OpenADR Task Force

OpenADR Functional Requirements and Use Case Document

Open ADR

Functional Requirements and Use Case Document

Version 1.0

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Albert Chiu, Pacific Gas and Electric

Gerald R. Gray, Consumers Energy

Erich Gunther, EnerNex

Wayne Longcore, Consumers Energy

Randy Lowe, American Electric Power

Ed Koch, Akuacom

John Mani, Converge

Greg Robinson, Xtensible Solutions

Craig Rodine, Grid Net

Daniel J. Rogier, American Electric Power

Kay Stefferud, Lockheed Martin

Joe Zhou, Xtensible Solutions

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1.0 INTRODUCTION

Demand Response is the proactive management of electric and gas utility loads in order to more efficiently and reliably market, produce, transmit and deliver energy. Applications of demand response are as simple as the Utility interrupting load in response to severe grid transients or supply shortages (direct load control or active demand-side management), or as complex as millions of customers voluntarily reducing their consumption/load in response to price signals (passive demand-side management). With the exception of having to address emergencies, DR is generally used to flatten the demand peaks. In any case, the Utility must have a communications gateway to either directly control the consumer's loads, or provide a pricing signal to allow the consumer to manage their consumption directly by:

* Making the decision when to use appliances/equipment
* As input to a home/premise energy management system

Large Commercial and Industrial Customer DR Programs are not new. They have been in-place for more than 20 years. Demand Response systems have traditionally been utilized with large commercial and industrial customers because the individual loads are larger, requiring fewer controls and automation, in achieving the desired load reduction/shedding. However, as demand has continued to grow, there has been a noticeable shift in the overall makeup and magnitude of the energy demand peak. Residential consumers now make up about 60% of the peak, with unprecedented growth occurring, such as 17% growth in the last three years in the U.S. Mid‑Atlantic states. Additional DR will have to come primarily from residential consumers. There currently are successful, residential DR programs – Florida Power and Light (FP&L) Company has about 750,000 residential customers enrolled with the capability to shed ~1,000 Mw of load.

OpenADR is an important component of the Smart Grid initiative that delivers dynamic price and reliability signals in a standardized communications data model between the Utilities and Independent System Operators (ISO's) and the energy management systems within the facilities.

To clarify terms, this document describes:

* Energy Efficiency – Reduce total kilowatt of load with permanent and efficient technologies
* Demand Response – Temporary reduction of peak energy usage for a defined duration. Curtailment events are triggered either by reliability events or pricing signals.
* Load Shifting – Flattening the peak by using off-peak power in place of on-peak power. This is often a permanent peak shift driven by combining technologies and time-of-use rates. An example includes thermal energy storage.

1.1 Purpose of Document

The Purpose of this Document is to define the Use Cases and functional requirements for an Open Automated Demand Response t (OpenADR) system deployable anywhere in the world. The desired system will be developed using open non-proprietary standards, will be scalable to any geographic area, and will be designed to be upwardly compatible with future enhancements.

2.0 Application Overview

Demand Response systems curtail load to maintain grid reliability and to reduce demand during peak load periods. Demand Response systems manage load by issueing Demand Response Events.

The illustration below (Figure 2-1) from the Recommendation to the NAESB Executive Committee represents the terms for timing events and time durations applicable to a Demand Response Event. The definitions of the ten elements in the illustration are the basis for describing the Timing of a Demand Response Event. The applicablity of these elements to a Demand Response Service is dependent on the Service type. The Grid Operator shall specify whether any or all of the elements illustrated in the Timing Demand Response Event figure are applicable. In some cases, some elements will not be applicable; the inclusion of the elements establish a requirement for said elements.



Source: Recommendation to the NAESB Executive Committee DSM-EE Subcommittee dated December 2, 2008

Figure 2-. Timing of a Demand Response Event

The following terms refer to the above Figure 2-1.

| Term | Definition |
| --- | --- |
| Advance Notification(s) | One or more communications to Demand Resources of an impending Demand Response Event in advance of the actual event. |
| Deployment | The time at which a Demand Resource begins reducing Demand on the system in response to an instruction. |
| Deployment Period | The time in a Demand Response Event beginning with the Deployment and ending with the Release/Recall. |
| Normal Operations | The time following Release/Recall at which a System Operator may require a Demand Resource to have returned its Load consumption to normal levels, and to be available again for Deployment. |
| Ramp Period | The time between Deployment and Reduction Deadline, representing the period of time over which a Demand Resource is expected to achieve its change in Demand. |
| Recovery Period | The time between Release/Recall and Normal Operations, representing the window over which Demand Resources are required to return to their normal Load. |
| Reduction Deadline | The time at the end of the Ramp Period when a Demand Resource is required to have met its Demand Reduction Value obligation. |
| Release/Recall | The time when a System Operator or Demand Response Provider notifies a Demand Resource that the Deployment Period has ended or will end. |
| Sustained Response Period | The time between Reduction Deadline and Release/Recall, representing the window over which a Demand Resource is required to maintain its reduced net consumption of electricity. |

A Baseline is an estimate of the electricity that would have been consumed by a Demand Resource in the absence of a Demand Response Event. The Baseline is compared to the actual metered electricity consumption during the Demand Response Event to determine the Demand Reduction Value. Depending on the type of Demand Response product or service, Baseline calculations may be performed in real-time or after-the-fact. The Grid Operator may offer multiple Baseline models and may assign a Demand Resource to a model based on the characteristics of the Demand Resource's Load or allow the Demand Resource to choose a performance evaluation model consistent with its load characteristics from a predefined list. A baseline model is the simple or complex mathematical relationship found to exist between Baseline Window demand readings and Independent Variables. A baseline model is used to derive the Baseline Adjustments which are part of the Baseline, which in turn is used to compute the Demand Reduction Value. Independent variable is a parameter that is expected to change regularly and have a measureable impact on demand. Figure 2-2 illustrates the concept of Baseline relative to a Demand Response Event.

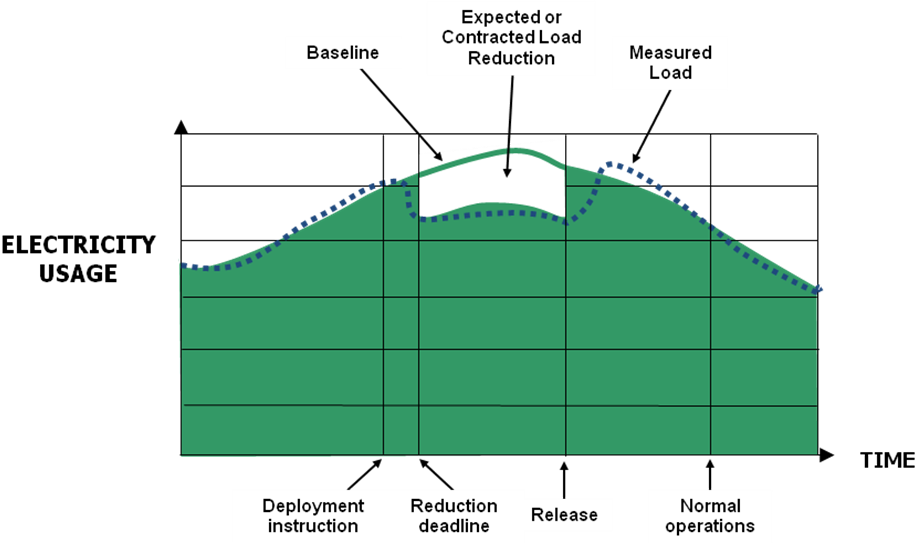
Source: Recommendation to the NAESB Executive Committee DSM-EE Subcommittee dated December 2, 2008

Figure 2-2. Illustration of Baseline Concept

DR Services define the typical services that a Grid Operator can request or correspondingly that a Demand Response Provider can supply.



Figure 2-3. Demand Response Service Types

2.1 Scope

Demand Response (DR) systems are currently being considered for adoption and expansion in a number of markets. Existing DR systems have been successfully deployed by organizations including ISO New England, co-ops and others using AMR meters, and through numerous programs controlling air conditioners with wireless signals.

Newer more automated demand response systems will ideally build upon features of existing systems while providing for future enhancements via open standards which anticipate technology advancements including smart meters, increased local generation, e.g., microgrids, and other SmartGrid infrastructure enhancements.

The specific OpenADR system covered by this document has been implemented and is in use by multiple public utilities and direct access providers. Automation of Demand Response (DR) programs has proven to be an effective means of obtaining more reliable and consistently higher performing electric load shifts and sheds than using manual techniques.

OpenADR was developed at the Demand Response Research Center managed by Lawrence Berkeley National Laboratory with funding from the California Energy Commission (CEC) Public Interest Energy Research (PIER) program, in collaboration with California Investor Owned Utilities. OpenADR is currently in use by four electric utilities to automate their DR programs and has been adopted by a wide range of building and industrial controls companies. In order to leverage both existing and future vendor investments in DR system development, the intent of the DR functionality described here is to be compatible with existing technology, and to be compliant with IEC electrical standards, specifically with IEC 61968.

2.2 Context

This document is targeted to utilities, regional transmission operators, third party aggregators and large demand response providers. Many OpenADR tasks have been completed or are in process including:

* Centralized development and documentation of information concerning Dynamic Rates, utility incentives, Demand Response tariffs and programs.
* Centralized development and documentation of information concerning OpenADR deployments, including lessons learned from previous deployments and the development of best practices.
* Education and training sessions to enable control vendors to incorporate the ability to consume OpenADR signals into their equipment.
* Education and training of system integrators and technical coordinators to enable them to install OpenADR enabled equipment into facilities.
* Education and training sessions targeted towards developing load management strategies for the facilities by using best practices gleamed from research and prior deployments.
* Co-development of marketing strategies between Utilities/ISO's and vendors for specific DR programs.
* Development of an OpenADR marketing portal targeted toward customers that may be interested in participating in an automated DR program. This portal could be used by members to advertise their offerings and direct interested parties to their own web sites for further information.
* Development programs to allow vendors to develop, test, and demonstrate their ability to integrate with OpenADR signals.
* Compliance testing of OpenADR clients and servers.

All these DR activities result in a need for implementation of business processes that are derived from a solid set of functional requirements. These activities will result in integration with utilities' internal systems as well as external clients. Information exchange will be a fundamental requirement to successful deployment of a OpenADR

2.3 Technical Summary

The North America Energy Standards Board (NAESB) Smart Grid Task Force (SGTF) took the responsibility of consolidating and developing DR use cases that provide requirements for developing DR control and pricing signal standards, which is called for by National Institute of Standards and Technology (NIST) Priority Action Plans (PAP) 03 and 09. This document addresses the business and functional requirements for standardizing control and pricing signals for Retail level Demand Response (DR) and Distributed Energy Resources (DER) as part of the Smart Grid implementation. The first step of use case development is the development of the Framework for Integrated DR and DER Models document, which provides an overall business context for DR and DER Models.

According to the Framework Document findings:

1. DR signals standardization must support all four market types; i.e. regions with a) no open wholesale and no retail competition, b) open wholesale market only, c) open retail competition only, d) open wholesale and open retail competition. It must also consider key differences that exist and will continue to exist in all four market types.
2. Wholesale market DR and pricing signals have different characteristics than retail market DR and pricing signals, although commonality in format is feasible.
3. Most Customers (with a few exception of Commercial and Industrial (C&I) Customers will not interact directly with wholesale market when it comes to DR and pricing signals.
4. Retail pricing models are complex, due to the numerous tariff rate structures that exist in both regulated and un-regulated markets. Attempts to standardize DR control and pricing signals must not hinder regulatory changes or market innovations when it comes to future tariff or pricing models.
5. New business entities (Energy Service Providers (ESP), Demand Response Providers (DRP), DR Aggregators, and Energy Information Service Providers (ESIP)) will play an increasing role in DR implementation.
6. DER may play an increasingly important role in DR, yet the development of tariff and/or pricing models that support DER’s role in DR is still in its infancy.
7. The Customer’s perspective and ability to react to DR control and pricing signals must be a key driver during the development of DR standards.

Due to market segmentation, the DR use cases are being developed under NASEB SGTF into two documents, one for wholesale and the other for retail. It should be noted that both document should include market types that are without open competitions.

This document deals exclusively with the retail level demand response signals requirements. The requirements are captured in the form of UML models where business requirements are captured in Use Case narrative format. The top level use cases for retail DR are:

1. Administrate DR Program
2. Administrate Customer for DR
3. Administrate DR Resource
4. Execute DR Event
5. Post DR Event Management

2.4 Terms and Definitions

This subsection provides the definition of terms in general use:

| Term | Definition |
| --- | --- |
| Adjustment Window | The period of time prior to a Demand Response Event used for calculating a Baseline adjustment. |
| Advanced Metering | Technology which allows two way communications between the utility and the meter. This communication enables the ability to analyze energy consumption resulting in more efficient demand response systems. |
| 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. |
| Aggregated Demand Resource | A group of independent Load facilities that provide Demand Response services as a single Demand Resource. |
| After-the-Fact Metering | Interval meter data separate from Telemetry that is used to measure Demand Response. May not apply to Demand Resources under Baseline Type II (Non‑Interval Meter). |
| Automated Meter Reading | Automated meter reading is a subcategory of AMI which allows for communication devices to transfer data from a meter to the utility or from a meter to the data management provider. |
| Baseline | A Baseline is an estimate of the electricity that would have been consumed by a Demand Resource in the absence of a Demand Response Event. The Baseline is compared to the actual metered electricity consumption during the Demand Response Event to determine the Demand Reduction Value. Depending on the type of Demand Response product or service, Baseline calculations may be performed in real-time or after-the-fact. The Grid Operator may offer multiple Baseline models and may assign a Demand Resource to a model based on the characteristics of the Demand Resource’s Load or allow the Demand Resource to choose a performance evaluation model consistent with its load characteristics from a predefined list. A baseline model is the simple or complex mathematical relationship found to exist between Baseline Window demand readings and Independent Variables. A baseline model is used to derive the Baseline Adjustments which are part of the Baseline, which in turn is used to compute the Demand Reduction Value. Independent variable is a parameter that is expected to change regularly and have a measureable impact on demand. |
| Baseline Adjustment | An adjustment that modifies the Baseline to reflect actual conditions immediately prior to or during a Demand Response Event to provide a better estimate of the energy the Demand Resource would have consumed but for the Demand Response Event. The adjustments may include but are not limited to weather conditions, near real time event facility Load, current Demand Resource operational information, or other parameters based on the System Operator’s requirements. |
| Baseline Type-I (Interval Metered) | A Baseline performance evaluation methodology based on a Demand Resource’s historical interval meter data which may also include other variables such as weather and calendar data. |
| Baseline Type-II (Non-Interval Metered) | A Baseline performance evaluation methodology that uses statistical sampling to estimate the electricity consumption of an Aggregated Demand Resource where interval metering is not available on the entire population. |
| Baseline Window | The window of time preceding and optionally following, a Demand Response Event over which the electricity consumption data is collected for the purpose of establishing a Baseline. The applicability of this term is limited to Meter Before/Meter After, and Baseline Type-I and Type-II. |
| Business Intelligence | A term describing the extraction and presentation of data to provide business value. |
| Business Service Provider | Software delivered over the internet as web services. The platform for integrating these web services is the enterprise service bus. |
| Capacity Service | A type of Demand Response service in which Demand Resources are obligated over a defined period of time to be available to provide Demand Response upon deployment by the System Operator. |
| Communicate | Interact and cooperate with people or organizations (groups of people). |
| Control | Monitor and regulate the supply (of electricity or other commodity) |
| Daily Consumption | The amount of energy a customer uses in a 24 hour period. This information is used to drive business intelligence solutions. |
| Demand | The rate at which electric energy is delivered to or by a system or part of a system, generally expressed in kilowatts or megawatts, at a given instant or averaged over any designated interval of time; and the rate at which energy is being used by the customer (NERC Definition). |
| Demand Billing | The energy demand of a customer upon which billing is calculated. This is often based on peak demand or some other demand related measurement. |
| Demand Interval | The interval of time between demand queries to the meter. This is typically in 15, 30, and 60 minute intervals. |
| Demand Reduction Value | Quantity of reduced electrical consumption by a Demand Resource, expressed as MW or MWh. |
| Demand Resource | A Load or aggregation of Loads capable of measurably and verifiably providing Demand Response. |
| Demand Response | An agreement between customer and utility that states that the customer agrees to allow the utility to manage their energy consumption when the utility deems necessary. Often times this result in the utility increasing or reducing energy distribution based on supply based metrics. Demand response mechanisms typical operate in on or off whereas dynamic response mechanisms may passively curtail energy usage as the mechanism senses stress on the grid. |
| Demand Response Provider | The entity that is responsible for delivering Demand reductions from Demand Resources and is compensated for providing such Demand Response products in accordance as specified by the System Operator. |
| Distributed Generation | Electricity generation from small energy sources allowing for more efficient energy distribution. This approach allows for energy to be generated closer to the source of the consumption which reduces the distance the generated energy has to travel. |
| Energy Data Acquisition | Obtaining meter data by way of handheld devices. Essentially a non automated meter reading typically administered by a utility worker. |
| Energy Data Management | Analyzing meter data for consumption by backend systems. Often times these back end systems will measure load, calculate demand response, billing intervals, etc. |
| Energy Service | A type of Demand Response service in which Demand Resources are compensated solely based on their performance during a Demand Response Event. |
| Enterprise Resource Planning | Integrating all back and front office data and process into one unified enterprise system. |
| ESB | Enterprise Service Bus. The ESB provides the features necessary for a service oriented architecture implementation by providing a place to host all of the web services. |
| Highly-Variable Load | A Load with a fluctuating or unpredictable electricity consumption pattern. |
| 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. |
| Load | An end-use device or customer that receives power from the electric system (NERC Definition). |
| Load Shedding | Reducing a customer's demand in order to maintain integrity of the grid. Load shedding in utility operations, is monitoring electric usage continuously (usually by automated instrumentation) and shutting down certain pre-arranged electric loads or devices if a certain upper threshold of electric usage is approached. |
| 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. |
| Maintain | Keep up to date information on, typically associated with data storage. |
| Manage | Control and effectively handle devices or processes. |
| Maximum Base Load | A performance evaluation methodology based solely on a Demand Resource’s ability to reduce to a specified level of electricity Demand, regardless of its electricity consumption or Demand at Deployment. |
| Meter Before/ Meter After | A performance evaluation methodology where electricity Demand over a prescribed period of time prior to Deployment is compared to similar readings during the Sustained Response Period. |
| Meter Bus (M‑bus) | Allows for the interconnecting of many different utility measuring units (i.e. gas, electric, water, etc.) The M-Bus acts as the central station for these different utilities to communicate with. |
| Meter Data Management | A system for storing, processing, consuming and analyzing large quantities of meter data. |
| Meter Data Recording Interval | The time between electricity meter consumption recordings. |
| Metering Date Reporting Deadline | The maximum allowed time from the end of a Demand Response Event (Normal Operations) to the time when meter data is required to be submitted for performance evaluation and settlement. The Meter Data Reporting Deadline may be either relative (a number of hours/days after Normal Operations) or fixed (a fixed calendar time, such as end-of-month). |
| Metering Generator Output | A performance evaluation methodology, used when a generation asset is located behind the Demand Resource’s revenue meter, in which the Demand Reduction Value is based on the output of the generation asset. |
| Performance Window | The period of time in a Demand Response Event analyzed by the System Operator to measure and verify the Demand Reduction Value for a Demand Resource. |
| Price Signals | Messages sent to consumers which specify a commodity price. |
| Provide | Feature/possess the capability to. System has the ability to perform the specified function. |
| Ramp Rate | The rate, expressed in megawatts per minute, that a generator changes its output. (NERC Definition) Demand Resource ramp rate is the rate, expressed in megawatts per minute, that a Demand Resource changes its Load. |
| Real Time Metering | Meter readings taken almost in real time to allow for adjustments to be made as the energy market fluctuates. |
| Regulation Service | A type of Demand Response service in which a Demand Resource increases and decreases Load in response to real-time signals from the System Operator. Demand Resources providing Regulation Service are subject to dispatch continuously during a commitment period. Provision of Regulation Service does not correlate to Demand Response Event timelines, deadlines and durations. |
| Receive | Accept messages from devices. |
| Reserve Service | A type of Demand Response service in which Demand Resources are obligated to be available to provide Demand reduction upon deployment by the System Operator, based on reserve capacity requirements that are established to meet applicable reliability standards. |
| SLA | Service Level Agreement: the part of a service contract where the level of the services are agreed upon between two systems. |
| Smart Grid | The term smart grid represents the digital upgrade of our distribution and long distance transmission grid allowing for increased energy efficiency as well as a boost in optimization of current systems. |
| Smart Meters | Meters with extra functionality that allow for more accurate and useful meter readings. This extra functionality allows the meter to collect usage data and transmit this data back to the utility over a network. |
| SOA | Service oriented architecture - The concept of grouping business functionality around business processes. These services are than packaged as interoperable services. A SOA architecture allows for the transmission of data between multiple systems as they participate in multiple business processes. |
| SOAP | Simple Object Access Protocol (XML protocol) - A protocol for exchanging xml messages for web services in a service oriented architecture implementation. |
| Supervisory Control and Data Acquisition (SCADA) | SCADA systems monitor and control the electric power generation, transmission, and distribution. |
| Supply Resources | Devices which have the capability to supply electricity. |
| System 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 Advance Notifications, Deployment, and Release/Recall instructions. |
| Telemetry | Real-time continuous communication between a Demand Resource or Demand Response Provider and the System Operator. |
| Telemetry Interval | The time unit between communications between a Demand Resource or Demand Response Provider and a System Operator. |
| Transmit | Send messages to devices. |
| UML | Unified Modeling Language is a general purpose modeling language commonly used for object/data modeling. |
| Utility Sub Metering | An implementation that allows for a multi tenant property to bill tenants for individual energy usage. This is most commonly implemented in apartments and condominiums. |
| Validation, Editing and Estimation | The process of taking raw meter data and performing validation and, as necessary, editing and estimation of corrupt or missing data, to create validated data. (VEE guidelines are published in the Edison Electric Institute’s Uniform Business Practices for Unbundled Electricity Metering, Volume Two, Published 12/05/00, <http://www.naesb.org/REQ/req_form.asp>). |
| WSDL | Web Services Description Language is a xml format used to describe web services and the messages that interface with the web services. |
| XML | Extensible Markup Language – general purpose markup language for creating custom mark-up languages. |
| XSD | A description describing a specific xml document focusing primarily on the restraints and structure of that xml document. |

3.1 Business Process Models

3.1.1 Business Functions



Figure 3-1. IEG-61968 IRM

3.1.2 Demand Response Business Process Model



Figure 3-2.

3.1.8.1 Performance Requirements

Performance requirements define parameters such as transactions per second, network latency, form load times and other measurable aspects of the system that govern overall speed and responsiveness.

3.1.8.2



Figure 3-3.

3.1.8.3



Figure 3-4.

3.1.8.3.1

The DR solution shall scale to up to current market size and includes known programs with 10,000,000 meters with up to 50,000,000 devices.

3.1.8.3.2

Future markets may contain entities with up to a 1000 participants in a single geographic location.

3.1.8.4

The DR solution shall be in compliance with the AMI System Security Requirements and Guidelines, version 1.0, approved at the January 8, 2009 AMI-SEC meeting held in Palo Alto, California.

3.1.8.5



Figure 3-5.

3.1.8.5.1

The DR solution shall be compliant with the latest IEC TC57 Reference Architecture. See the reference architecture in Figure 3-6.



Figure 3-6. Reference Architecture

3.1.9 Actors

Actors are the users of the system being modeled. Each Actor will have a well-defined role, and in the context of that role have useful interactions with the system.

A person may perform the role of more than one Actor, although they will only assume one role during one use case interaction.

An Actor role may be performed by a non-human system, such as another computer program.



Figure 3-7.

3.1.9.1 Billing Agent

The billing agent determines the cost including applicable credits for customers.  Typically costs vary among different classes of customers.

3.1.9.2 Customer

A customer of a utility, including customers who provide more power than they consume.

3.1.9.3 Demand Response Provider

An entity responsible for delivering demand reductions which is compensated in accordance with policy.

3.1.9.4 Distributor

A system which transfers energy from generation systems to consumers.

3.1.9.5

An Independent System Operator (ISO).

3.1.9.6 ISO or Grid Operator

An organization which manages the grid.

3.1.9.7 Large C/I Customer and Co-Generator

A customer whose usage typically exceeds a threshold and which is capable of providing electricity to the grid.

3.1.9.8 Metering Agent

Records the DR meter information during the time of the DR event onto persistent media.  Provides DR event meter data to the MDMS. Typically a smart meter.

3.1.9.9

Public commission that approves demand response programs.

3.1.9.10 Scheduling Agent

Sometimes is an IOU and sometimes is independent operator who provides an estimate of system demand.

3.1.9.11 Settlement Agent

A system which provides the accounting services necessary to determine payments and bills for customers and energy providers including 3rd party aggregators.

3.1.9.12 Small-Scale Merchant Generator

A customer whose usage typically exceeds a threshold and which is capable of proving electricity to the grid.

3.2 Primary OpenADR Use Cases

The Primary OpenADR Use Cases are shown in the diagram below:



Figure 3-8. Primary OpenADR Use Case Diagram

The primary OpenADR use cases are described in the following sections.

1. Administrate DR Program

Typically DR programs are created for specific business needs of demand side management. However, it is not required to affect demand behavior. It is also likely that DR programs will evolve over time. Following are the three main use cases concerning the creation, update and removal of DR programs. It is unlikely that this step of the DR management will be automated.



**Create DR Program**

**Description**

A DR program is created to meet a reliability need, i.e., a projected insufficient energy supply, and/or for economic purposes, i.e., when market prices are peaking.

A properly designed DR program will have a clearly stated goal or objective, System Operator or Program Administrator, activation and operational protocols, and responsibilities and obligations.  The items that should be considered include, but are not limited to:

* The type and size of the target customer
* The type of program to be implemented, e.g., Direct Load Control, Firm Service Level, Guaranteed Load Drop, etc.
* Metering and telemetry
* Any regulatory requirements
* Method of communication
* Activation protocol
* Marketing and sales activities
* Customer education activities
* Duration
* Delivery Period
* LSE/UDC Compensation
* Data Exchange Protocols
* Customer Authorization
* Third Party Participation
* Registration / Enrollment Process
* Approval Process
* Baseline Calculations
* Settlement Process
* Payment Process
* DR Resource enablement, including incentives
* DR Resource deployment process
* M&V Methodology
* Contractual Agreements
* Dispute Resolution Process
* Phase-in or Roll-out Plan
* Product type offering to the ISO/RTO; energy only, ancillary service (regulation up/down, spinning/non-spinning, etc.)
* If offering to ISO/RTO, specific metering/telemetry or other requirements needed to actively participate
* Address multiple participation in other DR programs (retail and wholesale)
* Include/exclude full/partial co-generation system, back-up generation, DER, etc.
* UDC verifying DR resource physical electric grid location

Once the DR program is developed, it should be tested and certified prior it implementation. Such testing may be accomplished through a pilot program. The results of the test/pilot should then be compared against the goal/objective of the program and any needed modifications made.  Upon satisfactory results, the DR program should be filed with and approved by the Applicable Regulatory Authority, if any.  Depending on which Entity is creating the DR program, it must also be submitted to and approved by the System Operator.  Finally, the DR program must be implemented. Upon activation of a DR program, an observable demand reduction should occur.

**Sequence Diagram**



**Update DR Program**

Once a DR program is initiated, changes in various elements of the program may be required or desired.  After indentifying the specific modification required, each of the considerations identified in the “Create” step should be investigated to insure that no unintended impacts occur as a result of the modification. If such unintended impacts occur, further investigation of the modification is required prior to implementation.

A regulated Entity must then present the modifications to the Applicable Regulatory Authority for approval and, then to the System Operator for approval. Once approved, the modifications must be communicated to customers.

**Sequence Diagram**



**Remove DR Program**

Termination of a DR program must take into account any DR resource long term commitments in System and Market Operator programs and contractual obligations with DR Providers, Load Serving Entities and Energy Service Providers.  In addition, State and or Federal regulatory agency filings and approvals must be considered prior to terminating a DR program.  Termination of a DR program may involve the removal of DR infrastructure, such as Direct Load Control Devices and advanced metering and pulse devices used in the M+V of the program. All outstanding payments to the DR resources should be completed prior to the termination of the DR program.

**Sequence Diagram**



Once the DR programs are established, there will be campaigns from DR Provider to get customers enrolled into the programs. Following are the three main use cases concerning the creation, update and removal of customers for a DR program. Enrollment may affect how a customer is compensated for demand responses. It is unlikely that this step of the DR management will be automated.



###### 2.1 Register / Enroll Customer for DR Program

**Description**

The registration/enrollment process must capture the key identifiers in order to enable accurate accounting and classification of DR resources, as well as to ensure customer understanding of the type and specific requirements of demand response service they are providing.  A registration process to track registrations of System and Market Operators or facilitating agencies and the movement of DR resources from one DR aggregator to another as may occur from time to time is necessary. Internet-based applications for the registration/enrollment process are ideal for this type of program administration.  There may be different applications for various service types and customer types.

**Sequence Diagram**



**2.2 Update Customer Identity**

**Description**

Once a DR registration is completed, changes in various elements of the registration may be required or desired.  After identifying the specific modification required, each of the considerations identified in the register/enroll step should be investigated to ensure that it is accurate and complete.

All parties (Utility, Aggregators, Energy Consultants, DR resources, Regulatory Agencies) affected by the update should be given reasonable time to review, dispute, and approve/disapprove the update(s).

**Sequence Diagram**



###### 2.3 Remove Customer from DR Program

**Description**

Removing a Customer Entity from a DR Program enrollment must take into account any DR resource long term commitments in System and Market Operator programs, and contractual obligations with DR Aggregators or Load Serving Entities.  In addition, State and/or Federal regulatory agency filings and approvals must be considered prior to removing a customer enrollment from a DR program.

**Sequence Diagram**



1. Administrate DR Resource

As part of enrolling customers to a DR program, specific DR resources and assets that are associated with customers accounts and premises will also need to be registered. The following use cases deal with the registration, update, and removal of DR resources and assets associated with a customer. When updating DR resources, there will also be potential use cases of DR bidding process, either for supplying or for buying power. There are also cases where Distributed Energy Resources will act as DR assets.



###### 3.2 Administrate Distribution DR Resource

These activities are used to administer all of the DR Resources and Assets, including a variety of activities surrounding the registration of DR Resources and the management of information surrounding the DR Resources that a Controlling entity may call upon during a DR event. Before a DR Resource may be called upon, it must be registered with the Controlling entity.  The administration of a DR Resource covers the following requirements:

* The need of the Controlling entity to identify a DR Resource for communications purposes;
* The need of the Controlling entity to establish DR Resource accounts for accounting purposes;
* The need of the Controlling entity to collect information from DR Resources prior to DR events for the purposes of determining which DR Resources to call upon during a DR Event; and
* The need of the Controlling entity to collect information from DR Resources prior to DR events for the purposes of determining the nature of the DR signals to send to the DR Resources.

###### 3.2.1 Update DR Resource

**Description**

When the base capacity of a DR Resource changes from when it was last registered with the DR provider, customer needs to provide updated information to the DR provider so that such information can be factored into the consideration for DR event planning.

**Sequence Diagram**



**3.2.2 Register DR Resource**

**Description**

A party with ownership, controlling interest, or administrative responsibilities for a DR Asset or DR Resource that communicates status-related operational information about the DR Asset or DR Resource to a controlling entity. For example, the owner of a DR Resource or Asset may wish to declare their inability to shed load (an outage) due to summer shutdown or may wish to reduce the available capacity of a resource/asset due to equipment maintenance or other causes.

**Sequence Diagram**



**3.2.3 Remove DR Resources**

**Description**

When a DR resource is no longer available permanently for DR purpose, it needs to be removed from the DR program for that customer so that it will be accounted for DR event planning.

**Sequence Diagram**



**3.2.4 Administrate DR Asset (Direct)**

3.2.4.1 Register DR Asset

**Description**

The DR Asset registration process must capture key identifiers to enable accurate tracking of DR assets and their capabilities. A requirement for a System and Market Operator, Load Serving Entity, DR Aggregator, or other entity facilitating the registration process (hereinafter referred to as DR Asset Administrator) is to track assets. This is done through DR asset registration and association of physical DR assets to DR Resources to recognize the asset and its potential contribution as part of a DR Resource.  The DR Asset Administrator ultimately administers the DR Asset registration process to recognize DR Assets that can serve as part of a DR Resource, although the Customer may be party to the registration process.

**Sequence Diagram**



**3.2.4.2 Update DR Asset**

**Description**

Once a DR asset registration is completed, changes to elements of the registration may be required or desired. After identifying the specific required modification and verifying the authorization to perform the update, each of the considerations identified in the DR Asset registration step should be evaluated and utilized, where necessary, during the update of the DR Asset information. The ability to update DR Asset information helps to ensure the asset information on record is current and complete.

Parties that are privy to and rely on the update should be notified of updates as soon as practicable after they are made. Additionally, these parties should have access to review and, in some cases, to approve/disapprove the update(s).

**Sequence Diagram**



**3.4.2.3 Remove DR Asset**

**Description**

Removing a DR Asset must take into account any DR Resource long term commitments in System and Market Operator programs and contractual obligations with DR Aggregators or Load Serving Entities.  In addition, State and or Federal regulatory agency filings and approvals must be considered prior to removing a DR Asset from a DR program.

**Sequence Diagram**



**3.2.5 Administrate DER for DR Purpose**

In the context of this report, Distributed Energy Resources (DER) are small and dispatchable energy generation and storage technologies that are interconnected to the distribution grid to provide electric capacity and/or energy to a customer or a group of customers, and potentially export the excess to the gird for economical purposes[[1]](#footnote-1). DER systems can generate electric power, as opposed to curtailable or interruptible loads that can just reduce electric loading on the grid. DER systems are typically less than 10 megawatts (MW) in size, in terms of capacity rating. However, some markets or operating regions define them as less than 1MW in size.

DER may be subdivided into distributed generation (DG), distributed storage, and plug-in electric vehicles (PEVs):

Distributed generation (DG) technologies can be divided into a) **Renewable Generation**, e.g., small wind power systems, solar photovoltaics (PV), Fuel Cells, Bio-fuel generators and Digesters, and other generation resources using renewable fuel, and b) **Non-Renewable Generation**, e.g., micro-turbines, small combustion turbines, diesel, natural gas and dual-fueled engines, etc.

Storage resources could be divided into a) **Electric Storage,** e.g., battery systems and uninterruptible power supplies (UPS), flywheel, superconducting magnetic energy storage (SMES), etc. and b) **Thermal Storage –** These convert electric power to thermal (cooling/heating) energy for later use, e.g., Ice-based air cooling system, and high-capacity brick-based air heating system.

Plug-in electric and hybrid vehicles (PEV/PHEV) may also be considered as DER, The electric vehicles may be used to supply stored electric energy back to the grid, a.k.a. Vehicle-to-grid (V2G).

Behind-the-meter DER may be bundled with regular load and managed alongside the demand response resources – such as a residential roof-top PV solar panel. But often, DER is treated separately in part due to its control capabilities. In addition to a regular retail tariff, behind-the-meter DER may be subject to net-metering or feed-in tariff, where excess generation can be exported to the grid at an established or a dynamic price.

Similar to DR resources, DER assets need to be registered and enrolled into a DR program. Furthermore, for DER assets typically require to meet additional technical requirements and certification for grid interconnection. Depending on the size of a DER and its export capabilities, sub-metering and telemetry capabilities may be required to monitor the impact of the DER operation on the distribution grid reliability and power quality. Also, renewable resources may receive Renewable Energy Credits (RECs) and may also qualify as a must-run resource, e.g., wind power in some regions. These need to be incorporated into pricing and control signals associated with DER operation.

###### 3.3 DR Bidding

**Description**

Demand Response Bidding occurs after the DR Assets and Resources that are to comprise the desired bid have been registered and a bid is to be formed. The DR Bidding use case has two sub-use cases, depending on the type of bid to be developed for submission: a bid to supply (i.e., an offer), or a bid to buy. The entity operating the DR bidding program (the Bid Receiver) receives bids from participants (the Bidders). The Bidder may be a Customer bidding with either an energy retailer (e.g., LSE, ESP), a DR Aggregator (e.g., CSP, DRP), or a power marketer (i.e., wholesale market participant). The Bidder may also be a DR Aggregator bidding up to a LSE or power marketer.

Before the start of the bidding process, it is assumed that DR Resources available for selection are already registered to provide the physical resource participating in the DR Bidding program. It is also assumed that the bidder has already registered to bid with the bid receiver and has been informed on the appropriate timing and parameters for bid participation. The DR bidding process starts with the decision of the Bidder to develop a bid for submission. The Bidder submits its bid to the Bid Receiver within the appropriate time window and following set guidelines for bidding. The Bidder receives information on the outcome of the submitted bid from the Bid Receiver, who notifies of the bid outcome (e.g., a resource award or other DR commitment).

Examples of retail DR Bidding programs include:

* Demand Bidding
* Capacity Bidding

Examples of types of ISO/RTO products that may be (or become) eligible for DR bidding include:

* Installed Capacity
* Day-ahead Energy
* Real-time Imbalance Energy
* Ancillary Service Operating Reserve
* Regulation

The above are wholesale products that retail DR capabilities may be (or become) aggregated to bid into. Required advances to establish linkages between purely retail DR bidding and ISO/RTO DR bidding programs are works in progress, and beyond the scope of this document.

**3.3.1 DR Bid to Supply (Retail Offers)**

**Description**

The Bid Receiver opens the forum/venue for receiving a bid. This may include initiating the bidding process by sending initial information to Bidders indicating parameters of acceptability for bids to be made. The Bidder communicates an offer to supply a specified product/service and the pricing or other incentive structure the bidder is willing to accept for DR. This may be as simple as the customer sending a response back to the Bid Receiver that accepts or rejects the initial bid sought, or may involve more complex bid structuring.

Each bid will have a clearly specified product or service that is being bid and the pricing/incentive structure being offered. The bidder also nominates the amount of and nature of supply being offered, the DR Resource to physically provide the service, and other physical parameters affecting resource availability and capability, in addition to the identity (or ID) of the bidder and resource(s) that comprise the bid.

The Bid Receiver reviews bids received and clears them, notifying the bidders of the outcome.

The Bidder receives the notification of awards or resource commitments and uses the information internally in preparation for DR Resource Dispatch.

**Sequence Diagram**



**3.3.2 DR Bid to Buy**

**Description**

The Bid Receiver opens the forum/venue for receiving a bid. This may include initiating the bidding process by sending initial information to Bidders indicating parameters of acceptability for bids to be made. The Bidder communicates a bid to buy a specified product/service and the pricing or other incentive structure the bidder is willing to pay to avoid DR. This may be as simple as the customer sending a response back to the Bid Receiver that accepts or rejects the initial bid sought, or may involve more complex bid structuring.

Each bid will have a clearly specified product or service that is being bid for purchase and the corresponding pricing structure that is acceptable to the Bidder. The Bidder also includes the quantity of product/service in the bid to buy, and specifies any DR Resource(s) that can physically substitute for the product/service in the event the bid to buy is not cleared (i.e., the bidder is unwilling to pay more than the going/market outcome price for the product/service). Other information submitted include physical parameters affecting resource availability and capability, in addition to the identity (or ID) of the bidder and resource(s) that comprise the bid.

The Bid Receiver reviews bids received and clears all bids, notifying the bidders of the outcome.

The Bidder receives the notification of resource commitments and uses the information internally in preparation for DR Resource Dispatch.

**Sequence Diagram**



1. Execute DR Event

The execution of a DR event takes different forms depending on operational situation and the type of DR programs being executed. Typically, they fall into one of the following four use cases:

1. Advanced DR Notification
2. Broadcast DR Message (price plus information)
3. DR dispatch instruction
4. DR direct load control.

Operational considerations for DR event execution are also associated with DR programs where direct load control or dispatching instructions are carried out.



###### 4.2 Notify DR Event (Distribution)

**4.2.1 Advanced Notification for DR (Distribution)**

**Description**

This is used by the Controlling entity to send the DR Event notification (i.e., DR signal) to the DR Resource.

**Sequence Diagram**



**4.2.2 Update a DR Event (Distribution)**

**Description**

This is used to update a DR event that has been previously notified.  The requirements for this use case are the same as those for the "Advanced Notification for DR" use case.

**Sequence Diagram**



**4.2.3 Cancel a DR Event (Distribution)**

**Description**

This is used by the Controlling entity to notify the DR Resource that a DR Event is being cancelled. It should only be executed if a DR Resource has previously received notification of a DR Event and that event has subsequently been cancelled.

**Sequence Diagram**



**4.2.4 DR Resource Confirmation (Distribution)**

**Description**

This is a confirmation message that is sent by a DR Resource to the Controlling entity as a result of receiving a DR Signal form the Controlling entity. It may 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.

**Sequence Diagram**



##### 4.4 Broadcast DR Message (Price Plus Information)

**Description**

Demand Response programs are designed to address different power system concerns caused by the imbalance between generation, transmission and consumption, or environmental concerns. Some DR programs are conducted on a voluntary basis, where the customer can opt to maintain the level or load. Some DR programs are mandatory, where either the customer loads will be curtailed under certain conditions or the customer will incur financial penalties for noncompliance.

In retail market, certain “DR Messages” can be broadcasted to DR resources either directly or through Service Providers. DR Message is defined as information about the DR signals that may affect the demand behaviors of the energy consumers. Obviously, the main component of the DR Message is the pricing information. However, there are other attributes of energy being delivered that may be of interest to energy consumers and could be included in the DR Message.

Based on the OpenADR discussion, the broadcasting function is mainly used for volunteer or non-mission critical DR messages. Therefore, message acknowledgement or confirmation is optional.

**DR Source of Power/Generation**

“DR Message” also can be source of power or generation. ANSI C12.19-2008 defined the following source of power/generation in Standard Table 12.

Precondition:

The DR controlling entity sends the DR message to service providers. In the case of DR pricing, the DR controlling entity calculates the wholesale price per location and communicates the appropriate price associated with the DR product to service providers.

Post Condition:

DR Resources received the DR pricing information, and may or may not act based on the DR agreement or contract.

**Sequence Diagram**



## 4.6 Dispatch DR Instructions (Distribution)

**Description**

This interaction is used to dispatch DR Resources.  This type of interaction is used when the Controlling entity needs to achieve specific objectives from the DR Resources during DR events. This means that specific instructions will be given to the DR Resource with objectives (e.g. shed 100KW) for the load profile of the DR Resource.

Note that for the retail use cases, a Dispatch is considered a special type of DR Notification, and thus, it is very similar in nature to the requirements given for that interaction.

**Sequence Diagram**



## 4.7 DR Direct Load Control (Distribution)

**Description**

This use case covers direct interactions between the DR Controlling entity 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.

**Sequence Diagram**



### 4.7.1 Monitor DR Event (DR Resource)

**Description**

This interaction is 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.

**Sequence Diagram**



### 4.7.2 Monitor DR Event (DR Asset)

**Description**

This interaction is used to monitor the state of a DR Asset.  It may be executed as a result of the DR Asset receiving a DR signal or it may be conducted continuously.

Sequence Diagram



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## 4.8 DR Event Execution

Demand Response is deployed for economic or a reliability purposes. At high penetration levels, demand response has has to be integrated with the power supply scheduling process, and it may impact the distribution grid operation and reliability, and perhaps the transmission grid operation and reliability. Thus it is impotant that include the required considerations for the grid and system level operations when developing DR Use Cases and DR signal standards. Such impacts may not be significant at low penetration levels, howvere, proper considerations must be given to support scalability and expandability for future deployments.

Power system operates based on a real-time balancing of supply and demand. To economically schedule the supply, an accurate load forecast is needed. Traditionally, load forecast was generated using the historical consumption patterns, weather forecast and other similar parameters. With the potential of high-penetration of DR, it will be necessary to incorporate the planned or a forecasted DR levels into the load forecast. Also, DR capabilities can be used to support the power system capacity or emergency supply (ancillary service) needs. Such services require proper scheduling and monitoring capabilities.

A demand response event may be initiated by a power system operator in response to a reliability event, e.g., loss of a generating station causing a lack of supply to meet demand, or an uncontrolled set of PEVs overloading of a distribution trasnformer. A demand response event may also be initiated by system based on economic considerations, e.g., reducing or shifting peak load at the system level or at spcific feeder or facility. Demand response may also be initiated by a customer in response to a market pricing signal

Considering that the distribution grid in the US is typically a three-phase imbalance circuit, i.e., many customers are on a single-phase or two-phase of the three-phase system. Thus significant changes in customer load patters could result in undesiable imbalanced conditions on a feeder. Also, load pickup following the termination of a major DR event could possibly cause overloads and other operational problems, if the load pickup is not properly scattered/managed.

The following provides three representative use cases to highlight some the key interactions. These include:

* Dynamic Price-based DR
* Notification-based DR
* Direct Load Control

### 4.8.1 DR Execution - Real-Time Pricing (RTP)

**Description**

Traditionally, retail tariff has based on a fixed or tiered rate structure with possible considerations of static rates for pre-established time of use (TOU) conditions. Real time or dynamic pricing (RTP) represent retail electricity rate that could vary as a function of time and is intended to modify demand. It requires interval metering for accurate billing based on time-varying prices. A number of states have implemented RTP or other dynamic pricing tariffs for large customers. With a broader deployment of advanced meters, RTP rates may become more common nation-wide.

The scenario presented here is represents a case where a location-dependent real-time retail pricing for energy is established based on the wholesale Locational Marginal Price (LMP) for that location. LMP values are typically established by an ISO (for regions covered by an ISO/RTO) on a day-ahead (hourly resolution) and real-time basis, typically on a five minute resolution. For the RTP, it will be appropriate to use the real-time LMP as the basis for computing the retail dynamic tariff. However, decisions should be made on the time and the spatial resolution of the RTP. For example, an hourly RTP averaging the five minute pricing values, or a Critical Peak Pricing model to reflect the extreme conditions only, may be adopted. In addition to the wholesale energy price, the retail RTP rate may also include the appropriate uplift charges to cover for distribution wire/services charges and for the power loss compensations. Note that the uplift charges are typically subject to a regulatory review and approval.

Special care must be given to the RTP rate design to ensure customer acceptance and adaptation. Also grid operational issues may have to be addressed. For example, during low LMP (RTP) periods (e.g., at night), certain distribution circuits may get over loaded (congested), with customers shifting consumption, e.g., charging PEVs, to that period. This improves the overall system economy, but may cause circuit congestion. To combat this, some have proposed use of demand charges or an additional incentive payment for load reduction, a locational incentive to relief congestion.

Sequence Diagram



### 4.8.2 DR Execution - Notification Based

**Description**

Notification-based DR is mostly used for economic purposes based on a day-ahead or hours or hour-ahead basis. Notification-based DR may also be used for 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.

Considering that the business processes for demand response have not yet been standardized across the nations, the following is a representative scenario that captures some of the interactions between the key stakeholders (actors).

At high penetration levels, the DR operation, especially on a day-ahead or hour ahead basis, need to be coordinated with the overall operations and supply scheduling process. As is shown in the Sequence Diagram below, this may require a timely update of the “locational” load forecast and an up-to-date nomination of the DR capabilities. This information may be supplied to the “system” and/or market operator to be incorporated in the overall supply and demand scheduling process. 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. The DR Provider may also inform the Load Serving Entity (LSE) of the locational available DR capabilities.

The notification-based DR dispatch process is typically initiated by the System or Market Operator; the process may also be initiated by an LSE or UDC. It is also possible that the DR Provider be the initiator of the DR process based on a market opportunity (economic operation) or based on a pre-established program.

At high DR penetration levels, it is expected that the DR provider will need to clear the DR schedule with the Distribution Grid Operator, the UDC. This is to insure that the high penetration DR has no adverse impact on the distribution grid reliability and power quality, e.g., cause of excessive imbalances, voltage violation, or an overload during load pickup period.   The UDC, in a timely fashion, will inform the DR Provider, if the schedule is cleared or requires an adjustment. Please note that if the DR deployed by a utility company that includes both LSE and UDC functions, such coordination is performed within the company’s operational systems (e.g., DRMS, DMS, etc.), or it can be an integral part of the DR scheduling application.

Following the clearing the DR schedule, notifications are sent to customers for DR operation. Under this scenario, the Market Operator and the LSE are also informed of the final DR schedule.

Sequence Diagram



### 4.8.2 DR Execution - Direct Load Control (DLC)

**Description**

Direct-Load Control is typically used for reliability-based events such as contingency and emergency support, supply of balancing energy or other ancillary service. Many of these programs require quick response time, e.g., five minutes or faster, that is practically only possible through a DLC capability. Direct-Load Control may also be used for economic operations, e.g., water heater programs to reduce or shift peak load.

Considering that the business processes for demand response have not yet been standardized across the nations, the following is a representative DLC scenario that captures the interactions between the key stakeholders (actors).

Direct Load Control is typically called for by a system operator, a transmission or distribution operator. It could be also issued by a Market Operator based on an ancillary service DR award, or by an LSE or DRP for an economic purpose. At high penetration levels, DLC operation needs to be coordinated with the distribution grid operator, the UDC.

As is shown in the sequence diagram below, the customer DR capabilities are aggregated by location and specified/nominated to the Distribution Grid Operator, Load Serving Entity, and/or to the System/Market Operator. In addition to location, the capabilities may also be aggregated by the DR response time, e.g., four seconds, five minutes, 30 minutes, etc.

The DLC Dispatch process is typically initiated by the Transmission or Distribution Operator. The process may also be initiated by the Market Operator of the LSE. The actual control of the DR resources may be done by the DR provider based on the dispatch signal received.

At high DR penetration levels, it is expected that the DLC activation schedule to be coordinated with the Distribution Grid Operator, the UDC. This is to insure that there are no adverse impact on the distribution grid reliability and power quality, e.g., voltage violation, excessive phase imbalances, or an overload during load pickup period.   If the DLC deployed by a utility company such coordination can be accomplished within the company’s DR and distribution management systems, or performed as an integral part of the DR control functions.

For a “fast” DR, e.g., provision of ancillary services, a telemetry capability is required to enable the real-time monitoring of the resource condition and its response to the DR control signal.

Sequence Diagram



## 4.9 Operational Coordination

Due to the existing differences in the regional retail energy market regulations, wholesale market structure and protocols, and supply and demand conditions, currently there are regional differences in business practices and processes governing demand response. As a result, operational coordination requirements for demand response somewhat vary from region to region, depending on the available retail tariff, retail market structure, available wholesale market for DR and the market mechanics.

The following table summarizes the major roles and responsibilities of the key stakeholders with respect to demand response operation. As can be seen in this table, a significant level of stakeholder coordination is required for an end-to-end DR operation spanning from the wholesale markets to the end-use customers.

| **Stake Holder** | **Key Responsibilities** |
| --- | --- |
| Wholesale Market Operator | * Establish, administer, and operate wholesale demand response programs and markets; * Determine and publish locational prices for wholesale demand response products; * Improve energy market efficiencies (economics) by integrating demand response products and capabilities; * Monitor compliance to wholesale DR instructions and financially settle with the participating stakeholders. |
| Transmission Grid / System Operator - Balancing Authority | * Monitor and maintain transmission grid reliability, and call upon wholesale demand-side (demand response) capabilities to address contingency/emergency conditions; * Dispatch demand-side capabilities to balance supply and demand, e.g., mitigating impact of variable generation (e.g., wind). * In regions with no organized wholesale energy market, economically dispatch available generation and demand resources including demand response to optimize supply economics. |
| Distribution Grid Operator – Utility Distribution Company | * Monitor and maintain the distribution grid reliability and the quality of power supply (e.g., voltage levels). Call upon DR to mitigate the distribution contingencies and reliability concerns. * Review and approve the integration of distributed energy resources with the distribution grid. * Assess the operational impact of distributed resources and demand response (DR/DER) on power quality and reliability of the distribution grid, approve high-penetration DR schedules (especially cold-load pickup operation). * Coordinate with the respective Load Serving Entity and Energy Service Providers for the assessment of distribution service and loss compensation charges to retail customers. |
| Load Serving Entity | * Forecast load and economically schedule supply to meet demand at all times. Incorporate demand response capabilities to improve load factor, reducing/shifting peak load. * Establish and obtain regulatory approval for a fair and unbiased retail tariff for all customer classes. For real-time dynamic pricing (RTP) tariff, apply distribution service, loss compensation and other uplifts to the wholesale locational prices. * Establish and administer demand response and distributed resource management programs including DR tariff. * Meet regional requirements for Renewable Portfolio Standards compliance for power delivery. * Aggregate and schedule DR capabilities in wholesale markets, manage DR programs. * Manage customer metering and billing process. |
| Energy Service Provider | * Operate only in regions with competitive retail market * Be an alternative supplier of electric power to end-use customers by offering competitive products, services and prices. * Forecast aggregated load of the enrolled customers by location as required. * Coordinate the power supply with the respective LSE and UDC. * Support demand response programs (DR/DER) for enrolled customers. * Aggregate demand and demand-side capabilities; schedule the aggregated load and DR capabilities in wholesale markets. * Provide for DR telemetry and other monitoring requirements, on a resource or aggregated basis. * Apply the necessary uplifts (e.g., distribution service and loss compensation charges) to the wholesale locational prices. * Meet regional requirements for Renewable Portfolio Standards compliance for power delivery. * Bill and settle with customers for energy supply and DR operation. |
| Demand Response Provider | * Offer competitive demand response services to the end-use customers. * Design and manage DR programs, establish pricing structure and signals for DR operation * Aggregate demand and demand-side capabilities; and offer/schedule these capabilities with the respective LSE or the wholesale market. * Provide for DR telemetry and other monitoring requirements, on a resource or aggregated basis. * Bill and settle with customers for energy supply and DR operation. |
| Electricity Customer | * Subscribe to a DR program, and update DR availability and capability information as appropriate * Maintain DR resources, data communications, telemetry, metering and control devices as required. * Respond to pricing signals, DR notifications, or control signals as appropriate. |

1. Post DR Event Management

Post DR event management mainly concerns with the reconciliation of the actual consumption of energy within the duration of a DR event with the expected behavior so that proper financial reward or penalties could be carried out. The NAESB M&V standard for DR defines the requirements for most of the post event management. The following use cases describe post DR event management for three different market types.



###### 5.1 Post DR Event M&V / Settlement (Open Wholesale, No Open Retail)

**Description**

After DR Event has been completed, then Measurement and Verification (M&V) can confirm whether action has been taken or to measure the impact of the response.  After the M&V, then the Financial Settlement is calculated and sent to the Electricity Customer.

This Use Case covers the scenarios with an open Wholesale, but no Open Retail Markets.

**Sequence Diagram**



RELEASE-RECALL

This indicates when DR has finished its Deployment Period and calculations for M&V and Settlement can take place.

## 5.2 Post DR Event M&V / Settlement (No Open Wholesale, No Open Retail)

**Description**

After a DR Event has been completed, then Measurement and Verification (M&V) can confirm action has been taken or to measure the impact of the response.  After the M&V, the Financial Settlement is calculated and sent to the Electricity Customer.

This Use Case covers the scenarios with no Open Wholesale or Retail Markets.

**Sequence Diagram**



RELEASE-RECALL

This indicates when DR has finished its Deployment Period and calculations for M&V and Settlement can take place.

## 5.3 Post DR Event M&V / Settlement (Open or Not Open Wholesale, Open Retail)

**Description**

After DR Event has been completed, Measurement and Verification (M&V) can confirm action has been taken or to measure the impact of the response.  After the M&V, the Financial Settlement is calculated and sent to the Electricity Customer.

This Use Case covers the scenarios with no Open Retail Markets, and includes either Open or Closed Wholesale Markets.

**Sequence Diagram**



RELEASE-RECALL

This indicates when DR has finished its Deployment Period and calculations for M&V and Settlement can take place.

1. EPRI Report – Angela Chuang, Ali Ipakchi [↑](#footnote-ref-1)