> Itron white paper

OpenWay® by Itron

OpenWay Demand Response

Maximizing Value and Efficiency in Energy Delivery

Stephen Johnson
Senior Marketing Manager, OpenWay

Introduction

This white paper explores how Itron's OpenWay solution enables demand response programs for residential, as well as commercial and industrial (C&I), energy consumers. OpenWay's flexible architectural approach, combined with the adoption of open standards, provides the foundation on which utilities, independent system operators (ISOs), regional transmission organizations (RTOs) and energy service companies can optimize the efficiency of energy delivery across a diverse service territory.

The concepts in this document assume a basic understanding of regulatory structures and concepts; as such, definitions for specific terms such as rate tariffs and decoupling are not addressed. This document is intended primarily for electric utility directors and managers who are evaluating demand response and energy efficiency strategies.

Overview of Demand Response

Demand response (DR) generally refers to any action taken to reduce customer energy demand based on a financial incentive. The U.S Department of Energy formally defines demand response as:

Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.

This definition encapsulates a broad spectrum of programs which target different customer segments to achieve different results. However, DR programs are generally defined by three common characteristics:

- Incentives for participants
- Actuation methods
- Desired objectives

Incentives for Participants

Incentives are often financial, and can vary based on the targeted participants. For example, C&I customers may contract to remain below a certain demand threshold, whereas residential customers may receive rebates for actively participating in voluntary events. Other mass-market DR programs may simply utilize existing tariffs to encourage energy efficiency by signaling to energy customers when they are entering a higher energy pricing tier.

Actuation Methods

Actuation methods include any signals intended to result in a load reduction. These may be as simple as text messages to customers, indicating a temporary spike in the price of energy—which would then result in a manual load reduction by the customer. Other methods include automated signals to cycle an HVAC system through a programmable communicating thermostat (PCT), or a direct load control signal to a switch attached to a specific appliance, such as a hot water heater or pool pump.

Desired Objectives

The desired objective of a DR program or event is linked to the motivation of the party initiating DR events or signals. Some parties, such as ISOs, dispatch emergency events in response to critical generation shortfalls. Utilities enlist participation in DR programs to minimize customers' exposure to spikes in the wholesale price of energy, whereas energy service companies may aggregate demand resources to bid capacity into ancillary service programs.DR programs are not new—in fact, many have been in successful operation long before the advent of current smart meter or AMI deployments. However, smart meter deployments offer several features which can extend the reach and impact of DR programs:

- Two-way communications between utilities and service points
- In-home communications technology

- Network monitoring and management infrastructure
- Multiple channels of time-stamped load profile data
- Time-of-use (TOU) and critical peak pricing (CPP) registers in meters

Support for Demand Response within OpenWay

The OpenWay solution is a blend of smart meters, software and communications infrastructure that combines individual features of an AMI system to deliver business value to utilities. OpenWay delivers metering applications over multiple communications substrates using the ANSI C12.22 protocol. All OpenWay meters include a high-powered ZigBee® transceiver for reliable two-way communications with in-home devices. In the back office, the OpenWay Collection Engine software communicates with a number of industry-leading meter data management (MDM) and demand response management (DRM) systems through a publicly available service-oriented architecture (SOA) interface. By focusing the Collection Engine on reliable, scalable and secure management of network communications and data delivery, a wide variety of DR systems and devices can leverage OpenWay to deliver DR programs and benefits to various market participants.

At the solution level, OpenWay enables DR by:

- Providing two-way communications for delivering DR event messages and managing DR infrastructure
- Providing advanced metering support for DR programs
- Integrating with industry-leading DR management systems, including Tendril and Comverge
- Leveraging in-home communications for a variety of DR enabling and automating devices

Itron partners integrate with OpenWay to provide the following DR program management features:

- Program design
- Event execution
- Analytics for program effectiveness

OpenWay is designed to be a flexible and scalable communications platform for enabling DR solutions. A single OpenWay network may be used with different DRM platforms. By remaining agnostic to DR programs managed by upstream systems and focused instead on application delivery, OpenWay does not limit the deployment possibilities of DR programs or system designs. As a result, OpenWay maximizes the value of a utility's existing technology investment and ensures that future program design will not be impeded by system assumptions hard-wired into the AMI network.

Demand Response Programs

Each regulatory and grid management jurisdiction imposes different requirements on how a utility can structure DR programs. Additionally, the portfolio of possible incentives to motivate customer behavior presents a number of options to a utility program designer. OpenWay supports the breadth of possible solutions, and Itron provides ongoing leadership within standards development organizations to ensure that the list of options continues to expand.

As previously mentioned, DR programs typically carry a financial incentive to motivate participation. Incentives may take the form of either a special utility-supplied service, which requires participation in DR events, or application of a tariff which exposes the customer to fluctuations in wholesale energy prices. The most common residential DR programs are incented by the following tariffs:

- Critical peak pricing (CPP)
- Variable peak pricing (VPP)
- Time-of-use (TOU)
- Peak time rebate (PTR)

Additionally, some regulatory jurisdictions—particularly those with decoupled rates—encourage energy efficiency and reductions in consumption for their own sake, regardless of available generation supply. Still other jurisdictions have strict requirements mandating the maintenance of spinning and non-spinning reserves which can be met with demand management resources (such as a DR program). The point here is while rate tariffs may often define DR programs, they will not always. This again highlights the need for infrastructure which can accommodate any number of programs, which may run concurrently and may change over time.
Likewise, for in-home technology for automation and customer engagement, there will not be a single model for ensuring customer participation in programs. Some customers will rely on web presentment and SMS text messages to stay informed about events and incentives; others will rely on dedicated in-home displays. Automation of demand reduction through the use of programmable communicating thermostats and load control switches and/or "smart plugs" may be linked to DR programs sponsored by a utility, or may be part of an energy management strategy that has nothing to do with the utility or retail energy rates. The diversity of customer engagement technologies illustrates the importance of enabling an ecosystem of innovative customer-facing products through the adoption of open standards, such as the Smart Energy Profile.

Delivering Demand Response through OpenWay

OpenWay accommodates the diversity of DR programs and customer engagement tools by focusing on solution delivery. Any given utility implementing an AMI network will need to run multiple DR programs, some of which may be controlled by third parties other than the utility. Over the lifetime of a 20-year AMI deployment, a utility's portfolio of DR programs and associated device and software vendors may also change. Such a diverse and dynamic environment demands a flexible, open architecture to ensure the successful implementation of DR and customer engagement. OpenWay provides this flexibility by meeting three strategic requirements:

1. Enable DR capability throughout an entire service territory (see *Ubiquitous Demand Response Capability* on page 5)
2. Ensure efficient addressing and grouping of meters and devices (see *Meter Addressing and Grouping* on page 7)
3. Allow smart meter functionality to provide edge intelligence for robust DR applications (see *Smart Meter Edge Intelligence* on page 7)

Ubiquitous Demand Response Capability

Every OpenWay meter (electricity or gas) is equipped with a ZigBee Smart Energy component for behind-the-meter communications, and each OpenWay meter integrates system-wide solutions with Smart Energy-compliant devices.

Every OpenWay electricity meter, whether an Itron CENTRON® meter or a third party meter integrating OpenWay communications, functions as a Security Trust Center and ZigBee network coordinator which provides device management and diagnostics. High-power, high-link margin RF communications, device management, security policy enforcement and home-to-grid communications gateway functionality is supported in every OpenWay electricity meter; these are not optional features which may or may not be present at various service points. As a result, every C&I and residential location in an OpenWay deployment are potential participants in DR programs.

The ZigBee Smart Energy Profile implementation on OpenWay electricity meters includes functionality for device provisioning and management, dynamic pricing including TOU and CPP, text messaging, and metering/sub-metering. OpenWay meters support management of up to 10 home area network (HAN) devices at a given time. Two-way communications are supported by delivering messages from upstream systems to devices, as well as logging responses and HAN system events. HAN logs maintained in electricity meters can be retrieved at any time, using either point-to-point "interactive" reads to a single meter, or using periodic reads of groups of meters (the frequency of periodic reads, typically several per day, is configured by the utility). These features combine to enable OpenWay service point to participate in DR programs actuated by various mechanisms, including direct load control, price triggers, or direct manual intervention informed by energy management tools which leverage near-real time metering and sub-metering data.

On the AMI network, ubiquitous DR capability also requires consistent delivery and quality of service for DR messaging and two-way data traffic. This consistency must apply even where non-Itron meters are used, and when various local area network (LAN) transport technologies are used. OpenWay delivers DR functionality consistently by abstracting advanced metering functionality from underlying communications systems. Every meter and utility-controlled device on the OpenWay system is a C12.22 node, and thus uses a common application-level abstraction

layer protocol for registration, addressing, routing and message delivery. By default, most OpenWay meters communicate using Itron's 900MHz RFLAN mesh networking technology. However, as Figure 1 below illustrates, OpenWay ensures that even if other LAN technologies are in use, such as Itron's P-LAN power line carrier (PLC) technology or SmartSynch direct-connect modules, DR functionality will be consistently delivered to behind-the-meter devices and application platforms. This flexibility empowers utilities to maximize the value of their AMI investment by designing and managing DR programs across their entire service territory.

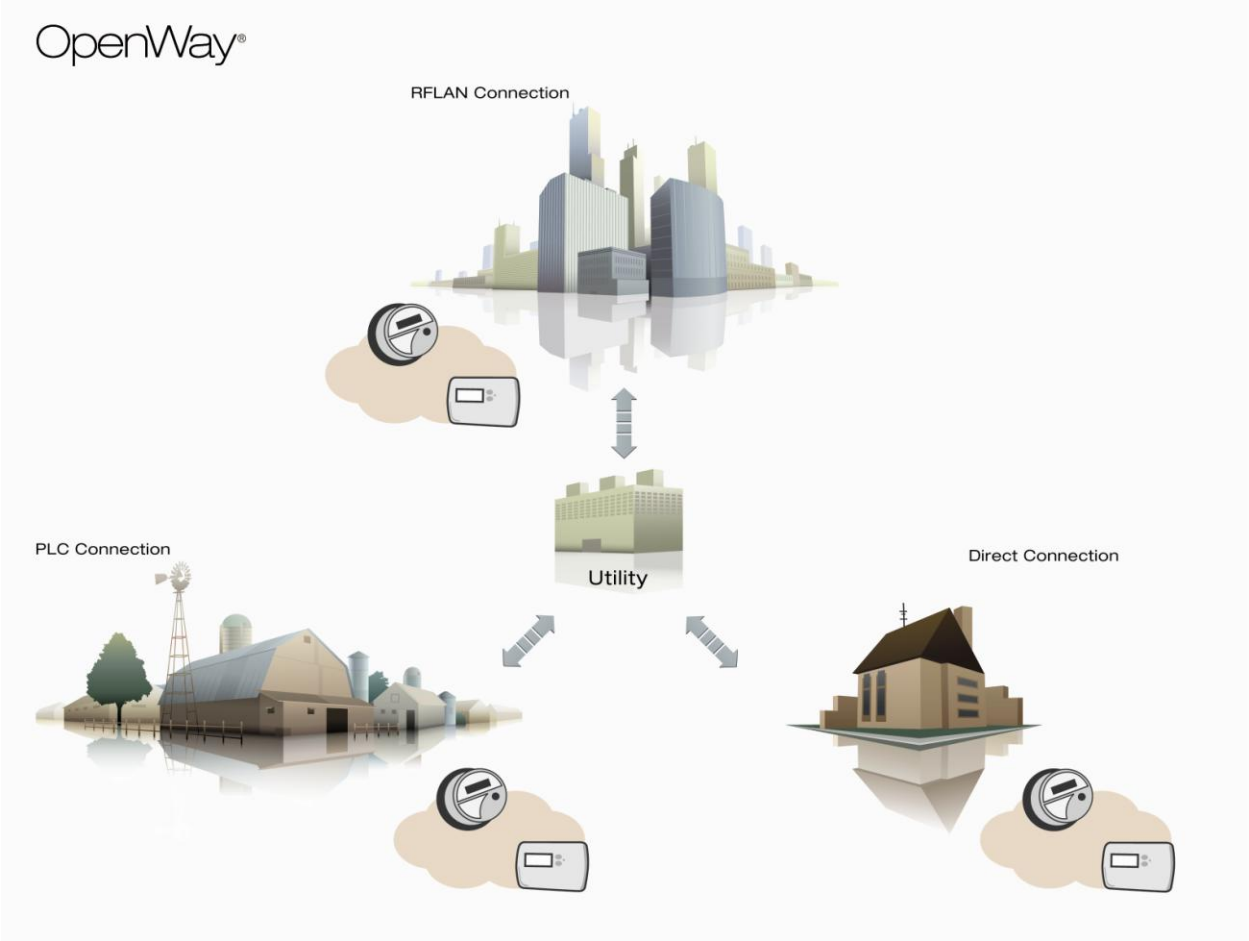

Figure 1: OpenWay Ensures Consistent Functionality

Meter Addressing and Grouping

Another important OpenWay feature is the ability to dynamically create addressable groups of meters and endpoints on a network. A group of endpoints (called “application groups” in OpenWay) can be defined based on any criteria, such as grid topology (e.g., substation or feeder), demographics, or geographic identifiers such as zip code, billing cycle, etc. Once an application group has been defined, a single message dispatched from back-office systems can target each member of the group in a single transmission, regardless of where the participating endpoints are located in the OpenWay system, or what communications technology is used by those endpoints. This means that DR program design and enrollment can proceed independently of system design, and changes in one do not impact the other. Since DR programs and their participants will change over time, decoupling communications networks from application functionality provides freedom in how DR programs are rolled out and modified over time.

Smart Meter Edge Intelligence

Since OpenWay electric meters are connected to both AMI networks (“in front of the meter”), and home area networks (“behind the meter”), security and scalability become concerns as more DR messaging traffic is targeted at growing numbers of HAN devices. DRM and MDMS systems should not be burdened with managing every aspect of device provisioning, security, addressing, and communications monitoring for each HAN device added to the system. However, the effectiveness of DR as a means of achieving load-shifting and load-shaping objectives is increased by encouraging more participating HAN devices on the system, including customer-purchased devices.

To overcome this problem, OpenWay provides ‘edge intelligence’ in smart meters to reduce device management burden on AMI network and back-office systems, while at the same time support increasing numbers of in-premise HAN devices. OpenWay meters provide device management and tracking functionality. This edge intelligence includes logic for provisioning HAN devices, establishing security keys, implementing retry transmissions for dropped messages, maintaining detailed communications logs for HAN devices, routing messages to appropriate devices and monitoring the state of devices on the home area network. Since these functions are performed at the meter, message traffic on the AMI network is kept to a minimum, and is only focused on the details of delivering utility functionality, not micro-managing devices. When issues do occur which require the attention of upstream devices or personnel, events and alarms are returned through OpenWay to enable appropriate action to be taken.

It is important to note that including support for these functions in OpenWay electric meters does not preclude a customer from deploying third party IP-to-ZigBee gateway devices or energy management platforms. HAN architectures in which customer broadband is used as a separate communications pathway, or in which energy service companies market services directly to customers, are also supported. This is possible because those gateway devices can provision securely with the electric meter, and communicate with devices independently of the electric meter. For example, Figure 2 below shows a deployment in which an energy management device provisions to the meter, and customer-purchased devices provision directly to the energy management device, In this way, utility and customer domains are separated, but all devices can consume the near-real time metering data from the electric meter.

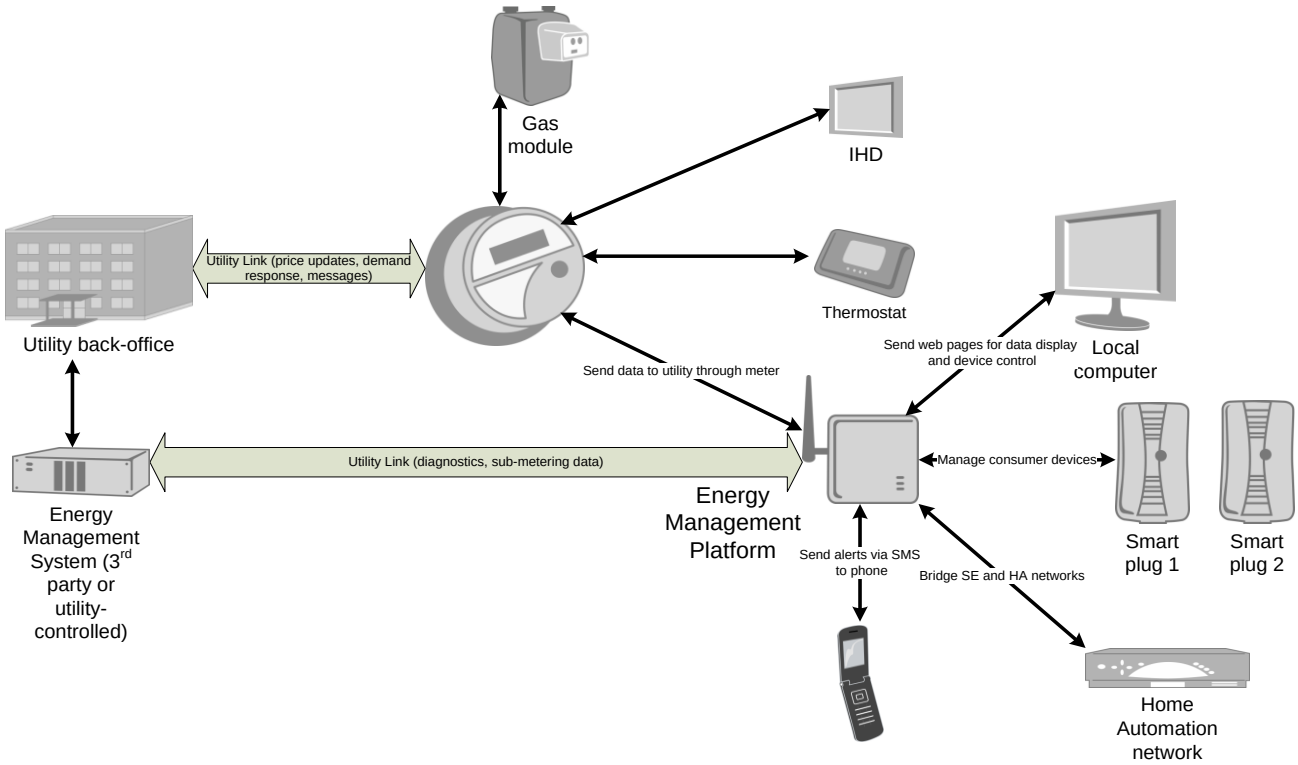

Figure 2: Utility and Customer Domains in the HAN

Measurement & Verification

An important aspect of many DR programs is the need to gauge the effectiveness of a particular DR event. Measurement and Verification (M&V) for demand response includes monitoring during a DR event, as well as reporting on participation and load shed after the event. Requirements for M&V reporting may vary by jurisdiction, but typically include validation of participation and load shed within a certain time frame after the event was dispatched. Generally, individual participation is determined by analysis of time-stamped interval data in an MDMS system. However, utilities must also demonstrate their effectiveness at dispatching DR events efficiently to qualify load as a biddable resource within an ISO. For residential programs, in which many small loads are aggregated into a single resource, it would be cost-prohibitive to provide real-time monitoring on each device capable of automating load reduction.

However, statistical sampling techniques can meet M&V requirements by closely monitoring a small subset of residential participants. Monitoring mechanisms may vary, but could include such techniques as:

- Immediately reporting DR event status messages from HAN devices to the DRM system
- Dedicated sub-metering on a specific load, for instance a hot water heater, to directly measure curtailment
- Immediately reporting exceptions, such as customer opt-outs and communications failures, to the DRM system

While it is the responsibility of the DRM system to capture data from OpenWay and create M&V reports, OpenWay supports all of these mechanisms for closely monitoring load resources. By targeting the right technology at representative samples, M&V requirements can be met in a cost-effective manner.

Security

Since DR messages include device control commands, as well as price signals delivered to in-home devices, security is of paramount importance to ensure that data originates from a trusted source and cannot be compromised by third party attackers. DR security must address three separate domains: the utility back office, the AMI network and the HAN.

- In the utility back office, NERC CIP cyber security standards consider systems and facilities capable of controlling more than 300MW of load to be "critical cyber assets" that must be protected by a CIP-compliant security perimeter. OpenWay includes security and key management appliances that meet this requirement by controlling physical access to security infrastructure and protecting cryptographic materials.
- On the AMI network, OpenWay extends C12.22 security by applying 128-bit Advanced Encryption Standard (AES) encryption to all network traffic, and signing command messages with digital signatures which allow OpenWay smart meters to verify the originator of messages. Messages returned to the utility are encrypted with a 128-bit AES key unique to the given meter, ensuring the privacy of the data, and limiting the ability of an attacker to forge data.
- On the HAN, digital certificates are used to authenticate devices to the correct OpenWay electricity meter, which acts as a Trust Center for enforcing security policy on the HAN. OpenWay includes a Trust Center policy in each electricity meter which enforces authentication policy, authorizes communications between devices on the HAN, and logs changes in device status on the HAN. Over the air traffic on the HAN is encrypted using 128-bit device-specific link keys that are computed using asymmetric cryptography. The OpenWay system allows monitoring of security events and denying device privileges based on violation of policy. Security measures within the HAN protect consumers by ensuring that data is not compromised by untrusted third parties, and ensuring that only control signals originated from a trusted source are acted upon by devices.

Conclusion

Residential and C&I DR programs vary in scope, objectives, and communications requirements. Support for DR programs in OpenWay allows utilities to leverage AMI and smart metering investments to maximize the efficiency of energy delivery. OpenWay's focus on open standards and architectural flexibility ensures the success of DR program deployment. The OpenWay features outlined in this document allow utilities to adapt to changes as new DR programs are rolled out, existing programs are modified, and more DR-capable devices are installed by customers. DR has the potential to transform the relationship between energy suppliers and energy consumers into a collaboration focused on maximizing the value of energy. OpenWay's DR infrastructure empowers utilities to take advantage of this trend over the lifetime of their advanced metering deployments.

Itron Inc.

Itron Inc. is a leading technology provider to the global energy and water industries. Our company is the world's leading provider of metering, data collection and utility software solutions, with nearly 8,000 utilities worldwide relying on our technology to optimize the delivery and use of energy and water. Our products include electricity, gas and water meters, data collection and communication systems, including automated meter reading (AMR) and advanced metering infrastructure (AMI); meter data management and related software applications; as well as project management, installation, and consulting services. To know more, start here: www.itron.com

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Itron Inc.
Corporate Headquarters
2111 North Molter Road
Liberty Lake, Washington 99019
U.S.A.
Tel.: 1.800.635.5461
Fax: 1.509.891.3355

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