OpenADR Advances

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Abstract

An important goal for the advancement of smart grid deployments is to enable buildings to dynamically respond to the supply of electricity. Buildings should respond to grid event and price signals in order to manage peak demands on the electric grid and fluctuations of intermittent renewable generation. The Open Automated Demand Response—OpenADR—communications standard is an important tool to help develop this market for demand response (DR). This article reviews progress in the development and implementation of OpenADR, focusing on updates since the release of OpenADR 2.0 in December, 2011. We introduce the OpenADR Alliance, established in late 2010 to foster the adoption of OpenADR 2.0 profile specifications and provide a testing and certification program to meet U.S. smart grid interoperability goals. The Alliance has developed two profiles of OpenADR to meet the needs of simple DR clients (receiving DR event signals) up to full-featured implementations that enable bidding into wholesale markets. In addition, this article presents details of a pilot conducted in spring 2012 where OpenADR 2.0 was implemented for wholesale DR programs. OpenADR will be a key standard for moving the smart grid forward, both in the U.S. as well as internationally.

Keywords: automated demand response; OpenADR; smart grid

Introduction

Part of the vision for smart grid is to have facilities (commercial, industrial, and residential) respond dynamically to electric grid price and demand response (DR) signals. Facilities can be operated in a way that supports grid reliability by managing loads and storage to balance grid-wide demand and fluctuations of renewable energy sources (adjusting load schedules to run when the wind blows and sun shines). The vision also includes facilities hosting electric vehicles that are charged with off-peak power, and facilities as part of microgrids that promote better local power system reliability. Progress is being made in realizing the vision through the development of standards for communicating electricity price, DR events, and usage information; through changes in the regulatory space to move toward tariffs that incentivize home and building owners to manage energy usage; and through growth of renewables and microgrids.

One key area – the development of the OpenADR communication standard – has tremendous benefits for both facilities and utilities. Having more products implement a single DR standard worldwide reduces the cost of implementing DR technology and program management. More DR programs and variable price tariffs means more savings to customers through program participation. Strong participation by facilities reduces the need for new generation plants to take up peak loads. Automated DR resources provide a tool to help manage the variability of intermittent solar and wind energy sources. All benefit from increased grid reliability. Finally, enabling customers to respond to grid signals often leads customers to be better stewards of energy, with better understanding of their energy usage and ability to control that usage [1].

In 2009, Bushby and Holmberg [2] shared the vision that the combination of standard OpenADR communications between utilities and customers, advances in BACnet for the building control space, and new federal government policies to advance smart grid, would lead to a strong development path for automated DR. Now OpenADR has not only gained prominence and strength in the U.S., but also grown in visibility and application throughout the world. This is due to the standards development work initiated by the National Institute of Standards and Technology (NIST), built upon the foundation of a decade of work by Lawrence Berkeley National Laboratory's (LBNL) Demand Response Research Center (DRRC) in automating DR [3].

OpenADR for the Smart Grid

OpenADR development began in 2002 as a research project to support California's energy policy objectives to move toward dynamic pricing to improve the economics and reliability of the electric grid. Initial field tests focused on automating a number of event-based DR utility programs for commercial and industrial (C&I) customers. LBNL's DRRC developed the OpenADR system in conjunction with studies on DR control strategies to enable C&I facilities to respond to common DR signals and shed load (*see DR Response Strategies sidebar*). OpenADR has also been implemented by transmission system operators (ISOs) for wholesale event-based and price-based DR programs, including ancillary services. Such implementations require tight coupling with the supply-side for fast responses (aka, "Fast-DR") [10].

Figure 1 shows the OpenADR communication architecture and interactions among service providers (Utility or ISO) and customers (Sites and/or Aggregated loads) using a standardized application programming interface (API). The Demand Response Automation Server is a logical separation and can be part of the service providers' information systems.

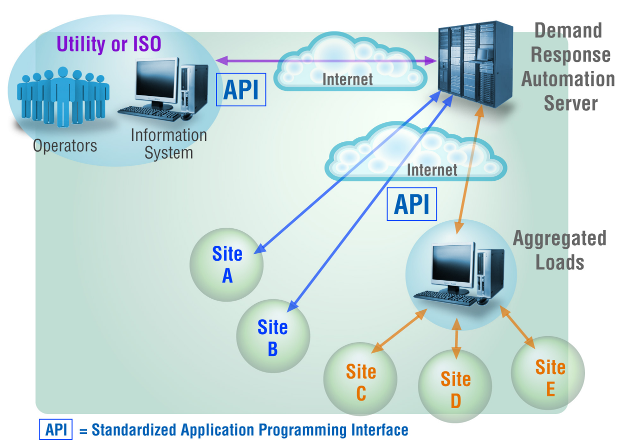

Figure 1: OpenADR Communication Architecture.

To enable greater use in the U.S. and globally, in 2009 OpenADR 1.0 was donated to the Organization for the Advancement of Structured Information Standards (OASIS) Energy Interoperation Technical

Committee (EI-TC) [11] for the development of formal standards (*see Smart Grid Standards Coordination and DR sidebar*). OpenADR 1.0 served as a foundation for the development of the Energy Interoperation standard published in December 2011 by the EI-TC [15]. OpenADR 2.0 is a profile (proper subset) within the Energy Interoperation standard. OpenADR 2.0 has a set of data models to facilitate simple DR programs, wholesale market transactions, ancillary services, dynamic pricing, and distributed resources management through storage and local generation [16].

While OpenADR 1.0 was developed for U.S. markets, global smart grid developments have led to the use of OpenADR in international deployments. Currently, OpenADR deployments are underway in China, Australia, Europe, India, Japan, South Korea, Canada, and elsewhere [17]. The expanded data models in OpenADR 2.0 will enable even wider-scale use for new applications. Table 1 below summarizes some key differences between OpenADR 1.0 and 2.0.

Table 1: Differences between OpenADR 1.0 and 2.0

OpenADR 1.0	OpenADR 2.0
Public specification based on a "de-facto" standard in California.	Public specification based on a formal industry standard and NIST's U.S. smart grid activities.
Commercially deployed to foster DR adoption and, initially, to meet California's automation goals.	Conforms to the U.S. Smart Grid Interoperability Panel (SGIP) interoperability framework.
No compliance tests/certification program. Focused on retail programs, pilots for wholesale markets and ancillary services.	Has compliance test-tools/certification program. Services for retail and wholesale markets, operations, and distributed energy resources.
Limited feedback capabilities.	Explicit feedback capabilities and enhanced schedule, dynamic pricing, and other services.

The OpenADR Alliance

The cornerstone of any standard is its ability to support interoperability between vendors in the marketplace. The OpenADR Alliance (www.openadr.org) was established in October 2010 to foster adoption of OpenADR 2.0 profile specifications and provide a testing and certification program. As of June 2012, OpenADR Alliance, an industry member-sponsored non-profit organization, has over 70 members including equipment and software vendors, electricity-service providers and operators, and research institutions. The Alliance is collaborating with many other organizations (SDOs, regulatory, other alliances) to advance OpenADR.

The Alliance is leveraging the OASIS Energy Interoperation standard to create a series of implementation profiles to support certification against that standard. The Alliance is currently developing two OpenADR 2.0 profile specifications to support different levels of functionality. Profile A supports simple applications with simple DR signals. Profile B targets fully functional devices, control systems, and IT systems that might receive more complex DR signals, and adds additional services such as for reporting consumption to DR signal providers, and for market interactions.

One of the primary goals of the Alliance is to develop the conformance, certification, and testing process/program for OpenADR. A strong testing and certification program will ensure interoperability and availability of standard-compliant products, easing the use of OpenADR. Standard implementation profiles of OpenADR will also lower automation costs within facilities and help eliminate stranded assets. The Alliance is spending considerable effort on cyber security to insure that OpenADR can be deployed securely. One of the challenges is to establish a range of security options so that OpenADR can be deployed in a way that best suits the service provider and customers that are commissioning systems for DR programs utilizing OpenADR.

To date, a number of vendors have demonstrated compliance with profile A and the OpenADR Alliance has begun formal certifications against that profile. In addition, the profiles and compliance/test specifications that have been developed by the OpenADR Alliance are being submitted to the SGIP process for inclusion in the SGIP Catalog of Standards [18]. The Energy Interoperation standard is already listed in the SGIP Catalog of Standards.

Additionally, the Alliance is working to train and provide resources for: system integrators, control vendors, and others to enable them to install "OpenADR-ready" equipment within facilities; and customers to help them develop load management strategies. Resources include: a repository of deployments information including lessons learned and best practices; and programs to allow vendors to develop, test, and demonstrate their ability to integrate with OpenADR signals.

PJM OpenADR pilot

OpenADR 2.0 was piloted for wholesale DR market communications during spring of 2012. PJM (the independent transmission system and wholesale market operator in all or parts of 13 Mid-Atlantic States and the District of Columbia) worked with IPKeys Technologies, LLC with the goal to test the ability of OpenADR 2.0 to securely implement some core DR use cases for PJM's wholesale DR programs.

There were five participants in the pilot in addition to PJM: a membership warehouse and supercenter-retailer with a headquarters-based monitoring and control system (Participant 1), a grocery chain retailer with no building automation (BA), a fast food restaurant with a cogeneration system, an energy reseller acting as a demand aggregator, and a commercial office building with no BA. The IPKeys Energy Interop™ Server and System ("EISS™")[1] was used by all participants to implement the pilot. The EISS™ system enables automatic reduction of energy consumption during periods of high prices with the implementation of machine-to-machine interactions and pre-programmed facility strategies for load reduction.

All participants, except Participant 1, used IPKeys-provided end point units called EISSBoxes. These units connected over the Internet to poll PJM's EISS Server. The EISSBoxes provide dry contact outputs to signal end use equipment. Meter telemetry (reporting energy usage) was obtained by current transformers recording one minute interval data. Four second telemetry rates were also implemented for future use in the regulation markets. Participant 1 created an OpenADR 2.0 client to receive

[1] Mention of commercial products or services in this paper does not imply approval or endorsement by NIST, nor does it imply that such products or services are necessarily the best available for the purpose.

messages then used its existing infrastructure to signal stores' energy management systems. This infrastructure also allowed real time telemetry monitoring of the load shed.

The pilot was used to implement three use cases: (UC1) a traditional demand response event, (UC2) a price based load response event and (UC3) the verification of load shed with real time meter telemetry. UC1 demonstrated two-way machine-to-machine conveyance of DR signals and receipt of automated confirmation messages. UC2 conveyed PJM pricing node (i.e., substation) Locational Marginal Prices (LMP) to end point devices as part of the PJM Price Responsive Demand program; the end point included logic to shed load based on pricing levels and return confirmation of the load shed. Pricing logic with hysteresis was implemented in the EISSBoxes. UC3 demonstrated receipt of one-minute interval meter telemetry collected via multiple methods including pulse counting and current transformers.

The OpenADR 2.0 Profile A was used as the framework for the pilot with the addition of some services from Profile B. Specifically, the EiEvent service [19] was used to communicate DR event signals for UC1 and return acknowledgement. For UC2, prices were sent via the EiEvent service with a Profile B payload; if a preset price was exceeded, then the end point EISSBox or other hardware returned notification of load shed. For UC3, the OpenADR Profile B EiReport service was used for returning real-time meter telemetry. Once implemented, UC3 was used to verify load shed in real time for UC1 and UC2.

Participating facilities used different strategies to reduce load. Response strategies included temperature setback and light dimming. The restaurant owner started up a waste-oil fueled generator.

Pilot participants appreciated the risk mitigation advantages provided by OpenADR, providing a "physical hedge" (as opposed to a financial hedge) where curtailment was automatic during periods of high prices. Real-time price monitoring enables customers to automatically curtail demand when energy prices are high to prevent unexpected energy charges.

The PJM Pilot successfully demonstrated the use of OpenADR 2.0 for each use case. Participants were pleased with the ability to implement a single open standard for communicating demand response and pricing signals. The national chain and demand aggregator are currently forced to implement differing protocols and methodologies for each wholesale energy market they participate in. They were very interested in the possibility of a single method for all markets.

Moving Forward

OpenADR continues to advance into commercial adoption in the U.S. and internationally. It is becoming the most common standard used by utility and wholesale market DR programs for DR automation. With a common standard will come more vendor products at competitive prices to support customers adopting automated DR. The benefits to customers include opportunities to participate in multiple DR programs that will reward them for responding to fluctuations in the intra-day value of electric power, and the ability to more readily acquire competitively priced services and equipment to interface with DR signals.

The OpenADR Alliance is finishing up its work on OpenADR 2.0 Profile specifications. At the same time, the Energy Interoperation/OpenADR standard is being evaluated for new applications with ongoing research. Pilots are being conducted to explore new applications for dynamic pricing, renewables integration, market interactions and ancillary services. OpenADR's services for distributed resources will lead to further advancements to meet the challenge of intermittency of renewable resources, supplementing grid-scale storage – in both the U.S. and globally. OpenADR 2.0 is now an input into an International Electrotechnical Commission process that can lead to international standardization and thus ease its adoption across the global smart grid markets. Together these efforts will support the realization of a vision for grid-responsive buildings that intelligently manage loads and distributed energy resources.

SIDEBAR: DR Response Strategies

A C&I facility manager or a heating ventilation and air-conditioning (HVAC) consultant may use lighting, HVAC or other end-use control strategies to respond automatically to an OpenADR signal. Common commercial building DR control strategies include HVAC global zone temperature adjustment, pre-cooling (for buildings with significant thermal mass), and lighting level adjustment (bi-level switching or dimming). Such HVAC and lighting strategies are well studied from field data and can provide a 10 % to 14 % average shed [4].

Implementing DR in the industrial sector is more challenging. There is a wide variation in loads and processes across industrial sectors and even within sectors, with resource-dependent loads influenced by external factors such as customer orders or time-critical processing. The uses of OpenADR in the industrial sector have proven that, with careful planning and preparation, there are significant opportunities for DR [5]. Recent studies from the DRRC describe DR strategies for peak load reduction in different types of industrial facilities (data centers [6], water and waste water facilities [7], and refrigerated warehouses and food processing facilities [8, 9]).

SIDEBAR: Smart Grid Standards Coordination and DR

After the passage of the Energy Independence and Security Act, NIST responded to its assignment for coordinating smart grid interoperability standards by forming the Smart Grid Interoperability Panel (SGIP) [12] as a public-private partnership. NIST also published its Framework and Roadmap for Smart Grid Interoperability Standards [13], which highlighted the importance of DR standards and called out OpenADR as an important specification. The formation of the OASIS EI-TC and submission of OpenADR 1.0 received public visibility and support with coordination from the SGIP and its Priority Action Plan 09 focused on "Standard DR and DER Signals" [14].

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