Execution – Real Time Pricing (RTP) / Dynamic Price Based	Forecast Load By Circuit	DR Controlling Entity	DR Controlling Entity provides Load Forecast to UDC and MO. [Content undefined]	Low compared to execution phase	
DR Execution – Real Time Pricing (RTP) / Dynamic Price Based	Broadcast Locational Wholesale Price	SO or MO	Wholesale Locational Price Information provided by the SO or MO to the LSE	Work with wholesale guys, touchpoint	
DR Execution –	Broadcast Locational	LSE	Retail Locational Price Information provided by the LSE to the Customer and DR	touchpoint	EIS[13]-UC-19,ID3

[12] Abbreviation for ZigBee Smart Energy Profile™ 2.0 Technical Requirements Document

[13] Abbreviation for *Energy Information Standards (EIS) Alliance Customer Domain Use Cases*

Use Case Scenario	Service Name	Provider	Functional Description of the Service	Priority/ Release	Requirements Source
Real Time Pricing (RTP) / Dynamic Price Based	Retail Price		Controlling Entity after aggregation and uplift.		
DR Execution – Real Time Pricing (RTP) / Dynamic Price Based	Update Load Forecast (Forecast DR)	DR Controlling Entity	DR Controlling Entity provides Load Forecast adjusted by expected DR to LSE.	Open issue on how modeled (PAP03) gap	EIS-ID15 (Customer to DRCE)
DR Execution – Real Time Pricing (RTP) / Dynamic Price Based	Update Load Forecast by Circuit (Forecast DR by Circuit)	DR Controlling Entity	DR Controlling Entity provides Load Forecast by Circuit adjusted by expected DR to UDC.		
DR Execution – Real Time Pricing (RTP) / Dynamic Price Based	Schedule Approved, No violations	UDC	UDC approves DR Schedule based on check against circuit limits		
DR Execution – Real Time Pricing (RTP) / Dynamic Price Based	Suggested Schedule Adjustment	UDC	UDC sends suggested schedule adjustments based on circuit limits. (Process for reprocessing schedule is not defined)		
DR Execution – Notification Based	Load Forecast	DR Controlling Entity	DR Controlling Entity provide Load Forecast to SO/MO		
DR Execution – Notification Based	Load Forecast by Circuit	DR Controlling Entity	DR Controlling Entity provides Load Forecast by Circuit to UDC		
DR Execution – Notification Based	DR Capability	Customer	Customer notifies DRP of DR Capability (Same as Status/State)		
DR Execution – Notification Based	DR Nomination	DR Controlling Entity	DR Controlling Entity Nominates DR Capability to LSE and SO/MO From PAP09 Retail – "The DR capabilities are specified by the DR Provider to the System Operator based on a DR Program, a price curve, or other nomination protocol." Message attributes include Dispatch instructions.		
DR Execution – Notification Based	DR Dispatch Instructions	SO/MO	SO/MO sends DR Dispatch Instructions to DRP and LSE		
DR Execution –	DR Schedule by Circuit	DR Controlling	DR Controlling Entity provides DR Schedule by Circuit to UDC.		

Use Case Scenario	Service Name	Provider	Functional Description of the Service	Priority/ Release	Requirements Source
Notification Based		Entity			
DR Execution – Notification Based	Schedule Approved, No violations	UDC	UDC approves DR Schedule based on check against circuit limits		
DR Execution – Notification Based	Suggested Schedule Adjustment	UDC	UDC sends suggested schedule adjustments based on circuit limits. (Process for reprocessing schedule is not defined)		
DR Execution – Notification Based	Final DR Schedule	DR Controlling Entity	DR Controlling Entity sends final DR Schedule to LSE based on Approved Schedules.		
DR Execution – Notification Based	Notify Customer of DR Schedule	DR Controlling Entity	DR Controlling Entity Notifies Customer of DR Schedule		
DR Execution – Direct Load Control (DLC)	DR Capability	Customer	Customer notified DRP of DR capability.		
DR Execution – Direct Load Control (DLC)	DR Capability Aggregated by Network Location	DR Controlling Entity	DR Controlling Entity provides DR Capability aggregated by network location to UDC.		
DR Execution – Direct Load Control (DLC)	DR Capability Aggregated by Location	DR Controlling Entity	DR Controlling Entity provides DR Capability aggregated by network location to SO/MO.		
DR Execution – Direct Load Control (DLC)	DR Dispatch Instructions	SO/MO	SO/MO sends DR Dispatch Instructions to DRP and LSE		
DR Execution – Direct Load Control (DLC)	Advisory Information on pending DR	DR Controlling Entity	DR Controlling Entity send advisory to LSE of pending DR Event		
DR Execution – Direct Load Control (DLC)	DR Control Schedule by Circuit	DR Controlling Entity	DR Controlling Entity provides DR Schedule by Circuit to UDC.		
DR Execution – Direct Load Control (DLC)	Schedule Approved, No violations	UDC	UDC approves DR Schedule based on check against circuit limits and notifies DRP.		
DR Execution – Direct Load Control (DLC)	Suggested Schedule Adjustment	UDC	UDC sends suggested schedule adjustments based on circuit limits to DRP. (Process for reprocessing schedule is not defined)		
DR	Control	DR	DR Controlling Entity send control signal to		

Use Case Scenario	Service Name	Provider	Functional Description of the Service	Priority/ Release	Requirements Source
Execution – Direct Load Control (DLC)	Signal	Controlling Entity	Customer asset.		
DR Execution – Direct Load Control (DLC)	Telemetry Data	Customer Asset	Customer Asset provides telemetry data to DR Controlling Entity.		
DR Execution – Direct Load Control (DLC)	Aggregated DR Telemetry	DR Controlling Entity	DR Controlling Entity provides aggregated telemetry data to SO/MO		
Post DR Event M&V / Settlement (Open Retail)	Request Meter Read	LSE	LSE requests meter read from Customer Resource		
Post DR Event M&V / Settlement (Open Retail)	Created Meter Read	Resource	Resource provides meter read to LSE		
Post DR Event M&V / Settlement (Open Retail)	Created Meter Read	LSE	LSE provides meter read to DR Controlling Entity		
Post DR Event M&V / Settlement (Open Retail)	Created Billing	DR Controlling Entity or LSE	DR Controlling Entity or LSE provides Billing information to Customer.		
Post DR Event M&V / Settlement (No Open Retail)	Request Meter Read	LSE	LSE requests meter read from Customer Resource		
Post DR Event M&V / Settlement (No Open Retail)	Created Meter Read	Resource	Resource provides meter read to LSE (Read interval must match interval of DR Event)		
Post DR Event M&V / Settlement (No Open Retail)	Created Billing	LSE	LSE provides Billing information to Customer.		

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