

STANDARDS RESEARCH

Standards to Enable Automated Demand Response in Canada

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List of Abbreviations

ADR	Automated Demand Response
AHRI	Air Conditioning, Heating, and Refrigeration Institute
API	Application Programming Interfaces
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
BAS	Building Automation System
CEC	California Energy Commission
CIP-13	Critical Infrastructure Protection Standard 13
DER	Distributed Energy Resource
DERMs	Distributed Energy Resource Management System
DNP3	Distributed Network Protocol
DR	Demand Response
EMS	Energy Managaement System
EV	Electric Vehicle
HAN	Home Area Network
HEMS	Home Energy Management System
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electrotechnical Committee
NERC	North American Electric Reliability Corporation
NIST	National Institute of Standards and Technology
OASIS	Organization for the Advancement of Structured Information Standards
OBIX	Open Building Information Exchange
OCPP	Open Charge Point Protocol
SDO	Standards Development Organization
SEP	Smart Energy Profile
TLS 1.2	Transport Layer Security 1.2
UCM	Universal Control Module
VEN	Virtual End Node
VTN	Virtual Top Node

Executive Summary

Demand response (DR) is becoming an increasingly valuable and important resource for electric utilities and grid operators across Canada. This is driven by the expansion of intermittent renewable energy sources on both the utility and customer-side of the meter, the electrification of heating and transportation loads, and distribution system constraints in many urban areas. Automated demand response (ADR) addresses the uncertainty in traditional DR by removing human agents from the DR signal pathway. In ADR, the utility, grid operator, or program aggregator sends a signal to participating buildings or devices to cut power to non-critical applications and to change heating, cooling, or ventilation set points to reduce the power consumption of predetermined equipment.

There is a growing portfolio of standards for devices and equipment on the customer side of the meter to support participation in ADR. Over the past several years, standards for end-use devices have expanded their scope and now address gateway devices and thermostats, electric resistance and heat pump water heaters, heat pumps and central air conditioners, packaged terminal air conditioners, and pool pumps. Canadian and US electric utilities are deploying new ADR programs and pilot projects, particularly for the residential sector. While these programs are in their early stages and represent a minority of utilities' total DR savings and budgets, they have shown the potential to reach a broad participant base in the residential sector.

The literature review and research interviews conducted for this report identified market barriers and gaps in the current standards portfolio, and addressed which may enhance the uptake or effectiveness of ADR initiatives across Canada. Specifically, the research identified the following six barriers and gaps and the recommendations to address them:

- Utility cost (barrier)
  - Consider developing appliance standards to require ADR-enabled water heating.
  - Develop best practices guidelines for ADR program design and delivery for policymakers and utility regulators.
- Participant value proposition (barrier)
  - No recommendation identified.
- Interoperability (gap)
  - No recommendation identified. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is currently developing Standard 223P.
- Electric resistance heating (gap)
  - Engage the OpenADR Alliance and Consumer Technology Association (CTA) to assess the opportunity to develop a standard for ADR-enabled thermostats for resistance heating.
- Cybersecurity (barrier and gap)
  - Provide support for manufacturers adhering to CSA/ANSI T200 .
- Siloed standards (gap)
  - Consider developing utility guidelines for integrated ADR-DER (distributed energy resource) solutions.



"Demand response (DR) is becoming an increasingly valuable and important resource for electric utilities and grid operators across Canada."

1 Introduction

Until large-scale power storage becomes technically and economically viable, a fundamental principle of the electrical system is that generation and demand must be balanced at all times. In practice, this has meant that electricity providers need flexible generators capable of quickly ramping up and down in response to electrical system needs. Those generators ensure that electricity supply meets demand and provides resource adequacy.

This dynamic is shifting as utilities and end users add renewable generation sources to electricity grids across Canada. Solar photovoltaic and wind represented 68% of new electricity generation resources installed in Canada between 2009 and 2018 [1]. As of 2020, Canada had more than 13,500 MW of wind and 3,300 MW of installed solar electricity generation capacity, representing 6.5% of total electricity demand. This represents important progress toward decarbonizing the Canadian electricity system, but it creates new challenges for electric system operators because these resources are not available at all times. In 2020, the utilization rates (the amount of energy produced compared to the capacity of these systems) for wind and solar generation in Canada were 27% and 14% respectively [2].

Renewable generation from solar and wind is intermittent, meaning that these sources produce electricity only when the sun is shining or the wind is blowing. This shift away from flexible, highly-controllable fossil generation to intermittent renewable generation increases the potential for electricity demand to exceed available supply, particularly during electricity system peaks.

Another trend that compounds the challenge for utilities and grid operators is the electrification of heating and transportation loads, which has the potential to significantly increase electricity demand. Residential and commercial heating already drives electrical system peaks across much of Canada. As more households and buildings shift from natural gas or oil heating systems to heat pumps, there will be an increase in electrical system winter peaks [3].

There are three primary solutions to the problem of intermittent generation:

- Battery storage to capture renewable electricity for use when it is needed;
- Over-development of renewable generation and expansion of transmission infrastructure to facilitate electricity sales from regions with excess to regions in shortfall; and
- Transformation of energy consuming systems so they consume electricity when it is inexpensive and available and ramp down or cease operations when electricity is expensive and in high demand [4].

Demand response (DR) refers to an action by an energy user in a home or building to change energy demand in response to the needs or conditions of the electricity system. Utility DR programs engage homes and businesses with reliable, flexible loads that can

be reduced (shed) or shifted for periods ranging from a few minutes to several hours during electric system peaks when the marginal price of power is high. DR is becoming an increasingly valuable and important resource for electric utilities and grid operators across Canada. This is driven by the expansion of intermittent renewable energy sources on both the utility and customer sides of the meter, the electrification of heating and transportation loads, and increasing distribution constraints in many urban areas. DR offers Canadian utilities a cost-effective way to reduce peaks, manage marginal prices, and balance loads throughout the day to optimize the use of the least expensive or least polluting electricity generation sources [5].

DR offers significant potential to Canadian electric utilities. In the residential sector alone, two key DR opportunities, space heating and water heating, represent a combined 39 GW of peak demand, more than twice the total wind and solar power generation capacity. Widespread DR participation by homes across Canada is an important component of an economically viable, low-carbon electricity grid [6].

In 2020, Canadian utilities achieved DR savings ranging from 0.25% to 3.64% of peak electricity demand [7]. Most of these DR initiatives rely on a day-ahead signal to each participant — typically a phone call, email, or text message — from the originating utility or DR aggregator. The person responsible for energy control at the participating home or building, such as a facility manager, energy manager, building operator, or homeowner, receives the signal and takes an action to reduce their electricity demand during the DR event period, which in most cases lasts from two to four hours. The actions that participants take to reduce their demand depend on the building type and other factors. For example, an operator for a large commercial building might set the building automation system (BAS) to pre-programmed set points or switch to onsite generation, an operations manager at a manufacturing facility might temporarily shut down an energy intense batch process or production line, and a homeowner might turn down their thermostat or refrain from using the clothes dryer or electrical vehicle (EV) charger until after the DR event [8].

Regardless of the building or business type, traditional DR relies on individuals receiving a signal and taking action. The DR signal may take the form of a peak event notification and request to shed load during a certain peak time or a price signal such as a time-of-use (TOU) rate that disincentivizes energy consumption during certain times when utility marginal costs are higher and incentivizes consumption when marginal costs are lower. The reliance on people to take actions to reduce their electricity demand when the grid needs flexibility introduces significant uncertainty for utilities and grid operators regarding the timing and amount of load that will be shed or shifted. That uncertainty is a barrier to DR becoming a larger part of electric utility portfolios of supply and demand options. Several leading Canadian utilities are beginning to address that barrier through emerging initiatives in automated demand response (ADR).

ADR addresses the uncertainty in traditional DR by removing human agents from the DR signal pathway. Under an ADR program, the utility, grid operator, or program aggregator sends a signal to participating buildings or devices to cut power to non-critical applications and to change heating, cooling, or ventilation set points to reduce the power consumption of predetermined equipment. Depending on the communication protocol that is used, the signal may be sent to gateway devices in commercial buildings, which translate the signal into common control and automation protocols (BACnet [9], Zigbee [10], or proprietary protocols) and communicate with a BAS or energy management system (EMS). Alternately, the grid operator, DR aggregator, or distributed energy resource management system (DERM) provider may use one or more dedicated application programming interfaces (API) to send a signal to a networked device such as a BAS, EMS, networked lighting control system, or smart thermostat supported by a particular manufacturer or service provider (such as Siemens, Nest, or Tesla). The BAS or EMS then sends control signals to end-use equipment to reduce its electricity consumption according to the given system programming.

The value of flexible loads is increasing, driven by higher intermittent electricity supplies and the expanding electrification of heating and transportation loads. However, most end-use systems in the market today are not capable of receiving and responding to DR signals. An important role for DR standards could help provide a consistent basis upon which device manufacturers, electric utilities, and policymakers could develop an installed base of ADR-ready appliances, heating and cooling systems, and other technologies capable of optimizing consumption based on grid conditions.

The research conducted for this report investigated DR programs and initiatives administered by electric utilities and grid operators, with a focus on ADR and automated, price-based load shifting. This report presents the following findings and recommendations:

1. The current portfolio of standards and protocols governing the ADR environment;
2. The landscape of ADR programs offered by utilities and grid operators across North America;
3. Current market barriers and gaps in the standards portfolio that limit the uptake or effectiveness of ADR initiatives; and
4. Recommendations for potential new standards development and other activities to enhance the participation or effectiveness of ADR programs in Canada.

2 Methods

The findings and recommendations outlined herein are based on a thorough review of the published literature regarding DR programs, pilot projects, technologies, protocols, and standards. The researchers also conducted interviews with experts and market stakeholders from Canada and the US.

2.1 Literature Review

The literature review focused primarily on ADR rather than on traditional DR, although many technologies and protocols are relevant in both use cases. The complete list of sources consulted as part of the literature review is presented in the References section.

2.2 Research Interviews

Interviews addressed a range of topics relevant to ADR, including peak reduction potential, priority end uses and sectors, roles and limitations of open standards, market barriers to ADR, technical challenges and interoperation, and cybersecurity. Certain interviews involved two or more individuals from a given organization to address a broader range of research topics. Table 1 presents the research topics and questions asked during research interviews.

Organizations interviewed for this research included Canadian utilities and grid operators, ADR aggregators, standards development organizations, researchers, and government agencies. Table 2 presents the list of organizations interviewed.

3 Results and Discussion

This section presents the results and analysis of the literature review and research interviews regarding the barriers to widespread ADR participation, the current portfolio of standards for ADR, and the ADR program landscape in Canada and the US.

The following definitions are used throughout this section:

Standard refers to a published requirement or process developed and maintained by an accredited standards development organization (SDO), such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), CSA Group, and Institute of Electrical and Electronics Engineers (IEEE). Some protocols are published as standards, such as IEEE 1815 [12].

Communications protocol refers to a system of rules that enables communication between two different entities. Protocols discussed herein include published, open protocols, such as BACnet and proprietary protocols used by many technology providers.

Framework refers to a document similar to a standard that was developed by an organization that is not an accredited SDO, such as the Organization for the Advancement of Structured Information Standards (OASIS).

Table 1: Interview Topics and Questions

Research Topics	Interview Questions
DR potential and priorities	How much DR potential (MW) is available in your jurisdiction?
	What equipment types offer the greatest DR value in homes and commercial buildings in your jurisdiction?
Open standards for ADR	What roles, if any, do open standards such as OpenADR and ANSI/CTA-2045-B [11] play in your ADR strategy/solution?
	What are the limitations of open standards for ADR?
	Are there gaps in the current portfolio of standards for ADR?
	Are there gaps in the portfolio of standards governing the interface between electrical infrastructure and ADR/DERM service providers?
Barriers and interventions	What are the most significant barriers to widespread ADR participation by homes and commercial buildings?
	Beyond standards, what interventions are needed to enable widespread participation in ADR?
Interoperation in commercial buildings	What role do controls technicians, integrators, and engineers have in implementing ADR in commercial buildings?
	What are the primary drivers of ADR implementation costs in commercial buildings?
	How are BACnet and other building communication protocols being adapted to support ADR?
Cybersecurity	Does ADR expose utility-grid operators and participants to new cybersecurity threats? What are the most significant threats?
	What are the limitations or gaps in the current portfolio of cybersecurity standards?
	What is the current state of cybersecurity practices among ADR service and technology providers?

Table 2: Organizations Interviewed

Type of Organization	Number of Interviews
Electric utilities and grid operators	5
Government agencies	2
Researchers	3
Standards developers	2
DR providers	3
Controls engineering firms	1

3.1 Standards for Electrical Infrastructure

There are many standards and specifications that govern different aspects of ADR. ADR standards related to electrical infrastructure and dispatching DR loads are developed and maintained primarily by the IEEE, the International Electrotechnical Committee (IEC), and the National Institute of Standards and Technology (NIST). As a whole, these standards define the data and communications architecture for interactions between electrical infrastructure and distributed resources, including DR aggregators and participants. The electrical infrastructure standards most relevant to ADR are presented in Table 3.

In general, standards governing the operation and intercommunication of electrical infrastructure components, and communication between the grid and distributed energy resources (DERs) are generally established. The literature review did not identify any significant gaps in the portfolio of standards pertaining to electrical infrastructure.

Interview participants consistently indicated that communication and control within electrical infrastructure and between the electrical infrastructure and DR aggregators did not pose significant challenges for the design and delivery of ADR initiatives and programs.

3.2 Standards and Protocols for Electrical End Uses

There is a growing portfolio of standards for devices and equipment on the customer side of the meter to support participation in ADR. As with standards for electrical infrastructure, many standards for end-use devices are complementary and organized according to shared definitions.

Table 3: ADR Standards and Frameworks for Electrical Infrastructure

Standard or Framework	Description
IEEE 1815 [12]	*Electric power systems communications-distributed network protocol (DNP3).* Widely used standard for communications with substations and utility-owned DERs (distributed energy resources).
IEEE P2030.5 [13]	*Smart energy profile application protocol.* Standard for smart grid interoperability of energy technology and information technology with the electric power system and end-use applications and loads.
IEEE 1547 [14]	*Interconnection and interoperability of distributed energy resources with associated electric power systems interfaces.*
IEC 61850 [15]	*Communication networks and systems for power utility automation.* International standard defining data models and communication protocols for intelligent electronic devices at electrical substations. Defines communication protocols for a range of resources, including generators and DERs, and between substations and control centres.
IEC 61968-5 [16]	*Application integration at electric utilities – System interfaces for distribution management – Part 5:* Distributed energy optimization. International standard describing information exchange for distributed energy optimization.
NIST Smart Grid Framework 4.0 [17]	*NIST Framework and roadmap for smart grid interoperability standards, release 4.0.* Defines the smart grid, including layers, agents, roles and actions. This definition provides the structure according to which other standards in Table 3 and Table 4 are organized.
OASIS Energy Interoperation Version 1.0 [18]	Defines the interaction between smart grids and their end nodes, including smart buildings, enterprises, industry, homes, and vehicles. The standard includes data and communication models that enable the interoperable and standard exchange of signals for dynamic pricing, reliability, and emergencies.
OASIS OBIX Version 1.1 [19]	OBIX (Open Building Information Exchange) enables mechanical and electrical control systems in buildings to communicate with enterprise applications and to provide a platform for developing new classes of applications that integrate control systems with other enterprise functions.

The scope of standards for end-use devices has been expanded in the past several years and now addresses gateway devices and thermostats, electric resistance and heat pump water heaters, heat pumps and central air conditioners, packaged terminal air conditioners, and pool pumps [20]. The Air Conditioning, Heating, and Refrigeration Institute (AHRI) is currently developing a new standard (AHRI 1430, see Table 4) [21] to define the capabilities of connected, ADR-enabled water heaters. The OpenADR Alliance and OpenCharge Alliance are also developing open communication protocols for EV charging equipment. Table 4 presents standards and protocols for end-use devices, including those that are in an advanced development stage.

3.2.1 OpenADR

OpenADR 2.0 [24] is currently the most widely used open standard data model for ADR among US and Canadian utilities and grid operators. OpenADR defines a consistent data model for communication between utilities or grid operators, DR service providers, and end users (or between utility-grid operators and end users directly). OpenADR was developed by the California Energy Commission (CEC) and Lawrence Berkeley National Laboratory, with support from the US Department of Energy, and is maintained by the OpenADR Alliance, a group of utilities, government agencies, device manufacturers, and energy service providers. OpenADR provides a non-proprietary, open, and standardized data model that facilitates communication between electricity providers and DR

Table 4: Standards and Protocols for End-Use Devices and Equipment

Standard or Protocol	Description
AHRI 1380 [22]	*Demand response through variable capacity HVAC systems in residential and small commercial applications.* Standard for connected, ADR-enabled HVAC equipment. References the OpenADR 2.0 specification and ANSI/CTA-2045-B standard [11].
AHRI 1430 (in development) [21]	*Demand Response for Electric Water Heaters.* Standard for connected, ADR-enabled water heaters will reference the OpenADR 2.0 specification and CTA-2045 standard.
ANSI/ CTA-2045-B [11]	*Modular communications interface for energy management.* Standard to communicate signals from electricity infrastructure to end-use devices via a universal control module and a dedicated physical port on the device.
ASHRAE 90.1 [23]	*Energy standard for buildings except low-rise residential buildings.* Proposal currently in committee would add energy credits for OpenADR and CTA-2045 enabled systems.
IEC 62746-10-1 [24]	*Systems interface between customer energy management system and the power management system - Part 10-1: Open automated demand response (OpenADR 2.0).* Standard data model for communication between utilities or DR aggregator servers and DR participant client nodes. Supports participant feedback and multiple signal types (see Figure 1).
OCPP 2.0.1 [25]	*Open Charge Point Protocol 2.0.1.* Communications protocol for networked EV chargers and EV charging management systems.
Smart Energy Profile (SEP) 2.0	Communications protocol for smart meters, appliances, battery-powered devices, and other device types. Supports pricing, DR, billing, and other signal types. Incorporated as part of the IEEE P2030.5 [13] standard (see Table 3).

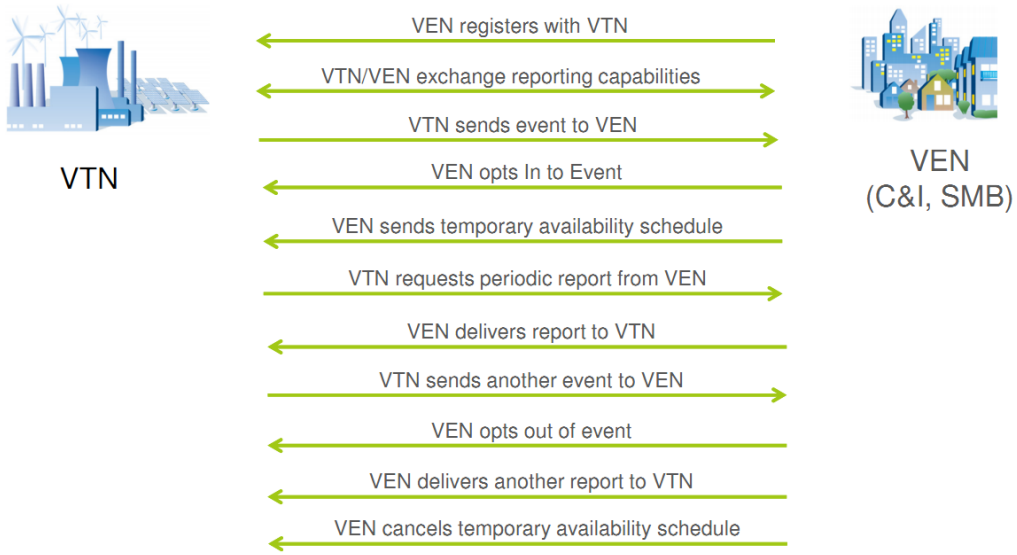
participants using a common language. The current version of the standard, OpenADR 2.0 [24], supports communication with end use, battery storage, and renewable energy generation devices on the customer side of the meter.

With OpenADR 2.0 [24], communication takes place between Virtual Top Nodes (VTNs) at the utility or DR service provider and Virtual End Nodes (VENs) at customer facilities, such as gateways, some thermostats and other devices, and ANSI/CTA-2045-B [11] enabled universal control modules. Depending on the level of on-board computing and communications, VENs may also send control signals to other appliances or devices at a location, such as to a building automation system (BAS) in a large building or to thermostats and other appliances in a home. OpenADR supports several types of communication between VTNs and VENs, including registration and set-up, DR event notifications, electricity price information, VEN event participation or opt-out feedback, and VEN availability (scheduling). These communication types and directions (VTN-to-VEN or VEN-to-VTN) are illustrated in Figure 1.

The OpenADR Alliance provides certification for supported devices and software. Devices and software may undergo a testing process to be labelled as OpenADR compatible (Intertek is the testing and certification agent in North America). Currently, the OpenADR Alliance has more than 100 device and software provider members, and there is a range of OpenADR certified products for the residential and commercial sectors, including lighting, thermostats, water heaters, gateways, BAS, EV charging software, and more.

OpenADR enables utilities and grid operators to communicate with DR aggregators or directly to a gateway device or other VEN at participating homes and buildings, but it does not offer visibility and communication at the device level. Communications and controls within the home or building are carried out using local protocols such as Wi-Fi, Zigbee, or BACnet. As discussed above, OpenADR enables communication to homes and buildings and several types of feedback signals from participants. These signals are sent intermittently. OpenADR does

Figure 1: OpenADR Communication Scenario



Excerpted from QualityLogic's OpenADR Training Workshop ©QualityLogic
Figure used with the permission of the OpenADR Alliance [26].

not support continuous information exchange between utilities, DR aggregators, and participants. The capabilities and limitations of OpenADR are summarized in Table 5.

Table 5: OpenADR Capabilities and Limitations

Capabilities	Limitations
Utility (VTN) to aggregator or customer building level (VEN).	Device level communication managed by the VEN using another protocol, such as Wi-Fi, Zigbee, or BACnet.
Participating VENs communicate to VTN using reports. Data packets sent at key times and intervals.	Participant data is intermittent, not continuous.

OpenADR uses the Transport Layer Security 1.2 (TLS 1.2) [27] encryption protocol for secure data communication. TLS 1.2 prevents eavesdropping on or tampering with the data transmitted between the utility or aggregator ADR server (the VTN) and client VENs in participant homes and buildings.

3.2.2 CTA-2045 Standard

ANSI/CTA-2045-B [11] standardizes the data format for signals from the grid to control actions at the device level. CTA-2045 compliant devices are equipped with a dedicated port (Ecoport) and enabled by a universal control module (UCM) that receives a load shedding or energy price signal from the utility or DR aggregator and then passes it to the device via the Ecoport. This interface is illustrated in Figure 2. As reported by Koch and Wickes [28], CTA-2045 UCMs can receive a range of signal types, including OpenADR [24], IEEE 1815 (DNP3) [12], and IEEE P2030.5 [13]. The standard was developed through a collaboration between the Consumer Technology Association (CTA), device manufacturers, the AHRI, and electric utilities. CTA-2045 enables smaller residential and commercial appliances (typically 5 kW or less) to participate in ADR. The standard currently supports water heaters, heat pumps, packaged terminal air conditioners, pool pumps, and EV chargers.

Figure 2: CTA-2045 Interface Diagram

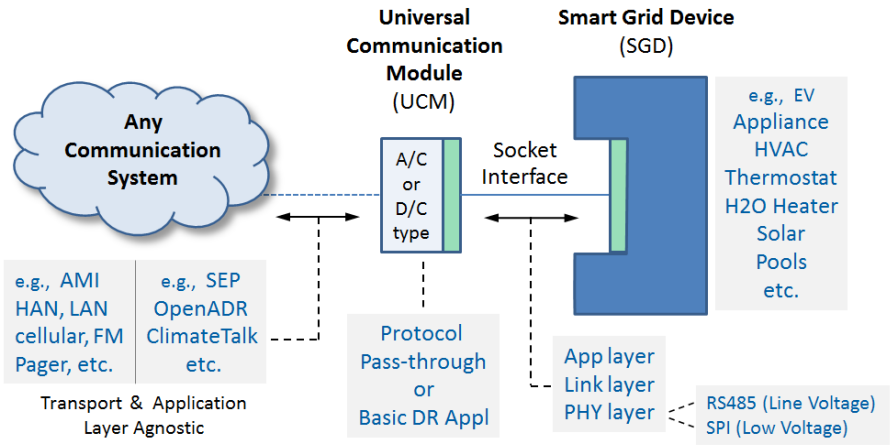


Figure used with the permission of the OpenADR Alliance [29].

CTA-2045 offers the potential for unmediated utility or aggregator visibility and control at the device level for certain appliances and equipment types used in homes and small businesses. Devices equipped with CTA-2045 ports and UCMs are capable of receiving and acting on OpenADR signals as well as providing feedback to the utility or aggregator. The current version supports a range of signal types, including the following:

- Three levels of load shed, including a grid emergency level that shuts down end use;
- Two levels of load up, including a soft start ramp;
- Electricity prices;
- Time-of-use rate schedules;
- Customer overriding (includes 72-hour return to grid control); and
- Efficiency recommendations.

3.2.3 Standards and Codes that Reference OpenADR and CTA-2045

AHRI standards use OpenADR and CTA-2045 to define networked, ADR-enabled HVAC and water heating equipment. Several US states have recently enacted legislation that includes appliance standards mandating CTA-2045 functionality in all new water heaters sold in those states.

AHRI 1380 provides standardized requirements for ADR-enabled HVAC systems in homes and small businesses. The standard relies heavily on the OpenADR 2.0 specification and CTA-2045 standard. AHRI 1380 specifies the communication pathways, protocols, connections, signals, and the DR actions that qualifying equipment can take.

AHRI 1430 (in development, anticipated publication in 2022) will establish a standard for ADR-enabled electric water heater application definitions, test requirements, operating and physical requirements, minimum data requirements for published ratings, marking and nameplating, as well as data and conformance conditions. The standard is being developed in collaboration with the OpenADR Alliance and is expected to reference OpenADR 2.0 and CTA-2045 in the definitions as well as in the operating and data requirements.

New appliance standards in California, Oregon, [30] and Washington [31] will require that new domestic water heaters sold in those states be ADR-enabled. In Oregon and Washington, new electric storage water heaters and heat pump water heaters are required to include a CTA-2045 port. Recent legislation in California (JA-13) [32] requires that new electric storage and heat pump water heaters be capable of receiving and responding to electricity price signals. CTA-2045 is referenced as one means of achieving this requirement.

3.3 Proprietary Systems for ADR

Another approach to enable utility communication with and control of end-use devices is to make direct partnerships with vendor companies that provide end-to-end ADR solutions. More and more technology providers and device manufacturers (Chargepoint, Tesla, GE, Google Nest) provide ADR solutions to utilities and grid operators. For example, Google Nest offers an ADR solution to utilities and DR aggregators for communication and control of Google's ADR-enabled smart thermostats. Tesla offers a similar service for EV chargers, customer-sited storage, and solar photovoltaic (PV) systems. These solutions may involve open standards such as IEEE P2030.5 [13] for communication with the utility operations centre or may be based entirely on proprietary telemetry. Utilities that take this approach are often confined to enrolling only participants that use devices or services from those vendors with whom they have an ADR relationship and dedicated API. The proprietary model typically entails ongoing costs (often associated with access to performance data) for utilities and sometimes also participants. Advantages and disadvantages of this approach are presented in Table 6.

Table 6: Advantages and Disadvantages of End-to-End Proprietary Systems for ADR

Proprietary Systems	
Advantages	**Disadvantages**
Minimal cost and technical challenge to launch.	Ongoing cost can impact cost-effectiveness.
	Participation limited to those using a given vendor's products (e.g., Nest).
Easy and familiar for participants.	Risk of stranded assets if a vendor discontinues support for a product or leaves the utility partner network.

3.4 Cybersecurity Standards and Frameworks for ADR

There are a range of cybersecurity standards and frameworks for utilities and network equipment providers. Despite this, many network-connected devices are highly vulnerable and not capable of identifying potential attacks or intrusions or notifying users that their data or control may be compromised. New standards based on foundational principles and best practices — such as "Do not include default usernames or passwords" or "Ensure that devices under attack cannot attack other devices" — have the potential to improve this situation by including audit protocols or test procedures that technology providers can use to assess and demonstrate compliance or their cybersecurity maturity level. Table 7 presents cybersecurity standards and frameworks that are relevant for utilities, DR aggregators, developers of network technologies, or connected equipment.

Utility regulation is a key to ensure that ADR vendors and the technologies of partners are secure [33]. The North American Electric Reliability Corporation (NERC) Critical infrastructure protection standard on *Cyber Security – Supply Chain Risk Management,* CIP-013 [34], requires utility supply chains and vendors to achieve a minimum level of cybersecurity.

Experts interviewed for this research indicated that, based on their experience, few technology and equipment vendors currently satisfy this minimum requirement.

Most of the standards and frameworks in Table 7 are intended for developers of network-connected equipment. Two of these, ETSI EN 303 645 [37] and CSA/ANSI T200 [36] provide guided structure for technology providers to assess the degree to which a device, or in some cases a company, complies with the standard. CSA/ANSI T200 is structured as a maturity model addressing six domains of cybersecurity and will allow companies to assess and demonstrate their maturity level across those six domains. CSA/ANSI T200 also includes an operational technology supplement specifically to guide utilities in using the standard to improve cybersecurity across their vendor network to achieve compliance with NERC CIP-13. At least one Canadian utility is currently using the draft CSA/ANSI T200 standard and OT supplement for electric utilities to assess the security level of all their vendors.

3.5 ADR-Enabled Appliances and Equipment

With the proliferation of intermittent renewable electricity generation and anticipated increases in electric system peaks across Canada, system operators will benefit from the high value of flexible loads

Table 7: Cybersecurity Standards and Frameworks Relevant to ADR

Standard or Framework	Relevant Sectors	Title
ANSI/CAN/UL 2900 [35]	Technology and equipment providers	*Standard for software cybersecurity for network-connectable products, part1: General requirements*
CSA/ANSI T200 [36]	Technology and equipment providers, utilities	*Software development and cybersecurity evaluation program*
ETSI EN 303 645 [37]	Technology and equipment providers	*Cyber security for consumer internet of things: Baseline requirements*
ISA/IEC 62443 [38]	Controls providers, utilities, industry	*Industrial communication networks – Network and system security*
ISO/IEC 27001 [39]	Controls providers, utilities, industry	*Information technology – Security techniques – Information security management systems – Requirements*
NERC CIP-013 [34]	Energy utilities	*Cyber security – Supply chain risk management*
NIST Cybersecurity Framework 1.1 [40]	Technology and equipment providers, buildings, industry, utilities	*Framework for improving critical infrastructure cybersecurity*

capable of optimizing their consumption based on grid conditions. One important role of standards could be to provide a consistent basis for device manufacturers, electric utilities, and policymakers to develop an installed base of ADR-ready heating and cooling systems and appliances.

AHRI Standards 1380 [22] and 1430 [21] provide new models for ADR-enabled equipment. AHRI 1380 sets out several principles that should be considered when developing requirements for other equipment types, including:

- Maximum temperature offset (heating-cooling): Establishes the maximum temperature set point change (reduction for heating, increase for cooling) for heating and cooling systems during DR events.
- Connectivity verification and operating state query-response: Equipment must be discoverable and available for monitoring to utility/DR aggregators to verify participation in DR events.
- Curtailment parameters: Equipment shall be capable of responding to three levels of DR curtailment: general, critical, and emergency. Curtailment levels correspond to maximum shares of equipment-rated loads (e.g., reduce to no more than 70% of rated load during general curtailment events) or direct the equipment to turn off certain components. This three-level curtailment is referred to as modulating curtailment in Table 8.
- Peak price signals: Equipment shall be capable of receiving a peak price signal and shall be configurable by the user to respond to the signals based on the user's price sensitivity.

Several other factors are also important to consider depending on the properties of a given type of equipment:

- Pre-heat/pre-cool: Heating and cooling systems with high thermal mass, such as hydronic heating systems and chillers, have the potential to pre-heat or pre-cool and use the stored thermal mass to "coast" the DR event with a controlled impact on occupant comfort.
- Post-event ramp: Chillers and electric boilers (for hydronic heating systems) could create demand spikes after DR events if they are not controlled to ramp up gradually, with potential costs for end users and the grid. Consider specifying default settings for chillers, boilers, and other technologies to ramp gradually back to full load after a DR event.
- Electro-mechanical technologies: Some important loads for DR programs, such as domestic water heaters and electric resistance heating, are most often sold as electro-mechanical equipment with no on-board digital controls.

Table 8 presents a summary of technologies with significant DR potential in Canada and the actions each can be used to curtail loads, based on the literature review and interviews. Two important technologies,

Table 8: DR Event Actions for ADR-Enabled Equipment

Equipment	Load Curtailment Actions
Domestic water heating	On/off response: Remove power from heating element(s) or adjust the heating element duty cycle. Modulating response: Reduce heating set point or remove power from one heating element or more (if a multi-element water heater).
Thermostat	Change temperature set point (heating or cooling), change timing or length of heating pulses.
Resistance heating	Adjust the duty cycle by changing timing or duration of power to heating coils.
Hydronic heating	Adjust the duty cycle by the changing timing or duration of power to heating element.
Air handler	Reduce fan speed (if variable speed) or shift to smaller fan (if two-fan system); change timing or duration of power to heating coils.
Rooftop makeup air unit	Reduce fan speed or shift to smaller fan/economy mode; change timing or duration of power to heating coils.
Chiller	Reduce compressor speed (if variable speed); change evaporator pressure, pre-cool; post-event ramp up.

heat pumps and air conditioners, are not included in the table, as these are addressed by AHRI 1380 [22].

In addition to the technologies discussed in Table 8, there are many types of home or building-scale thermal storage technologies, including solid state, ice thermal storage, phase change materials, and thermo-chemical processes. Their applications and efficiencies range according to technology and scale.

3.6 ADR Programs and Pilots

A small number of utilities and grid operators across the US and Canada currently offer ADR programs and pilots for their commercial and residential customers. The literature review and interviews identified two commercial and nine residential ADR programs and pilots in North America. These do not include traditional DR programs that rely on participating individuals to take action, such as executing a control sequence or changing a thermostat setting to reduce electricity demand.

The ADR programs and pilots follow three general designs:

- Utility-implemented peak event ADR;
- Aggregator-facilitated peak event ADR; and
- Load shifting based on time-of-use (TOU) or critical peak pricing signals.

Table 9 presents the ADR programs and pilots that were identified, their program designs, the participant sector and end uses, and the signal pathway along which the ADR signal travels.

Seven of the eleven utility ADR programs identified in Table 9 rely on OpenADR to communicate with participating loads. The water heater DR pilot from Bonneville Power Administration (BPA) uses OpenADR and CTA-2045 to directly control participating water heaters. The Sacramento Municipal Utility District (SMUD) commercial air conditioning DR program uses OpenADR to communicate with gateway devices owned and developed by the utility, which then send a control signal to BAS or networked thermostats over Wi-Fi. The SMUD EV load shifting program also relies on OpenADR signals sent to utility-owned gateway devices in homes, which communicate electricity price data to home EV charging equipment. Participating EV chargers use on-board logic to control charging based on electricity prices.

Programs developed by the California investor-owned utilities (IOUs; Pacific Gas and Electric, San Diego Gas and Electric, and Southern California Edison) use OpenADR in aggregator-led ADR offerings. For example, in the California residential air conditioning ADR program, the aggregator uses OpenADR to communicate DR events to participating OpenADR-enabled thermostats. BC Hydro's large commercial ADR pilot project installed gateway

Table 9: ADR Programs and Pilots

Program Administrator	Program Design	Sectors and End Uses	Communication Protocols	Signal Pathways
BC Hydro	Peak event ADR pilot	Large business – HVAC and lighting	OpenADR	Utility-originated OpenADR 2.0 signal sent to gateway device at customer facility. Gateway device communicates with end-use equipment via the BAS using BACnet or Zigbee protocols.
BC Hydro [41]	Peak rewards ADR pilot	Residential – Heating, water heating, EV charging	OpenADR and proprietary APIs	Utility-originated OpenADR signal sent to participating water heaters, EV chargers, and thermostats.
BPA-PGE [42] (OR-WA)	Peak event ADR pilot	Residential, low income – Water heating	OpenADR, CTA-2045	Utility-originated Wi-Fi or FM radio signal to CTA-2045 controller.
California IOUs [43]	Aggregator-facilitated ADR program	Residential – Air conditioning	OpenADR	Aggregator (Ohm Connect) communicates with participants' smart thermostats via TCP/IP signal.
Com Ed (IL) [44]	Peak event ADR pilot	Residential – Air conditioning	N/A	HAN with smart meter as the hub, based on Zigbee 2.0 communication protocol.
Consumers Energy (MI) [45]	Aggregator-facilitated ADR program	Residential – Heating, air conditioning	Proprietary (Google Nest)	Aggregator-originated signal to smart thermostats (Nest) via dedicated API during heating and cooling season peak events.
Energize Connecticut [46]	Peak event ADR pilot	Residential – Heat pump, water heating	Proprietary	Utility-originated signal to participating water heater manufacturers via dedicated APIs; manufacturers send control signals directly to water heaters.
Hydro-Québec [47]	Aggregator-facilitated DER program	Residential end uses (Commercial anticipated to launch in 2022)	Proprietary and OpenADR	Aggregator (Hilo) uses open standards and proprietary telemetry to communicate with and control end uses in response to grid peaks and electricity prices. Involves different signal pathways from the aggregator to participating homes and Zigbee for communication within the home.
SMUD (CA) [48]	Peak event ADR program	Commercial – HVAC, lighting, pumping, process, EV charging	OpenADR	Utility-originated OpenADR signal to OpenADR 2.0 certified VEN at the customer facility. VEN controls end uses directly or communicates with the BAS-BMS to control end uses.
SMUD (CA) [49]	Load shifting program with TOU and CPP	Residential – EV charging	OpenADR	Utility-originated OpenADR signal to utility-owned gateway devices in homes. Gateway device connects to the EV charger via a HAN and enables users to schedule charging times.
Yukon Energy [50]	Peak event ADR pilot	Residential – Resistance heating	Proprietary	Utility-originated signal to thermostats and water heaters via dedicated API during heating and cooling season peak events.

devices at participating businesses. During DR events, the gateways receive an OpenADR signal from the aggregator's VTN, which they translate and communicate into specific actions at the device level via BACNet, Modbus, or Zigbee. In both of these cases, the program aggregator collects feedback from participating loads to track demand reduction and program performance.

Three of the programs rely on technology vendors to manage communication and control interactions with participating devices. The Consumers Energy residential ADR program relies on an exclusive relationship with Google Nest and provided smart thermostats to participating homes. Google Nest functions as an aggregator using proprietary protocols to communicate with and control participating thermostats according to the needs of the grid. The Energize Connecticut residential water heater ADR program relies on relationships with several water heater manufacturers that offer connected, DR-enabled products. Energize Connecticut developed dedicated APIs to communicate DR event information and receive participation and performance feedback from each manufacturer's servers. The manufacturers were free to use proprietary telemetry or open standards to communicate with participating water heaters. The Yukon Energy pilot shows the risk that utilities face when working with a technology provider partner to deliver ADR. During the pilot, the thermostat provider ended its operations and ceased DR program support, leaving the utility unable to send DR signals to its participants.

3.7 Priority End Uses for ADR Programs

There was a high degree of consistency among utilities, grid operators, and third-party DR providers interviewed for this report regarding which end uses offer the greatest and most cost-effective ADR potential. According to these interviewees, electric storage water heaters and electric resistance heating offer the greatest ADR potential for Canadian utilities in the near term. This is consistent with other recent research on residential DR potential in Canada [6]. Domestic water heating is particularly valuable because short-term load shedding from water heaters often causes no reduction in comfort to a home's residents, who may not be aware their home is participating in a DR event.

EV charging was also cited as an important end use, but primarily from a risk mitigation perspective. Currently, the role of ADR programs with respect to EV charging is to shift charging times from peak daytime hours to off-peak times when utility marginal costs are lowest, generally at night. This research did not identify any load shedding DR programs enrolling EV chargers.

The value of commercial building loads to utility ADR programs varies across jurisdictions, depending on each utility's load shape and transmission or distribution constraints. Although commercial buildings offer higher load shedding or load shifting potential than homes on a per participant basis, the higher cost and complexity of enrolling building owners and overcoming interoperability challenges caused some interviewees to assign them as a lower priority for ADR programs than more accessible residential loads.

4 Barriers, Gaps, and Recommended Actions

This section identifies gaps in the current portfolio of ADR standards and other barriers to ADR participation. It also presents recommendations to enable the implementation of more widespread and effective ADR initiatives across Canada. In this section, *gap* refers to challenges directly related to standards, and *barrier* refers to other technical, market, or societal challenges.

As generation sources become increasingly intermittent and electric system peaks increase, standards have an important role to play in ensuring that the installed base of heating and cooling technologies are capable of optimizing electricity consumption in response to grid conditions. Some standards for key equipment already exist, including AHRI 1380 [22], for HVAC systems in homes and small businesses. Other standards are currently in development for residential water heating (AHRI 1430) [21] and for commercial buildings with BAS (ASHRAE 90.1) [23]. Although some important work has been done, there are still a number of barriers to ADR participation and gaps in the standards portfolio to address.

4.1 Barriers to ADR Participation

Although it offers important benefits for utilities and grid operators (reliability, feedback) and for participants (ease



"As generation sources become increasingly intermittent and electric system peaks increase, standards have an important role to play in ensuring that the installed base of heating and cooling technologies are capable of optimizing electricity consumption in response to grid conditions."

of use), there are significant barriers to the widespread adoption of ADR. Initial ADR research and development in North America began in 2002, and the OpenADR 1.0 specification was published in 2011 as part of a collaboration between the CEC and Lawrence Berkeley National Laboratory. Proprietary systems enabling ADR have been on the market since at least 2013. Despite being technically feasible and supported by both open standards and proprietary systems, ADR represents a small share of Canadian utility DR portfolios.

The literature review and research interviews identified three primary barriers to widespread participation in DR programs: utility costs, participant value proposition, and cybersecurity.

4.1.1 Utility Costs

Many traditional DR programs involving large commercial and industrial loads can justify participant acquisition and maintenance costs because each participant represents a sheddable load from tens of kilowatts to one megawatt or more. These costs present a bigger challenge for ADR programs serving the residential and small commercial sectors, where the DR potential per participant may only be a few kilowatts or lower. Residential ADR programs reviewed as part of this research reported demand savings of 0.3 to 2 kW per home during peak demand events.

Lower load shedding or load shifting potential means that it is not cost-effective for utility programs to offer site visits or equipment installations, such as sending electricians to participating homes to install receivers and switches to enable standard water heaters to receive and act on DR signals. Cost-effective mass market ADR programs for the residential and small commercial sectors will require appliances and other equipment with off-the-shelf DR capabilities.

Some technology and service provider business models rely on subscription revenues from utilities or grid operators to access energy performance data from their devices or participant homes or buildings using their platforms. Google Nest and Tesla are examples from the residential sector. Although the end-to-end DR solutions these companies offer can be attractive for utilities, the ongoing costs can pose a further challenge for program cost-effectiveness.

4.1.2 Participant Value Proposition

Similar to the utility cost challenge, the value proposition for home and small building owners to participate in ADR is weak in most jurisdictions. Because the sheddable loads from those participants are small, economic incentives from utilities and DR aggregators are very limited. These small incentives are generally insufficient to overcome the cost of purchasing and installing ADR-enabled appliances and completing the data sharing agreement or other paperwork required for program participation. Utility rate regulations in provinces across Canada also buffer electricity consumers from real-time spot prices, limiting or eliminating price signals that might otherwise underpin a robust value proposition for homes and small businesses to shift or shed loads according to grid needs.

Related to the value proposition, some of the interviewees for this research raised the issue of participant comfort and willingness to allow some degree of external control over their equipment or appliances. Any impact on comfort is likely to result in participants opting out of ADR initiatives, in part because the participant value proposition is already weak. Further, despite the increasing use of interval meter data and energy analytics to educate residents and building managers about their energy use, many utility customers are resistant to the idea of their electricity provider having visibility or control of their equipment. Interviewees expressed a range of opinions regarding ADR impacts on participant comfort, which may be related to the types of end uses enrolled in ADR programs. For example, shedding load from space heating and cooling is more noticeable and more likely to impact comfort than from domestic water heating.

4.1.3 Cybersecurity

Most ADR signal pathways involve communication via internet protocols, which raises potential risks for both participant data privacy and the physical security of electricity infrastructure.

Participation in ADR initiatives does not increase the risk to participant privacy in most cases because ADR generally does not involve new types of data or a new party with access or the responsibility to securely manage participant data. Regardless of whether electricity customers participate in ADR, electric utilities have access to and manage certain customer data. Likewise, if customers use networked or internet-connected devices such as smart thermostats, smart home hubs, or networked lighting control systems, their technology providers already have access and management responsibility for customer data.

Although participating in ADR itself is not likely to increase participant cybersecurity risks, the purchase and use of networked equipment such as smart thermostats and appliances may increase the overall cybersecurity risk to a home or business. These technologies inherently increase the user's exposure to privacy and physical security threats, including data breaches and control of equipment by hostile third parties, regardless of that user's participation in ADR.

Widespread ADR participation presents a somewhat increased risk of attacks targeting electrical infrastructure. If attackers achieve synchronized control of a group of networked devices such as smart thermostats or water heaters using the same control platform, they could potentially cause these devices to disconnect and create local frequency disruptions or create sudden, disruptive shifts in electricity demand. This risk is greater in homogenous networks (more devices using the same communication and control platforms). However, according to experts interviewed for this research, these types of attacks pose a low risk of causing damage or widespread service disruptions.

In addition to the security risks described above, utilities face potential risk of non-compliance with NERC CIP-013 [34] requirements if vendors involved in their DR programs and pilots cannot certify the security of their technologies.

4.2 Gaps in the ADR Standards Portfolio

In addition to the barriers discussed above, the literature review and research interviews highlighted several gaps in the current ADR standards portfolio, which are described below.

4.2.1 Interoperability of Commercial Building Technologies

ADR relies on seamless communication and control along a signal pathway beginning with electrical infrastructure and ending at a participant device. The pathway may pass through an aggregator or service provider cloud, a gateway or hub device in a building (such as a Tridium JACE [51] in large commercial buildings or a smart thermostat or smart meter in homes), or a BAS or home energy management system (HEMS) and may involve translation across multiple communications protocols. Communication and interoperation pose considerable challenges for ADR programs, particularly "bring your own" programs that allow participants to use the hub or platform of their choice.

The interoperability challenge is most acute in commercial buildings with controls and automation systems. Many automation systems rely on the BACnet protocol for communication between sensors, end-use systems, and control platforms. There is little

consistency across buildings or control providers in the way that those components are tagged and labelled. This lack of standardization means that any significant automation and control programming in a building with an existing BAS requires either prior knowledge of that building and the semantics of its programming or a lengthy discovery process carried out by an experienced technician. This lack of standardization entails significant risk in addition to time and cost. One interviewee provided the example of a building with an onsite server room: a technician without detailed knowledge about the building and its programming semantics might program the cooling systems to turn off or turn down in response to a DR signal, which could result in damage to the servers and potential data losses or IT service disruptions.

ASHRAE is currently developing an ambitious new standard, 223P, Designation and classification of semantic tags for building data [52], to provide clear guidelines to address programming semantics in BACnet.

4.2.2 Electric Resistance Heating

Electric heating in homes constitutes a large share of the electric system peak in many Canadian jurisdictions, but there are few commercially available DR-enabled resistance heating products. Electric resistance heating is not addressed by ANSI/CTA-2045-B [11]. The development of a low-cost, standardized solution for ADR-enabled resistance heating would provide Canadian ADR programs access to a large and valuable load resource. However, electric resistance heating may be a challenging load for DR programs because resistance heating units are typically small and decentralized in the home, with each unit or room using a dedicated thermostat. Adding ADR capabilities to these systems may increase their cost beyond what the market is willing to support.

4.2.3 Cybersecurity

Recent standards development has largely addressed the need for transparent, assessment-based cybersecurity standards for network technology and connected equipment providers. ETSI TS 103 701, *Cyber security for consumer internet of things: Conformance assessment of baseline requirements* [53] was published in late 2021 and CSA/ANSI T200 [36], *Software development and cybersecurity evaluation program* in 2022 (see Table 7 for details). Based on the experience of organizations whose representatives were interviewed for this research, most technology and equipment vendors today fail to comply with these standards. Likewise, many products installed in homes and buildings or on the market are vulnerable to cybersecurity threats. Utilities may be able to exercise significant pressure on their vendors and supply chains to improve the security of their products and certify their compliance with current standards.

4.2.4 Siloed Standards

Representatives from two organizations interviewed for this research noted that the current ADR standards and communication protocols, namely DERs such as customer-sited solar and energy storage and communication with EV charging networks, are siloed and do not facilitate the development of holistic smart grid or virtual power plant solutions. Current standards and protocols, including IEEE 2030.5 and OpenADR, are valuable building blocks, but there is an important role for smart grid service and technology providers to knit these blocks together into holistic solutions using proprietary telemetry. This issue does not specifically represent a gap in the ADR standards portfolio, however, as ADR and DERs represent elements of a holistic smart grid solution, the next big step in standards development for an integrated, agile grid may be to integrate communication standards for ADR, DERs, and EVs.

4.3 Recommended Actions

The recommendations are based on the gaps and barriers identified during the literature review and research interviews and on suggestions from interviewees. They are summarized in Table 10 and discussed in more details in this section.

Table 10: ADR Barriers, Gaps, and Recommendations

Capabilities	Recommended Actions
Barrier: Utility cost	Consider appliance regulation to require ADR-enabled water heating. Develop best practices for ADR program design and delivery.
Barrier: Participant value proposition	None identified.

Capabilities	Recommended Actions
Gap: Interoperability	None identified (ASHRAE currently developing Standard 223P) [52].
Gap: Electric resistance heating	Assess the opportunity to develop a standard for ADR-enabled thermostats for resistance heating.
	Investigate the market viability of ADR-enabled resistance heating.
Barrier and Gap: Cybersecurity	Provide support to manufacturers adhering to transparent, auditable cybersecurity standards.
Gap: Siloed standards	Develop utility guidelines for integrated ADR-DER solutions.

Consider appliance regulation to require ADR-enabled water heating

Domestic water heating presents an appealing load flexibility resource, but the cost of incentivizing new equipment or retrofitting existing water heaters to be ADR-ready presents a considerable challenge at scale. Washington, Oregon, and California recently adopted new appliance regulations requiring new water heaters sold in those states to be ADR-enabled; the legislation references Open ADR 2.0 and CTA-2045 as compliance pathways. Canadian provinces should consider adopting similar regulations to ensure that newly purchased water heaters are capable of participating in ADR programs and that grid operators have access to a broad base of flexible load resources.

Develop best practice guidance for ADR program design and delivery

Most Canadian utilities are in the pilot or demonstration phase of ADR program development. These early-stage activities will test different ADR communication and control strategies, program delivery models, and end-use technologies. This presents a good opportunity to conduct detailed research into ADR program design, delivery strategies, and lessons learned to inform the development of the next generation of ADR programs at scale. Another approach would be to convene Canadian utilities and facilitate knowledge sharing about their ADR pilot and demonstration project experiences and lessons learned.

Assess the opportunity to develop a new standard for ADR-ready thermostats for resistance heating.

Electric resistance heating emerged as a high priority end use among utility staff and grid operators interviewed for this project, but there are few DR-enabled electric resistance heating products available on the market. There is potential to build on the existing CSA standard for thermostats in resistance heating applications to develop a new standard for ADR-ready thermostats serving electric resistance heating. Standards developers should seek input from the OpenADR Alliance since it may have information or expertise to support such an effort.

This research should also assess the market viability of ADR-ready resistance heating. Resistance heating products are typically very inexpensive and disaggregated throughout the home. Adding network technology and controls to these devices has the potential to increase the cost of each device beyond the DR value each heating unit or home can provide to the electricity system.

Provide support to manufacturers adhering to transparent, auditable cybersecurity standards, such as CSA/ANSI T200

Recent cybersecurity standards such as ETSI EN 303 645 and CSA/ANSI T200 offer transparent frameworks to assess a product or company's level of cybersecurity. The OT supplement to CSA/ANSI T200 for electric utilities will be particularly valuable for the development of ADR or DER initiatives and programs. However, as interviewees pointed out, many smaller technology providers are likely to struggle to invest in improving the security of their devices. Support from Canadian utilities for small equipment and technology providers, such as DR-enabled electric resistance heating manufacturers, to undergo cybersecurity testing could address this barrier and advance the capabilities and competitiveness of domestic technology providers. Collaboration between Canadian utilities to provide funding to enable Canadian technology providers to grow and serve this market has the potential to improve the risk position and ADR potential for utilities and to provide economic development for local industries.

Develop utility best practices or key considerations for integrated ADR-DER solutions

Interviewees indicated that one gap in the current smart grid standards portfolio is that the most widely used communication standards and protocols for ADR (OpenADR) and DERs (IEEE 2030.5) are not well aligned. This increases the complexity of creating holistic smart grid solutions. Third-party technology providers such as Hilo and Sohnen Enterprises are addressing this challenge with proprietary



"DR, and ADR in particular, are important tools for utilities and grid operators to control peak demand and shift flexible loads to times when electricity is inexpensive and renewables are available."

standards and telemetry, but there may be value in the development of guidelines and key considerations for utilities and grid operators as they develop holistic offerings that include both ADR and DERs, whether they are partnering with a third-party provider or developing in-house technologies and solutions. Such guidance could also provide direction to third-party providers regarding Canadian utilities' priorities and needs and serve as a starting point for utility smart grid vendor engagements.

5 Conclusion

The proliferation of intermittent renewable energy sources and the rapid electrification of heating and transportation loads have the potential to drive electricity system peaks higher and dramatically increase costs to electricity ratepayers. DR, and ADR in particular, are important tools for utilities and grid operators to control peak demand and shift flexible loads to times when electricity is inexpensive and renewables are available. As these forces change the dynamics of the electricity system, it will be important to develop an installed base of ADR-ready end uses capable of shifting their consumption in response to signals from the grid. Standards have an important role to enable utility programs and regulators to develop programs and policies and to help consumers make informed purchase decisions that contribute to an installed base of ADR-enabled flexible loads.

ADR standards and protocols are in place or in development for many important end us–es, including heat pumps and central air conditioning for homes and buildings, domestic hot water (in development), and EV chargers. Standards and digital communication protocols have addressed some of the key technical barriers to ADR, such as interoperability across utility and end-user technology platforms and within complex home and building technology environments.

A number of utilities and grid operators across Canada and the US have pilot projects or programs for these technologies, the most common being programs for residential central heating and cooling. Electric resistance heating offers significant peak demand reduction potential in Canada but has generally not been the target of ADR programs to date. The development of new standards for ADR-ready electric resistance heating units and thermostats may provide Canadian utilities increased access to residential heating loads.

Though standards are necessary to enable widespread ADR participation, they may not be sufficient because some of the most important barriers to ADR participation are not technical. The ADR value proposition is very weak for most small loads, such as homes and small businesses. Because electricity customers in Canada generally pay a consistent price for the electricity they consume, regardless of time of day or the marginal cost of power, consumer economic incentives and the costs to utilities and society are poorly aligned. To encourage widespread ADR participation, it will be important to achieve better alignment of consumer and utility objectives during electric system peaks through rate design or other means.

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