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Connected Home IoT Energy Roadmap

LANDMARK RESEARCH REPORT

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Connected Home IoT Energy Roadmap

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The Steering Committee contributed their time and industry expertise to the project at numerous Web conference meetings, offline sessions with the research team, and through interim and final review of the research processes, discussion guides, and this extensive report. The organizations and their representatives are:

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PROJECT BACKGROUND AND INTRODUCTION

The Continental Automated Buildings Association (CABA) is a not-for-profit industry association dedicated to the advancement of connected home and intelligent building technologies. The Connected Home Council (CHC), a core working council of the Continental Automated Buildings Association (CABA), commissioned this landmark research project, titled "Connected Home IoT Energy Roadmap," to evaluate and obtain a comprehensive understanding of the industry and consumer perception regarding energy aspects of connected homes. CABA commissioned Frost & Sullivan to undertake this research project which commenced in December 2017 and was conducted over a 20-week time period.

The evolution of the connected homes industry has seen an increasing level of integration of various technologies which interact with each other for the purpose of controlling, monitoring, and coordinating occupant comfort/convenience and energy savings. Energy management is one of the key functions performed by integrated connected homes. As the market continues to evolve, the requirement for energy management will continue to grow because the consumption of energy is a key aspect of connected home technologies and plays a major role in overall home costs. Various adoption challenges for connected home devices in the context of energy management are present within the connected home ecosystem. As these could impact further market penetration of connected home products and solutions as a result of consumer skepticism and perceived virtual security risks, CHC members have sought to understand the implications of this on stakeholders.

The report provides an analysis and evaluation of industry trends and challenges in addition to consumer feedback regarding connected home energy aspects. It looks into consumers' concerns about high energy consumption, expectations regarding connected home energy solutions, challenges associated with adoption of connected home devices for optimizing home energy usage, current and future adoption of various connected home technologies and their impact on homeowners and industry value chain participants. Further, the development of a Connected Home IoT Energy Roadmap for short-, medium-, and long- terms has been undertaken.

The executive summary offers a concise snapshot of the entire research project in a distilled manner, concentrating on the high-level and critical aspects of the findings.

ROLE OF THE STEERING COMMITTEE

The Steering Committee represents a cross-section of vendors, service providers, industry associations, utilities, and experts in the connected home, automation, and smart devices marketplace. Representatives from each organization joined Frost & Sullivan and CABA on regular collaboration calls to guide the research scope and ensure that it met project objectives. Figure ES 1 shows the 14 companies and organizations that supported the project as Steering Committee members and funders.

Figure ES 1 Project Steering Committee and Funders

About CABA
The Continental Automated Buildings Association (CABA) is an international not-for-profit industry association, founded in 1988, dedicated to the advancement of connected home and building technologies. The organization is supported by an international membership of over 385 organizations involved in the design, manufacture, installation and retailing of products relating to home automation and building automation. Public organizations, including utilities and government are also members. CABA's mandate includes providing its members with networking and market research opportunities. CABA also encourages the development of industry standards and protocols, and leads cross-industry initiatives.

Please visit http://www.caba.org for more information.

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The Project Consulting Team
Frost & Sullivan led the research project for CABA, with integral support from Frost & Sullivan's Customer Research Group. The core consulting team and report contributors are:

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RESEARCH OVERVIEW

Connected homes represent innovative applications of technology meant to enable an improved lifestyle and optimize various functions for its occupants. Energy is an integral part of the connected home ecosystem, and one that is increasingly functioning in a less standalone manner. The connected home IoT energy landscape is evolving and industry participants are retooling old business models to include more services and innovative products. The focus of this research is to study aspects regarding the use and energy consumption/management of these systems in the home. The adoption of these advancements in technology has met with varying levels of success across different application areas due to factors such as initial cost, ease of use, ease of installation and maintenance, proven reliability, integration characteristics, and payback that can offset costs via energy savings.

Key Objectives of the Consumer Research Survey are:

- Current consumer understanding of the constituent characteristics of a connected home
- Concerns regarding home energy consumption and perceptions of cost trends
- Current and future adoption of various connected home technologies
- Perceptions of connected home technology challenges
- Adoption trends of home energy-saving solutions
- Consumer expectations regarding connected home energy solutions, and the degree of satisfaction in reference to those expectations
- Perceptions regarding involvement with utility energy programs

METHODOLOGY

Frost & Sullivan used a combination of primary and secondary research methodologies to compile information for this project. This included both qualitative research and quantitative tools for analysis and projection of key issues.

Primary Research Process
Primary research formed the basis of this project, with two major components: an industry-focused research module and a consumer research module. The description of each is provided below in Table ES 1.

Table ES 1 Primary Research Methodology Description

Item	Component	Description	Target Group Profile	Sample Size/ Actual Size	Research Technique
A	**Homeowners/ Consumers**	Consumers of connected homes/smart devices/energy efficient home technologies	Occupant/Homeowner in US and Canada	1,000-1,200/ 1,234	End-user survey through online panels and survey methods
B	**Connected Home Technology Vendors and Service Providers**	Vendors/suppliers of connected home technology solutions; IoT solution providers; managed service providers; third party assimilators and integrators	Vice Presidents, Directors, Product/ Sales Manager, R&D Specialists, CIOs, CTOs, Alliance Partners	60-75/ 80 percent of target achieved	Analyst Interviews with Industry Stakeholders
C	**Utilities and Energy Solution Providers**	Utility solutions like smart meters, Sensors and Controls, Renewable Energy Technology providers and grid based solution experts	Utility CEOs/Grid Architects; Retail Consumer Heads; Home Energy Solution and Business Model Decision Makers	25-30/ 70 percent of target achieved	By Invitation Panel/Forum based Analyst Discussion Techniques
D	**Industry Influencers**	Codes and Standard Development Organizations for connected environments and IoT, Energy Policy Influencers, Regulators, Industry Associations, Academic Influencers, Municipal Authorities	Consulting Engineers, General Contractor, Master Service Integrator, Technology Contractor, Project Designer, ESCO, Specifiers, Commissioning Agents	20-25/ 70 percent of target achieved	Analyst Interviews with Industry Stakeholders
Overall Sample Size (A+B+C+D) = 1,110-1,330					

Frost & Sullivan adopted extensively structured and high-profile discussion techniques with target participants for the industry-focused primary research, involving single or multiple senior level personnel and Frost & Sullivan's team of analysts and consultants to engage in insightful deliberations on the subject. This resulted in maximum value output in terms of information exchange and excellent validation of findings from the consumer research survey. Similarly findings of the consumer survey were triangulated with insights from the industry-focused primary research process.

Research Instruments: Questionnaire/Discussion Guide

The discussion guides for both modules of the primary research process were developed by Frost & Sullivan in consultation with the steering committee. Draft discussion guides were reviewed at the early stages of the project and feedback was mutually exchanged between the project team and the steering committee. Thereafter, the discussion guides were run through a soft launch process for market testing. Subsequently, the two research modules were launched. The sample for both research modules were generated using Frost & Sullivan's vast repository of contact sources and databases. The industry-focused primary research accomplished an average 75 percent fulfillment of the target sample. The data obtained from these discussions were analyzed and distilled into the commentary of the report. The online consumer survey was launched and remained active for a period of 10 weeks in the field. A total of 1,234 responses were collected against an original target of 1,200. The data from these responses were then analyzed using various qualitative and quantitative tools for interpretation in the report.

Secondary Research

Secondary research comprised the balance of the research effort and included published sources such as those from government bodies, think tanks, industry associations, Internet sources, the CABA Research Library, and Frost & Sullivan's repository of research publications and decision support databases. This information was used to enrich and externalize the primary data. References are cited on the first instance of occurrence. Dates associated with reference materials are provided where available.

Any reference to "Frost & Sullivan's research findings, industry interactions, and discussions" in this report is made in the context of primary research findings obtained from this project "Connected Home IoT Energy Roadmap," unless otherwise stated. However, the analysis and interpretation of data in this report are those of Frost & Sullivan's consulting team.

Definitions and Consumer Survey Qualification Criteria

For the purpose of this research, a connected home is defined as "a residential environment where owners/occupiers use smart devices, appliances, communication features, controls, centralized hubs, and other functionalities that are enabled by information technology that anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, energy savings, and security, among other functions. This definition helped in defining a rapidly evolving concept with a broad stroke, thus providing study participants a degree of flexibility in envisioning and discussing it. Based on this definition, the connected home landscape encompasses participants from all leading product and solution categories, including integrated platforms, connected home devices, energy management, network technologies, utilities, and IT and Internet security technologies.

Participants in the consumer survey were offered the same definition of a connected home; however, for easy understanding and screening purposes, a battery of screening questions was asked as part of the qualification criteria before allowing them to proceed with the survey. The respondent screening and qualification process entailed the following qualifiers:

- Had to be 18 years or older
- Country classification of respondents (US/ Canada)
- Number of people living in a house
- Average gross household income per year
- Played a role in the decision-making process for investments in connected home solutions

Qualified respondents were further categorized by the following:

- Geographic distribution—urban, suburban, rural
- Type of home unit— apartment, condominium, single family home, semi-detached home and townhouse.

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Figure ES 2 and ES 3 respectively show the respondents profile, geographic distribution and type of home.

Figure ES 2 Respondent Profile

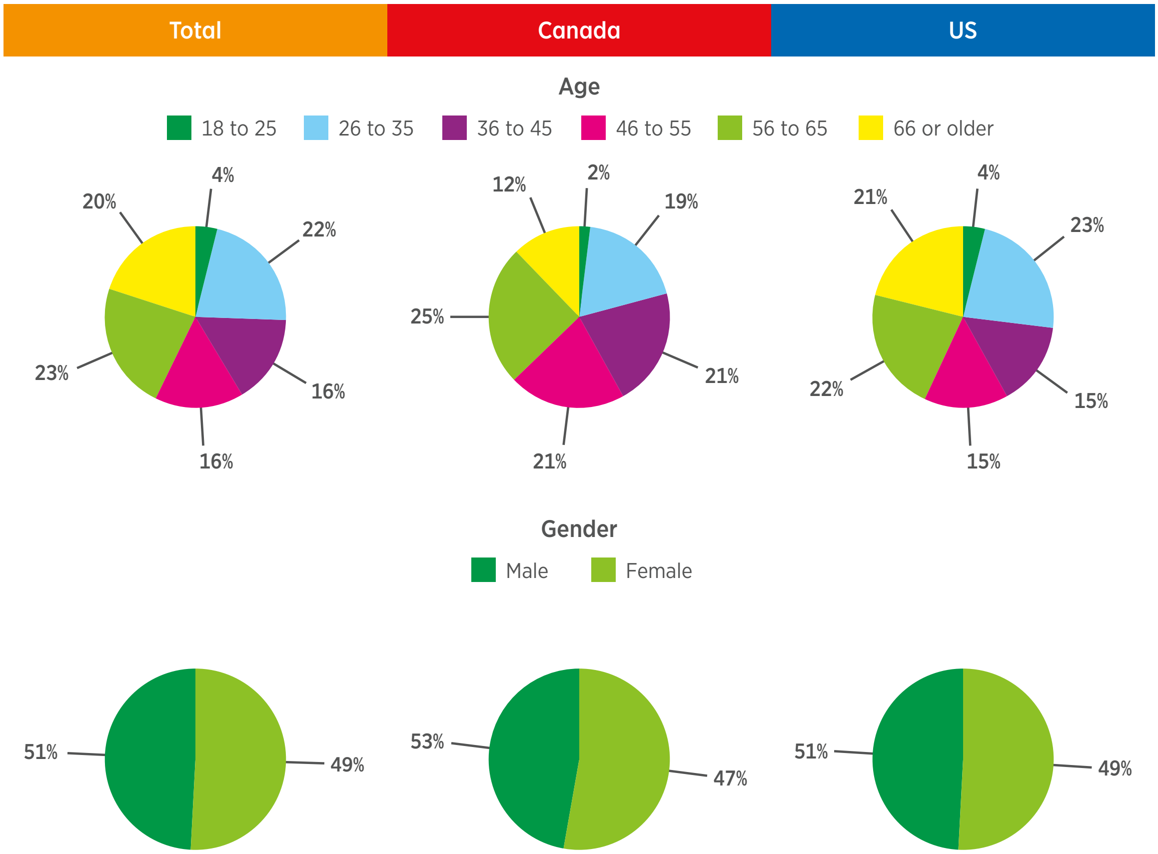

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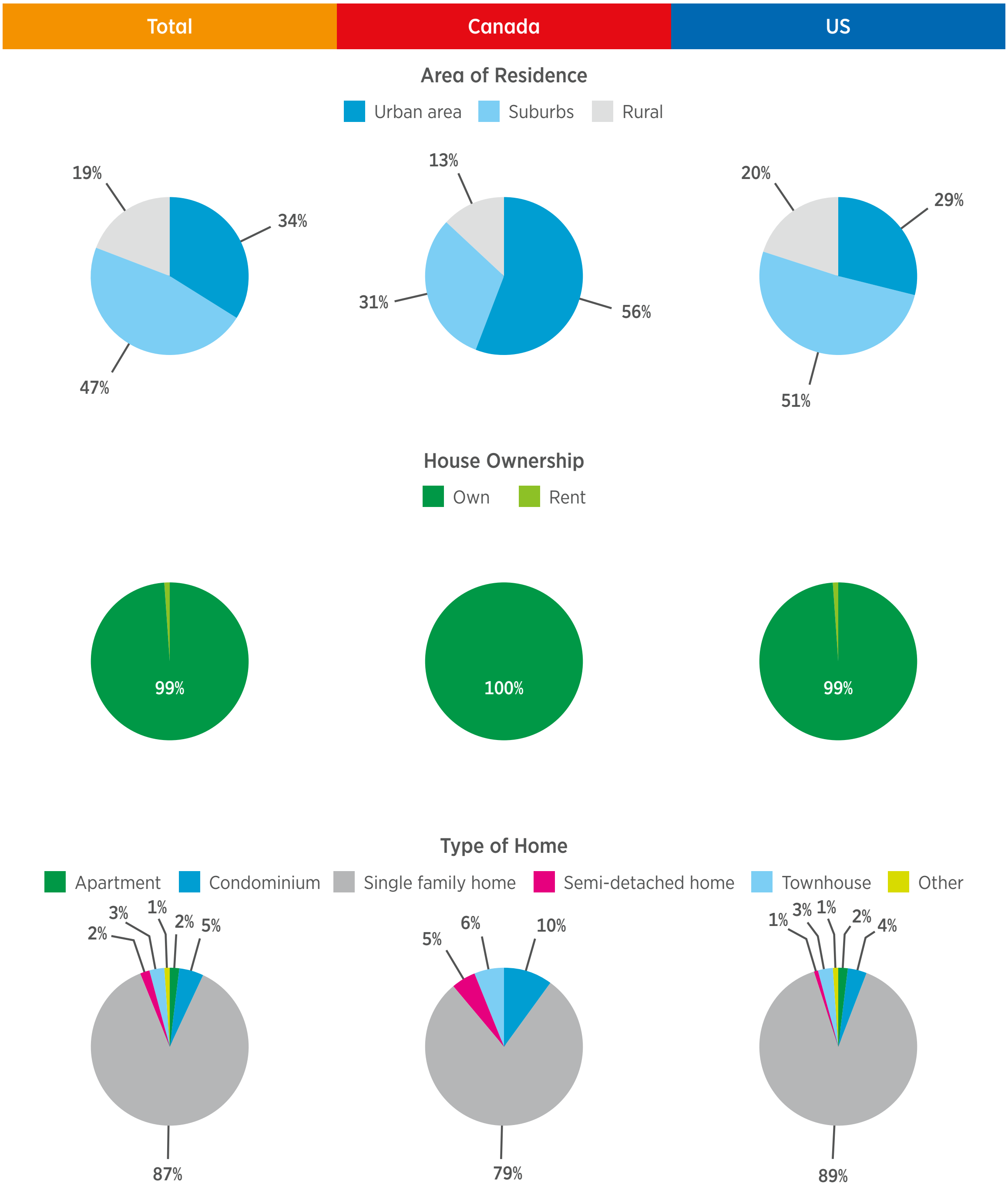
Figure ES 3 Area of Residence and Type of Home of the Sample



Layout of the Report

The report is structured into five chapters with an executive summary outlining the overall objectives, research areas and findings, Chapters 1-5 and an appendix. Table ES 2 provides a brief layout of the report to help navigate its contents.

Table ES 2 Connected Home IoT Energy Roadmap: Layout of the Report

Sections	Title	Content
Preface	Executive Summary	Background and introduction; objectives, methodology and definition, overview of top findings
Chapter 1	Connected Home Internet of Things Energy Market— An Overview	Overview of connected home, connected home energy management, industry participants, adoption by application category, industry's perspective of consumers, and drivers and challenges for the connected home energy market
Chapter 2	Perception Analysis	Introduction and methodology, sample classification, consumer profiling, current adoption trends, energy cost trends and perception, role of utility programs, and current and future potential of connected home technologies
Chapter 3	Addressing Key Connected Home Energy IoT Adoption Challenges	Issues and challenges in connected home adoption, consensus development on core issues, incentivizing technology and standardization initiatives
Chapter 4	Development of the Future Energy Roadmap	Elements necessitating roadmap milestones, the connected home IoT energy roadmap, dependencies for determining roadmap adherence and key participants in ensuring successful roadmap execution
Chapter 5	Conclusions and Recommendations	Conclusions of the research and key recommendations
Addendum	Appendix	Glossary of terms; references

SUMMARY OF KEY FINDINGS

The key findings of this research as discussed through Chapters 1-5 are outlined subsequently. Discussion under each heading represents a synopsis of the chapter corresponding to it in the report.

Summary of Chapter 1: Connected Home Internet of Things Energy Market–An Overview

Connected Homes Overview

A connected home can be defined as "A residential environment where owners/occupiers use smart devices, appliances, communication features, controls, centralized hubs, and other functionalities that are enabled by information technology that anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security, and entertainment, among other functions." Connected homes achieve this by enabling multiple system functions, such as smartphone- and tablet-controlled heating, ventilation, and air conditioning (HVAC) or lighting systems, Wi-Fi connected security, entertainment systems and appliances, programmable devices, and systems capable of driving energy efficiency. This definition was adopted through Frost & Sullivan's interactions with the connected home industry and consultations with the steering committee for this research. It builds upon previous Frost & Sullivan and CABA projects in the connected home arena.

The Connected Home and IoT

For effective intercommunication and increasing the mobility of control and monitoring aspects, connected homes rely on both an internal and external communication network. Internet of Things (IoT), in simple terms, refers to the connection of disparate products, systems, and platforms to the Internet.

In line with the IoT definition from the International Telecommunication Union (the United Nations' global agency for information and communication technologies), this research defines IoT as "the network of physical objects—devices, vehicles, buildings, and other items embedded with electronics, software, sensors, and network connectivity—that enables these objects to collect and exchange data."

The Internet Protocol (IP) layer brings in a higher level of accessibility and processing/monitoring capabilities to support the connected systems in the home.

Connected Homes: Energy Context

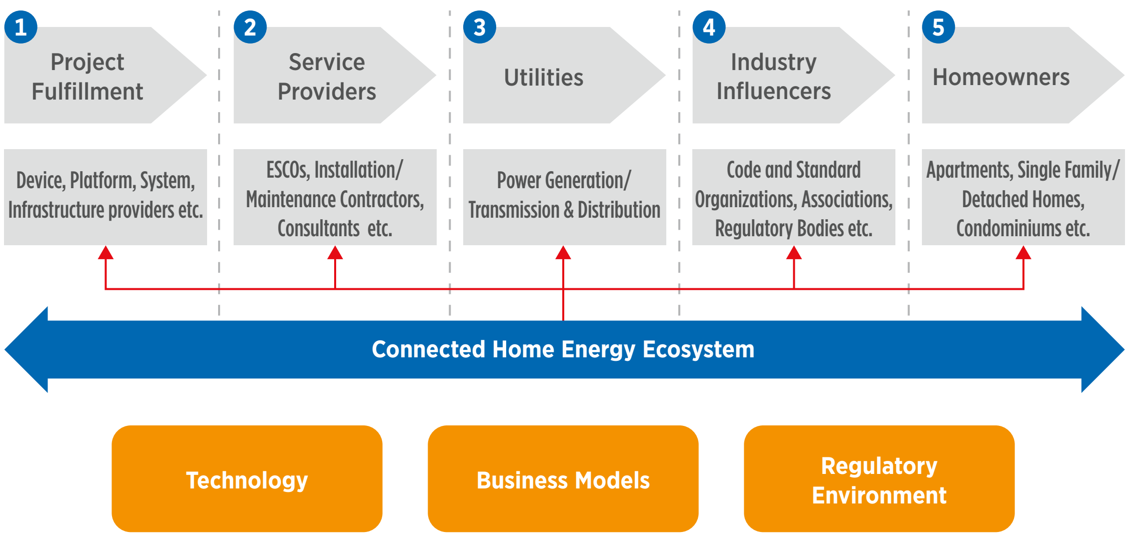
Energy management is one of the key functions performed by integrated connected homes. As the market continues to evolve, the requirement for energy management will continue to grow because the consumption of energy is a key aspect of connected home technologies and plays a key role in overall home costs. Current market forces are expected to drive energy saving initiatives and advancements, causing homeowners and other stakeholders to become increasingly judicious in their consumption of energy.

Industry Participants

There are multiple categories of participants in the connected home energy ecosystem and all of them play a part in driving the direction of the industry and developing the overall environment. To understand and develop a roadmap for connected home energy, it is imperative to gain an understanding of the various participant categories in the overall market.

Some key participant groups in the industry are illustrated in Figure ES 4 and described below:

Figure ES 4 Industry Participants in the Connected Home Energy Market



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Adoption by Application Category

The status of market maturity of connected/energy savings features across various home application categories has been provided below in Table ES 3.

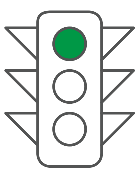
Table ES 3 Adoption by Application Category

Application Category	Market Maturity of Smart/ Connected Features	Market Maturity of Energy Saving Features	Impact on Home Energy Consumption
HVAC	Medium	High	High
Lighting	High	High	Medium
Thermostats	High	High	High
Energy Management, Information Monitoring, Diagnostics	Medium	Medium	High
Communication Infrastructure	High	Medium	Medium
Fire & Life Safety	High	Low	Low
Physical Security	High	Low	Low
Connected Appliances	Medium	Medium	Medium
Connected Home Entertainment	High	Low	Low
Smart Plugs and Power Strips	High	High	High

Drivers and Challenges for the Connected Home Energy Market

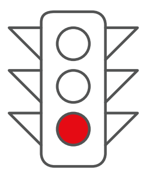
Some key drivers and challenges for the connected home energy market have been highlighted below in Figure ES 5.

Figure ES 5 Drivers and Challenges for the Connected Home Energy Market



Drivers

- Consumer awareness of benefits
- Mobility of solutions via smartphones
- Energy- and cost-saving opportunities
- Incentives provided for adoption
- Development of wireless networking technologies
- Reduction in the costs of connected devices



Challenges

- Cybersecurity and privacy concerns
- Complex installation and troubleshooting mechanisms
- Initial cost concerns

Summary of Chapter 2: Consumer Perception Analysis

The consumer research module was designed to capture valuable insights regarding energy aspects and adoption trends associated with connected home solutions. The key highlights and observations of the consumer research are discussed below.

Adoption Trends: Current and Future

It was observed that respondents closely related the perception of what constitutes a connected home to systems with high energy consumption. This was followed by systems/devices accessible over Wi-Fi such as connected security, entertainment systems and appliances. The primary drivers of interest in connected homes were observed to be utility/energy/cost savings followed by convenience and security. In terms of currently adopted connected home technologies, entertainment was the most popular. However, for intended adoption in the next 12 months, smart thermostats were found to be the most popular system.

System/Device Control Factors

When it comes to most preferred devices for control of home energy management systems, smartphones are the most popular among respondents with majority preference, followed by centralized control consoles. Voice-based control, which has high growth potential in the market, continues to be in early stages of adoption among respondents.

As a centralized control system that can control multiple energy consuming devices, thermostats form an important part of connected home energy control. In-built dedicated thermostat consoles remain the most preferred mode of thermostat control, followed by a dedicated smartphone application and an overall home energy smartphone application. Voice-based control is in nascent stages when analyzed for thermostats separately too.

Energy Cost Perceptions and Trends

Energy costs are a high concern area for most respondents in both Canada and the US. Energy saving investments made in this regard however, have an expected payback period of one to two years, which was the most desirable payback period among respondents. It is required to increase awareness among consumers regarding possible steps that can be taken for making their homes energy efficient. This stems from the observation that close to half of the consumers surveyed believed that home energy costs are either not within their control at all or half to most of costs are out of their control. In terms of most popular energy efficiency measures taken, installation of LED bulbs and Energy Star certified appliances were at the top of consumer minds. However, when considering the perceived impact of multiple energy efficiency measures, the increase of home insulation, adopting high efficiency HVAC equipment and Energy Star certified appliances were the most popular.

Utility-Related Insights

Among utility programs, the most popular among respondents were incentives for home energy efficiency upgrades followed by the provision of reports on home energy consumption and demand response programs. However, notably, demand response programs were found to be much higher in popularity among US respondents compared to Canadian respondents. This is expected to be due to a combination of multiple factors leading to lower incentives for the adoption of demand response programs in Canada currently.

In the case of consumers who have adopted demand response programs, the majority were found to have selected the control device themselves. This indicates a possible requirement for utilities to collaborate with multiple brand vendors for ensuring seamless communication between utilities, and connected homes for demand response purposes. Incentives could also be offered to consumers for selecting certain control devices. For demand response programs, close to half of respondents interested in such programs would be willing to offer utilities temporary control of a connected system in the home. Top capabilities that consumers would be willing to offer for utility control are cooling in summer, heating in winter, lighting and hot water tank heating.

With regard to additional offerings from utilities in the connected home energy space, the majority of respondents stated that they would prefer or consider the business model of a utility providing energy management services for their homes. Other popular potential offerings include utilities assisting with the finance of home energy products through the energy bill and utilities providing supplementary services such as security, safety, etc. Most respondents who opted for connected home services from utilities would prefer to have the services included in their energy bills. In case of system malfunctions

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under the utility provided services business model, utilities were found to be the most preferred first point of contact for consumers compared to device manufacturers and installing contractors.

Summary of Chapter 3: Addressing Key Connected Home Energy IoT Adoption Challenges

The core issues that challenge the adoption of connected home IoT devices revolve around broad topics of high initial and maintenance costs, low perceived benefits, issues associated with the integration of the latest technologies, and growing concern about the security and privacy of personal information. Furthermore, the lowcost of energy in some states, and the Trump administration's budget cuts for energy policy programs (including Energy Star) is adding to the challenges of continuously offering energy efficiency solutions for connected homes. Therefore, it is important to look at the dynamics that challenge and restrain the adoption of integrated home devices. Some key issues and challenges are shown in Table ES 4.

Table ES 4 Challenges in the Adoption of Connected IoT Home

Challenges	Propagated By	Description
Value Proposition	Homeowner	Generally, consumers are uncertain about the significance of connected devices and perceive them as solutions reserved for the tech savvy and the affluent individuals.
High Initial Setup Cost	Homeowner and technology vendors	The prices of IoT enabled home automation technologies are the primary barrier to adoption. This may indicate that consumer understanding about benefits is still relatively weak.
High Installation Cost	Homeowners and system integrators	The number of smart devices to be integrated adds a layer of complexity to the installation processes that consumers would rather avoid. Therefore, some consumers prefer to have a professional install their systems subsequently resulting in substantial increases in installation costs.
Security and Privacy Issues	Homeowner, technology vendors, and system integrators	The use of IoT in the connected home provides open access and control of devices to operators and service providers, making it vulnerable to cyber threats.
Integration and Connectivity Issues	Technology vendors and system integrators	Due to various proprietary technologies and sporadic adoption of open protocols, consumers and professional system integrators face an increasingly complex task in ensuring proper integration and communication of various smart devices. Some challenges in home automation IoT connectivity are interoperability, signalling, bandwidth, and power consumption.
Lack of Regulation and Standards	Professional regulatory bodies	Currently, there is no clear regulation and standards to secure data generated during the communication of various connected home devices. There are preferred best practices guidelines, but legislation and transparency about who gets the access to information and how the data is used is lacking and possibly creating a barrier in widespread consumer adoption of IoT home devices.
Credits and Incentives	Utility companies and administrative bodies	Financial incentives and rebates are motivating factors for the adoption of connected home devices. However, most consumers feel that the credits and incentives offered by utility companies are limited to relatively smaller gain.
Application Functionality	Technology vendors	When multiple devices are controlled from a single application, there can be disadvantages since many features of the devices might not be controllable by the application. This can occur due to a reduced level of customization.

Summary of Chapter 4: Development of the Future Energy Roadmap

A number of factors are expected to influence the future direction of the industry in terms of specific milestones along the industry development roadmap. An analysis is provided of the elements that can drive implementation of the roadmap and the roles of key participants in ensuring successful adherence to the roadmap.

Table ES 5 provides an overview of elements leading to the roadmap milestones.

Table ES 5 Overview of Elements Leading to Roadmap

Elements of Energy Roadmap	Roadmap Description
Device Compatibility Issues	Device compatibility is a current challenge that results in issues in the installation and operation of overall connected home ecosystems. Given that different communication protocols have advantages depending on respective applications, increased collaboration/partnerships between communication protocol providers would be beneficial for the industry at large, especially if the industry does not consolidate towards a particular protocol.
Monitoring High Energy (HVAC) Equipment	Given the large role that HVAC equipment can play in residential energy consumption, the monitoring of such equipment would be of interest to utilities. It could be of interest to utilities to form a consortium/association to certify products/installation and maintenance contractors to bring in larger control over the acceptance and maintenance of equipment in homes.
The Interest of Insurance Providers	Having mitigating measures to prevent home damages or having information to analyze behaviours that might lead to undesired events are of high interest to insurance organizations. This could bring an increased involvement of insurance organizations in the connected home energy ecosystem as they collaborate with technology vendors, service providers, or utilities.
Increased Diagnostics of Home Energy Equipment	An implementation of connected home energy technology will provide an enhanced diagnostics features such as real-time alert to users' smartphones in case of any required maintenance. This would help increase overall home efficiencies across the grid.
AI-based Troubleshooting and Customer Service	An additional feature in equipment diagnostics, an AI-based solution to self-rectify issues or provide alerts to consumers with guidance on rectifying issues could possibly find traction in the long term. Alerts could be then sent by the system to service providers/vendors in the case of issues not being rectified at the system/user level.
Connected Home Evaluation Services	Apart from home energy audits and ratings, overall home cybersecurity audits could also penetrate the market, either as standalone offerings or offerings bundled with home energy audits.
The Popularization of Energy Services from Utilities	The provision of energy management services from utilities for the residential sector on a large scale is a possibility in future years. The results of our consumer survey indicate that 71 percent of respondents would prefer or consider the business model of utilities providing energy management services.
Further Development of Voicebased Control Infrastructure	As the collaboration levels between vendors and platform providers increase, voice-based control is expected to further develop in sophistication to include complex control mechanisms for systems and also interaction with utility programs.
Monetization of Energy Usage Data	Various organizations can monetize the usage data and behaviour trend by providing it to technology vendors/other service providers so they can design innovations based on perceived acceptance from consumers.
Subscription-based Connected Home Energy Products	Given consumer concerns around initial costs for upgrading their infrastructure to make systems connected for energy efficiency purposes, business models for providing connected home devices on a subscription basis are expected to find higher acceptance.

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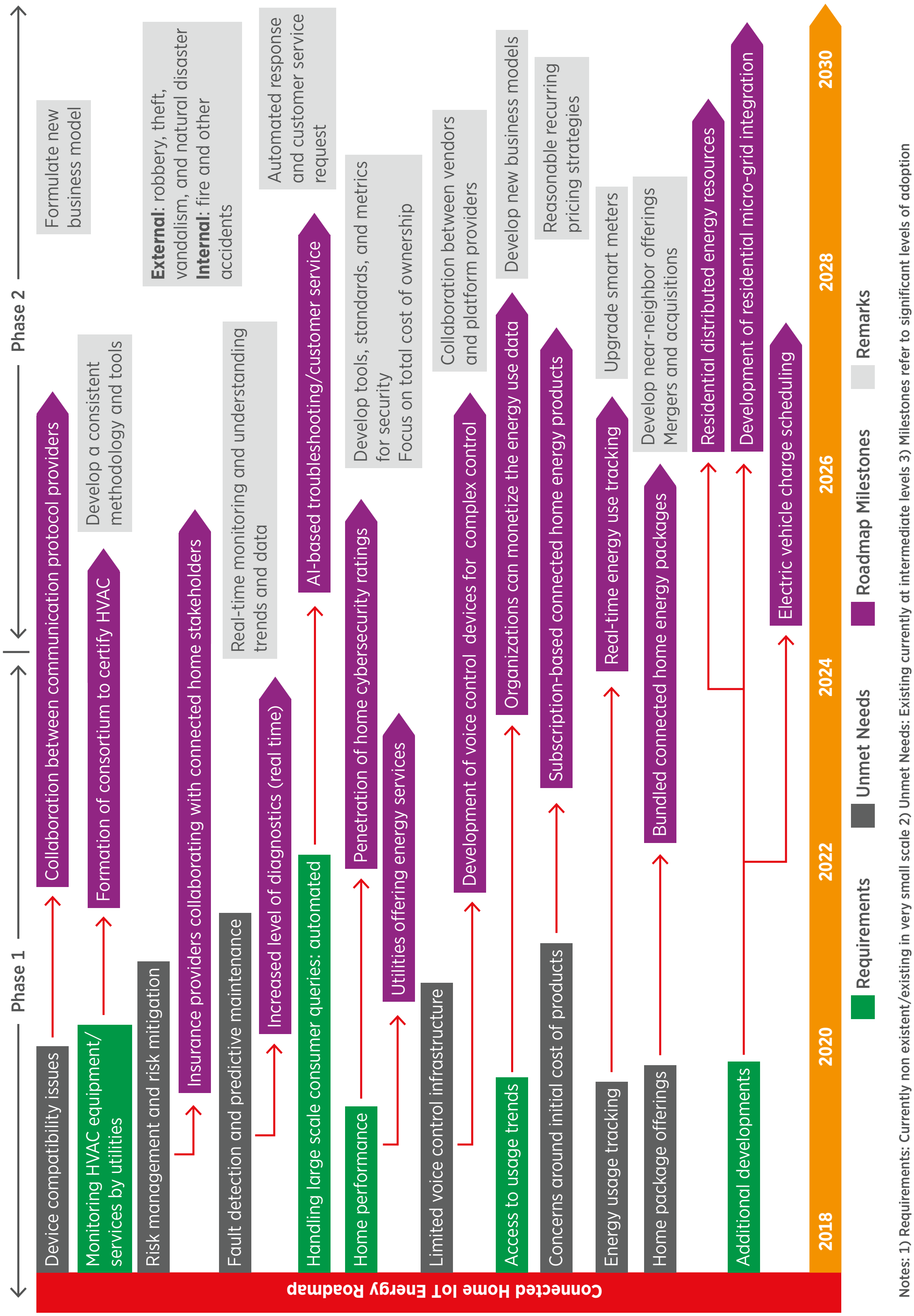
Elements of Energy Roadmap	Roadmap Description
Connected Home Energy Packages	Collaboration could be made possible to provide bundled connected home energy offerings to consumers requiring the installation of the overall ecosystem.
Residential Distributed Energy Resources (DER)	The addition of various technologies such as solar photovoltaic (PV) cells and battery storage, would have an impact on utility demand response program dynamics as consumers will also start to depend on battery storage options during peak demand periods in addition to utilizing net metering options.
EV Charge Scheduling	Scheduling of EV charging is expected to require interaction with the grid and could be assimilated into residential demand response programs. EV scheduling platforms could also be upgraded to allow for bi-directional charging where vehicles can both get charged from the grid and also discharge power back to the grid as per requirements, thus ensuring higher flexibility for consumers and utilities.
Residential Microgrid Integration	The development of residential microgrids in the long term is a possibility that could enable crossutilization of neighbourhood battery storage units during peak demand periods.

The Connected Home IoT Energy Roadmap - Ideal Scenario

Figure ES 6 Connected Home IoT Energy Roadmap – Ideal Scenario



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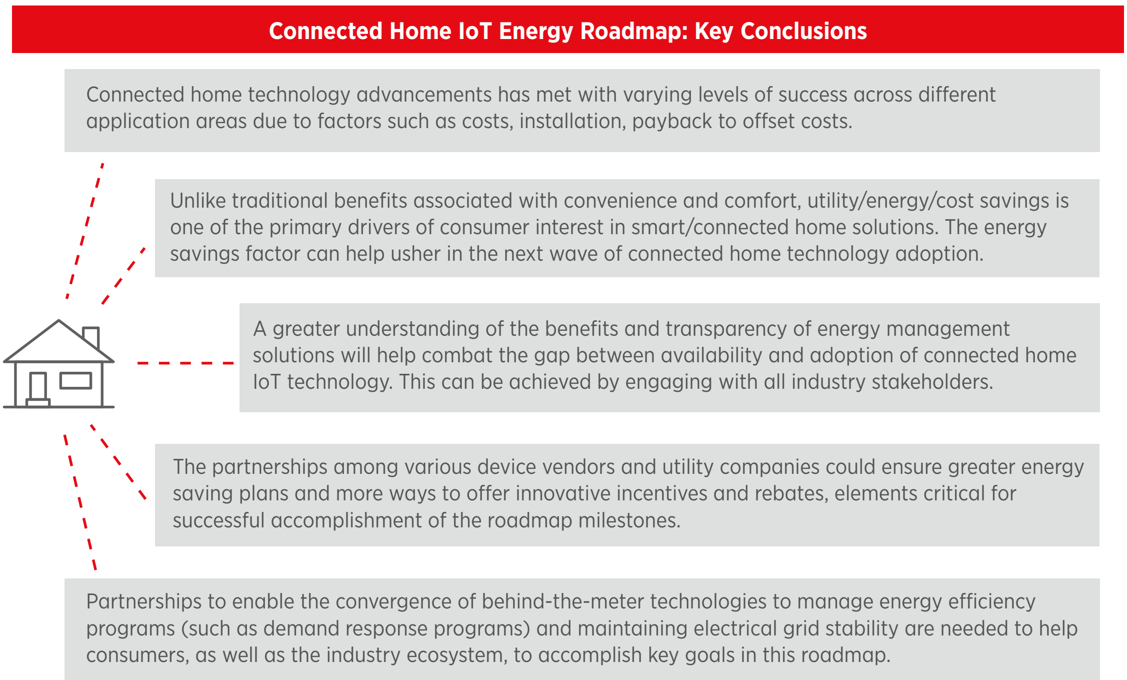
Considering the high impact that EV power demand is expected to have on the overall grid, analyzing initiatives taken in this regard is necessary to determine specific requirements for achieving the milestone of successful EV integration with the overall grid. The following case study provides valuable insights into this.

Summary of Chapter 5: Key Conclusions and Recommendations

The top findings of this research validate some of the early hypotheses around the opportunities associated with the concept of energy within an IoT enabled connected home environment, and the various dynamics, issues and challenges it presents for both, homeowners, and industry participants. Consumer concern about high energy consumption, expectations regarding connected home energy solutions, challenges associated with adoption of connected home devices for optimizing home energy usage, were juxtaposed against industry issues such as system complexities, ecosystem unification issues, lack of collaboration among various entities, and above all, a lagged development of the utility industry that may challenge accomplishing the identified milestones in this energy roadmap. The key conclusions of this research are summarized in Figure ES 7.

Figure ES 7 Connected Home IoT Energy Roadmap: Key Conclusions



The key recommendations of this research include following:

- Implement best practices to promote connected home certification based on energy savings, comfort, convenience, security and other performance attributes
- Develop real-time monitoring and data analytics capabilities to increase predictability of maintenance and consumer usage trends
- Develop common standards for open communication protocols for cross-compatibility of products and platforms
- Collaborate on connected home industry initiatives, policies and standards, and technology development to ensure interoperability, privacy, security, and transparency
- Innovate new business models that will become one of the primary means to create value for customers

HONDA CASE STUDY

Controlled Electric Vehicle Charging

Highlighting the opportunity for electric vehicles to create value by responding to the needs of the electric grid

Source: American Honda Motor Co., Inc.

American Honda Motor Co., Inc.

Project Partners:

eMotorWerks
Research and Project Partner

Electric Power Research Institute (EPRI)
OVGIP Project Manager

Project Address:
American Honda Motor Co., Inc.
1919 Torrance Blvd
Torrance, CA 90501

Key Highlights:

- Because most vehicles spend the vast majority of their time parked, there is an opportunity for electric vehicles to create value by responding to grid needs through scheduling or delaying charging or even providing power back to the grid (V2G).
- The revenues from grid services could help reduce total cost of ownership.
- Commanding vehicles during high renewable energy production could reduce CO_2 emissions, and
- Smart charging programs could increase brand awareness and loyalty
- Services in which EVs could participate include:
  - Demand response
  - Real time markets
  - Ancillary services
  - Demand mitigation
  - Energy arbitrage
  - Home backup power

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Controlled Electric Vehicle Charging - American Honda Motor Co. Inc.

Honda has a global target to reduce total CO2 emissions to 50% below 2000 levels by 2050.

This requires full-scale adoption of electrification and renewable energy to power our products!

Project Partners

eMotorWerks
Research and Project Partner

Electric Power Research Institute (EPRI)
OVGIP Project Manager

This case study has been provided in arrangements with American Honda Motor Co., Inc. ("Honda")

Project Overview

An average vehicle spends more than 90% of its lifetime parked. There is an opportunity for electric vehicles and plug-in hybrids to take advantage of this through intelligent charging. Average charge times for EVs (using a 240V station) range from one to three hours, compared with the average vehicle park time of over 12 hours for a weekday night. There is an opportunity to delay, slow, or temporarily stop charging without any impact to the customer's actual use of the vehicle.

Program Details

The study focuses on finding appropriate grid markets in which vehicles could participate, at multiple scales, from individual vehicles to aggregations of thousands.

Honda has already conducted initial real world testing in wholesale and utility markets of the vehicles' ability to respond to events, and customers' acceptance and perception of value.

Honda has also joined the Open Vehicle Grid Integration Project (OVGIP), a consortium of automobile manufacturers working together to further VGI collaboration with utilities. By working together with other automakers, utilities can reach out to customers through a single interface.

Key market needs necessitating program development:

- Reducing higher initial cost of EVs compared to gasoline vehicles through grid services
- Lowering environmental impact of EV charging by adjusting charge rates based upon grid CO_2 levels
- Increasing the grid's renewable energy penetration by charging when excess renewable energy is available and preventing renewable energy curtailment (while providing a zero emissions source of electricity for mobility!)
- Lowering the cost of providing power for charging by intelligently charging multiple EVs at one location (such as a workplace)

Controlled Charging (V1G) Use Cases

In each of the following use cases, the vehicle (or aggregate of vehicles) responds by either starting or stopping charging or otherwise adjusting the charging schedule.

Wholesale Market Participation

By aggregating many EVs into a larger resource, they can participate in wholesale energy markets. These markets are complex, vary by region, and can be volatile in nature. Using the California Independent System Operator (CAISO) as an example, EV resources can be bid into several markets such as the Demand Response Auction Mechanism (DRAM), Real Time Market (RTM), Day Ahead Market (DA) and Ancillary Service (AS) markets.

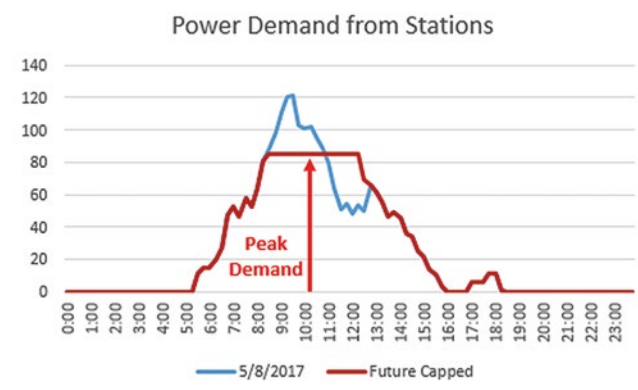
In general, vehicles would stop charging when wholesale prices are high, and resume when prices have lowered. If prices go very low, such as during excess production of renewables, vehicles could start charging in order to absorb the excess, low cost, low carbon electricity. Ancillary service dispatches would coordinate adjustments in vehicle charge rate based on grid needs.

Utility Specific Programs

These programs lower costs by reducing demand based on signals sent by the local utility when the distribution system is stressed. Aggregated EVs could be incorporated into existing demand response programs with the utility, or new programs could focus specifically on EVs to manage the overall demand curve, even to a distribution circuit level.

Site Level Demand Control

Site level demand control views the demand patterns of the entire site load (buildings or whole house including charging station) as seen by the utility's meter, and implements a control mechanism to reduce peak power demand while still meeting the driver's charging needs. For a charging station attached to a building (not separately metered), site level demand reduction is implemented by measuring the building load and delaying or slowing EV charging such that it does not add to peak level demand.



Source: American Honda Motor Co., Inc.

Renewable Energy Maximization

The ability of EVs to adjust charging schedules can be used to synchronize charging with excess renewable energy production. In March and April of 2017, the California ISO curtailed 160,000 MWh – an amount that could power approximately 560 million miles of driving. The energy curtailed was primarily solar, which peaks during the day. Incentives to encourage installation of workplace charging and encourage daytime home charging can be used to increase the load during the day.

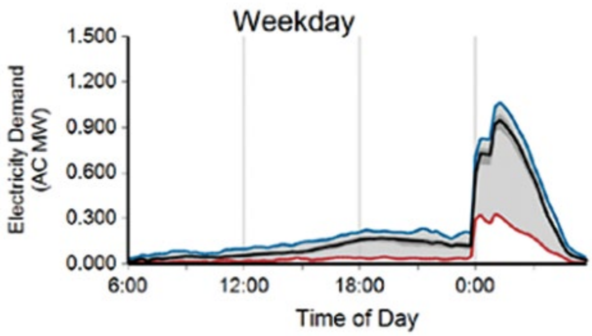
EXECUTIVE SUMMARY

Grid Challenges that Unmanaged Vehicles Could Cause

As EV adoption increases, Honda believes two key issues may arise:

- Time of use periods creating a "mini peak" around the TOU off peak start time, caused by timers in vehicles or stations that are set to begin charging at the same time
- Local load management at the final transformer level for residential load – the so-called "Neighborhood Effect", where multiple EVs on one residential transformer could cause overloading if all the vehicles charge around the same time

These challenges stem from the lack of "randomness" that is normally seen by other loads. For example, many residential air conditioners may be running on a hot day, but the thermostats of each AC unit are independent such that each unit is not cycling on and off at the exact same time. With time of use periods encouraging off peak charging at a fixed time each night, many drivers may set the same start time on their vehicle or station timer, causing local or even system-wide issues. Both of these challenges can theoretically be solved by introducing artificial randomness in the vehicle charging start time and coordination of vehicle clusters. However, there is currently no market mechanism, incentive, or means for them to be addressed. Therefore, these challenges are ripe for pilot testing and experimentation with utilities, automakers, EVSE manufacturers, and academia.



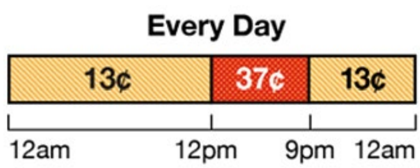
Source: Idaho National Labs Report

Bidirectional Charge/Discharge (V2G) Use Cases

The following are use cases in which the vehicle is able to both charge from the grid and supply power back to the grid. While the above use cases can benefit from V2G, the below use cases require discharge of the vehicle battery.

Energy Arbitrage

Increasingly, utilities are offering time of use rates to residential customers. With V2G technology, a vehicle could charge at an off peak (lowest cost) time period, and discharge back into the grid at the on peak (highest cost) time period, and would earn credit or income for the difference in the two. For a high differential rate, this could be quite valuable – in the example time of use rate shown at right, the earnings would be $0.25 per kWh moved. For a house using 10 kWh in the evening, this could be $2.50 per day or $55 per month (assuming 22 days a month of participation).



Source: Southern California Edison

Home Backup Power

Vehicle to grid technology enables the vehicle to provide power to the home. Such "vehicle to home", or V2H, technology utilizes an off-grid inverter to supply energy to the home. Honda has developed a Power Exporter that allows for up to 9kVA of AC power output, similar to a portable generator. he Power Exporter went on sale in Japan in 2016.

The electric vehicle represents a very different kind of load, one that can take its power at a multitude of power levels and timeframes without any impact to actual use of the vehicle.

With long plug in times found at home and workplaces, there is an opportunity to have vehicles provide grid services while they would otherwise be unused.

Consumer acceptance of controlled charging depends on properly capturing driving needs such that the vehicle is always charged when the customer expects it.

Communication and trust between the vehicle, customer, and controlling entity must be very strong to ensure a reliable system.

There are a multitude of grid services that vehicles can perform by slowing or delaying charging.

Vehicle to Grid technologies allow vehicles to provide power back to the grid. V2G enhances most use cases and enables several more.

Anticipated Challenges during Implementation for V1G

- Any failure to charge the vehicle by the customer's expected use time results in a negative impact and often causes drivers to opt out of future events or even the entire program.
- Verification data from the vehicle confirming response in a program is often not at utility revenue-grade meter standards.
- Today's programs often use the whole house meter in lieu of vehicle data. This has several drawbacks, including:
    - Variability in house load wiping out the vehicle response
    - Difficulty in getting the utility to authorize sharing of meter data with outside entities
    - Complications arising when the customer of record for the utility bill and the driver of the vehicle are not the same person

Anticipated Challenges during Implementation for V2G

- Properly anticipating the customer's use of the vehicle is critical - a misstep could leave the driver with much lower range than expected.
- Inverters on vehicles are currently certified to different standards than solar inverters. As vehicles become part of the grid, utilities will need to adopt equivalent automotive standards such as SAE J3072, which governs inverters on vehicles.
- Utilities are often not prepared for vehicles that could discharge in multiple locations. This presents logistical challenges such as billing and site certification that are new to the utility industry.

Concluding Remarks

The key to enabling widespread adoption of smart vehicle charging is finding the highest value application.

There are many ways EVs can be used to provide services for the grid, from site demand management of one vehicle to aggregated response of thousands of vehicles. There is also the potential to stack various programs together, for example, by providing energy arbitrage as well as backup power. Another example is a utility program that sends both stop and start charging commands depending on grid load, renewable generation, and a randomness factor to help smooth the dispatch of many cars. In any case, the future is bright within this space as more consumers are turning to EVs for their next purchase.

1. CONNECTED HOME INTERNET-OF-THINGS (IOT) ENERGY MARKET – AN OVERVIEW

1.1 CONNECTED HOMES IOT INDUSTRY OVERVIEW

Connected Homes Overview

A connected home can be defined as "A residential environment where owners/occupiers use smart devices, appliances, communication features, controls, centralized hubs, and other functionalities that are enabled by information technology that anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security, and entertainment, among other functions.". The executive summary offers more details on the definition and various inclusions of technologies and solutions that pertain to it.

The connected homes industry has seen an increasing level of integration of various technologies. Multiple systems are required to interact with each other for the purpose of controlling, monitoring, and coordinating various purposes such as occupant comfort/convenience and energy savings. This has necessitated the creation of multiple environments to facilitate the interaction and interoperability of these systems. This intercommunication and interoperability enables occupants to provide inputs (where required) to dictate present and future parameters, such as thermostat schedules, LED dimming, etc. regarding a connected home.

A connected home's level of complexity can range from one or more personal devices being connected via a home area network; through to a comprehensive, dwelling-wide integrated platform that brings together all controllable functions. In the last five years, the industry has witnessed a pronounced transition towards a more responsive and connected home ecosystem as multiple participants have banded together to continue to break down the technology silos that had hindered this level of integration.

The Connected Home and IoT

For effective intercommunication and increasing the mobility of control and monitoring aspects, connected homes rely on both internal and external communication networks, further accentuated by leveraging IoT[1]. For the purpose of this research, the IoT definition from the International Telecommunication Union (the United Nations' global agency for information and communication technologies) has been referenced. More details are provided in the executive summary segment of the report.

Connected Homes: Energy Context

Energy management is one of the key functions performed by integrated connected homes. Current market forces are expected to drive energy saving initiatives and advancements, causing homeowners and other stakeholders to become increasingly judicious in their consumption of energy. As the market continues to evolve, the requirement for energy management will continue to grow because the consumption of energy is a key aspect of connected home technologies and plays a key role in overall home costs.

Connected home energy management devices deals with the real-time monitoring and customization of functions of various home appliances based on the user's preferences. This is achieved through the use of intelligent ambient systems controlled by human–machine interfaces in connected homes, which are designed to reduce electricity costs by improving energy utilization.

However, the full potential of connected homes is still found lacking in many areas due to the complexity and diversity of the systems and to the frequent problem of suboptimal control strategies. Consequently, energy consumption is still higher than necessary and users are unable to ensure expected levels of comfort in their smart/connected homes.

The increased effectiveness of connected home energy management systems is driven by the following broad factors[2]:

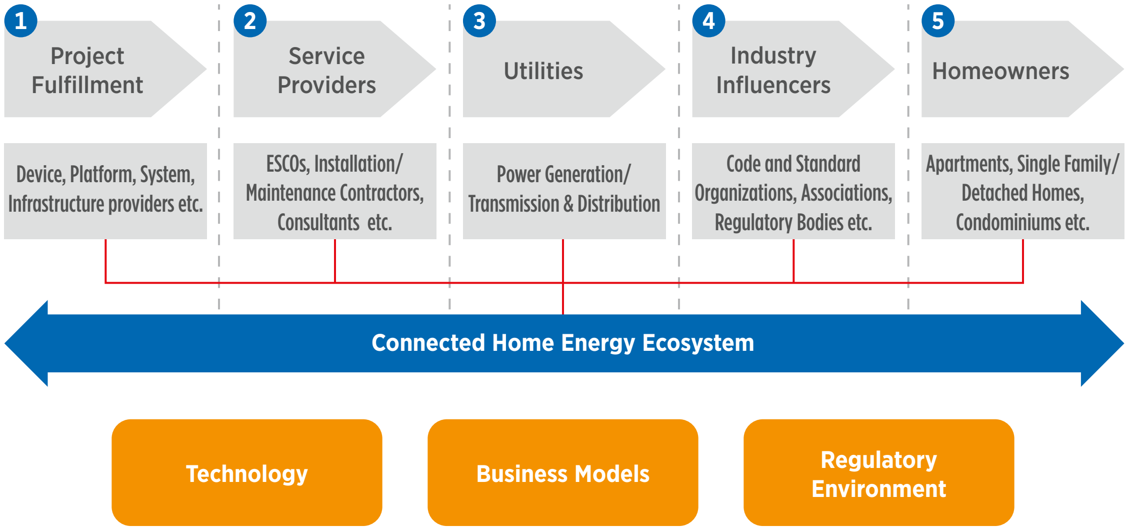
- **The implementation of smart grids** and the resultant level of control and monitoring from the grid side can contribute to home networking from an energy management perspective. Smart grids enable the provision of detailed energy reports and can help drive programs such as demand response management which could curtail the energy usage of individual devices. This helps to drive the adoption of sophisticated energy management platforms.
- **The growth in Web-based cloud computing applications** enables low-cost home energy data storage, data display, and data analysis for energy management purposes.
- **Advancements in smartphone technology**, such as in batteries, user interfaces, and material, are expected to aid the development and adoption of home energy management systems by enabling a robust connection to remotely operated systems, higher usage time, processing power and ease of control.
- Residential equipment and appliance manufacturers continue to embed **additional sensors and control capabilities** in new connected home appliances that are Internet-ready, can respond to requests from service providers, and offer advanced cycle controls. These controls include multi-mode or variable speed controls, fault diagnostic sensors for space-conditioning equipment, and "eco" modes for dishwashers, clothes washers, and other major home appliances.
- **Integration of energy services into other networked product offerings**, such as security systems, television services, and telephony services.

Industry Participants

There are multiple categories of participants in the connected home energy ecosystem who all play a part in driving the direction of the industry and developing the overall environment. To understand and develop a roadmap for connected home energy, it is imperative to gain an understanding of the various participant categories in the overall market.

Key participant groups in the industry are illustrated in Figure 1 and described below:

Figure 1 Industry Participants in the Connected Home Energy Market



Technology Vendors

This category of technology vendor includes multiple types of participants, such as device/system manufacturers, communication protocol providers, network infrastructure providers, platform providers, hub manufacturers, control and automation equipment providers, and sensor manufacturers. The various types of technology vendors can drive multiple advances in home energy efficiency and integration efforts through internal research and development (R&D), collaboration with each other, and collaboration with other categories of participant groups.

Home energy efficiency can be driven by innovation in the core design of particular equipment and by an increased level of connectivity and integration of the equipment within the home. For example, HVAC/lighting equipment manufacturers are increasingly ensuring that their multiple product lines can be integration-enabled so they can be assimilated into the overall home ecosystem.

Connected Home Service Providers

The Connected Home Service Providers category is comprised of participants who provide various levels of service that enable the establishment of, or cater to, the operational requirements of connected homes. Types of service providers include installation contractors, maintenance contractors, energy service companies (ESCOs), and home energy consultants.

In many cases, these participants are the point of contact for homeowners with technology vendors. Homeowner feedback is essential for technology vendors and other participants because they have an overall understanding of on-the-ground conditions and possible issues in connected homes. ESCOs are expected to have the highest homeowner involvement within this group, but the concept is currently in early adoption stages for the residential market.

Utilities

Utilities ensure the supply of energy for connected homes as per varying demand requirements. They also provide a host of ancillary offerings, such as discounted home appliances/equipment, analysis of energy consumption, rebates based on energy efficiency measures, and demand response initiatives. To drive targeted initiatives, utilities can leverage their connections to people's homes and the vast quantities of data they collect on consumer power use.

Utilities also generally have an energy generation component, which is one of the factors driving their interest in managing home energy. Managing home energy to mitigate peak loads can be beneficial from the energy generation point of view since reducing peak loads on the grid can prevent the need to bring additional power plants online and save on fixed start-up costs. In addition to providing advantages in the energy generation area, mitigating peak loads ensures less strain on grid infrastructure such as transmission wires and circuit breakers, which helps in prolonging their usage life.

Industry Influencers

Industry influencers refer to the participants that have the ability to directly influence regulations and standards and that have a larger reach in terms of driving industry opinions. Participants include code and standard development organizations, regulatory bodies, industry associations, and connected environment organizations.

Developing the certification/regulatory landscape, driving adoption of best practices, addressing industry-wide issues of energy security and cybersecurity, and influencing energy policy and industry-wide incentives are some of the functions performed by the participants in this group.

Homeowners

Homeowners are, for obvious reasons, the core of the connected home energy industry. Homeowners drive initiatives and innovations in the industry based on feedback given to multiple participant groups. Their behavior in terms of system use, energy conservation measures, new technology adoption, and industry engagement helps shape the myriad solutions available and under development today.

1.2 CONNECTED HOME ENERGY: ADOPTION BY APPLICATION CATEGORY

Connected homes have multiple functions to perform to ensure the comfort and safety of occupants. Based on the nature of the tasks to be performed and the technology used for them, these functions can be performed by multiple systems utilizing varying amounts of energy for different durations of time. The focus of this research is to study aspects regarding the use and energy consumption/management of these systems in the home.

In this regard, advancements have been made and continue to be made in both connected/integration aspects and core technology aspects of the systems. The adoption of these advancements in technology has met with varying levels of success across different application areas due to factors such as costs involved, ease of use, ease of installation, proven reliability, use characteristics, and payback periods for the additional costs via energy savings.

Some of these factors could be interdependent in determining benefits for different consumers. For example, use characteristics could play a large role in determining payback periods for different application areas.[3] An LED lamp that is usually kept on for about three hours a day has a break-even point at almost five years. On the other hand, an LED used in a lamp that stays on for 12 hours a day will pay itself off in almost one year. These estimations are based on replacing traditional light bulbs with LEDs. This is apart from the additional savings that might come from an automated program that could turn off lights that are left on. However, many companies offer an away lighting feature—turning lights on and off—to provide the appearance of occupancy. Turning lights on when the home is unoccupied will, of course, increase electric consumption.

The status of market maturity of connected/energy savings features across various home application categories has been provided below in Table 1.

Table 1 Adoption by Application Category

Application Category	Market Maturity of Smart/ Connected Features	Market Maturity of Energy Saving Features	Impact on Home Energy Consumption	Remarks
HVAC	Medium	High	High	HVAC equipment generally consumes the largest quantity of energy in the home, however, connected features are currently limited and connectivity is primarily established via thermostats.
Lighting	High	High	Medium	The advent of LED lighting and increased upgrade options has driven penetration of connected and energy savings aspects for lighting.
Thermostats	High	High	High	Thermostats currently available in the market have features such as scheduling, geofencing, smartphone control, etc. Self-learning capabilities are available with limited offerings.
Energy Management, Information Monitoring, Diagnostics	Medium	Medium	High	Hardware and software infrastructure for energy management and diagnostics is limited by data availability in devices/systems and the connectivity status.
Communication Infrastructure	High	Medium	Medium	While available hardware such as communication bridges, transmitters and receivers has enabled inter-device communications, energy saving aspects of communications in connected homes is recently receiving increased attention.
Fire & Life Safety	High	Low	Low	Connected smoke alarms and flood detectors are increasingly accessible and controllable.
Physical Security	High	Low	Low	Home security infrastructure currently includes remote access components and leverages sensors and facial recognition provisions.
Connected Appliances	Medium	Medium	Medium	High range of energy savings impacts depending on the appliance type. Consumer adoption is yet to reach advanced stages.
Connected Home Entertainment	High	Low	Low	The most widely adopted form of connected home technology. However, impact of energy consumption is limited.
Smart Plugs and Power Strips	High	High	High	Popular option for quick-fix home upgrades to remotely control and monitor power consumption for devices.

Increasing consumer awareness and education is a key factor for driving adoption of connected home solutions in this dynamic market. This is a function that is required to be performed by all the product groups based on their respective areas and reach in the market. Industry participants can also assuage concerns regarding ease of use, data theft, or unwanted monitoring if they make consumers aware of the mitigating actions they take to address these issues.

Consumer concerns regarding ease of use are complex due to the number of devices/systems that need to be controlled. This is where the concept of a unifying home energy management system plays a mitigating role. In the last five years, there has been an upsurge in the number of overall home control platforms because an increasing number of systems have been added to the connected home ecosystem.

Home energy management systems can be controlled by a variety of means, such as smartphone applications, tablets, voice control, and other centralized consoles like connected thermostats. The range of functionalities available with each system in the home is not standardized and can have different levels of availability when integrated into a common home energy management system. This can be a deterrent in driving adoption because the functionalities available to end-users are limited despite existing innovations in their installed equipment.

Smart plugs are an alternative for consumers who do not wish to upgrade their existing home systems due to connectivity/integration issues. These are only effective in applications that require a simple on/off function. For example, switching sprinklers, air purifiers, or water heaters on/off could be enabled by a smart switch.

The ecosystem[4] to enable device control and interaction also plays a large role in driving adoption because it affects the ease of installation and subsequent use of the connected home energy management system. Other than the controlled devices, controlling devices, and software aspect of the connected home energy management system, there are two major technology areas of the connected home. These are the control-related hardware (such as sensors, radio frequency bridges, and relays) and the communication protocol (used to allow various devices and systems to interact with each other). Due to inherent disadvantages of traditional Wi-Fi, such as reliability and energy consumption, there are multiple communication mechanisms operating at varying frequencies. Devices either have to be compatible with a common protocol to function as a part of a home energy management system or they need to be integrated using communication hubs. These hubs can translate signals from multiple communication protocols to ensure integration.

1.3 INDUSTRY'S PERSPECTIVE OF CONSUMERS

Industry participants drive the direction of many technological innovations, business models, and consumer offers based either on direct homeowner feedback or via connected home service providers. They determine insights regarding the pain points of homeowners with existing technology, for which product groups consumers would want connected features added, the mode of control homeowners might prefer for their technology, and the types of incentives or business models that will find success with homeowners. The traditional opinion of industry participants is that the primary connected home technology drivers are occupant convenience, comfort, and novelty. However, as can be seen in Figure 9 in Chapter 2 of this report[5], utility/energy/cost savings is one of the primary drivers of consumer interest in smart/connected home solutions. Some factors for this include increased consumer awareness of connected home technologies and the resulting increased understanding of potential energy saving benefits. The cost factor has traditionally hindered the wide adoption of connected home technologies because the benefits were widely associated with non-measurable convenience factors. As associated energy-related benefits translate into measurable cost savings, previously hesitant consumers are expected to have a higher propensity to adopt such technologies.

In a sense, the energy savings factor for connected home technologies can help usher in the next wave of connected home technology adoption — adoption that would be on a much wider scale than ever observed before. This factor has been popularized by the various incentives available from industry participants, such as tax rebates provided for adopting various technologies and incentives provided by utilities for participating in demand response programs and for adopting various technologies.

While it might be relatively easier to offer connected technologies for newly constructed homes, the existing potential market for retrofits is large and challenging. This is where an increased level of collaboration would be beneficial between technology vendors and service providers due to the unique challenges present in upgrading existing home systems.

The LED lighting revolution successfully managed to achieve widespread adoption because it also addressed the retrofit market successfully. Products were created in such a way that there is minimal cost on the part of consumers to replace the existing lighting infrastructure. For example, features such as integrated LED drivers, wireless sensors, and control mechanisms that ensure minimal wiring requirements helped increase the appeal of retrofitting a non-LED infrastructure. Upgrading lighting to LED also helped drive connected lighting, as in some cases consumers opted to add a control layer to their upgrade since it was convenient to add both together.

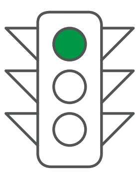
A new and growing connected home feature is the intuitiveness of various systems designed to identify behavioral patterns and real-time information. These systems then use that information to increase comfort, awareness, convenience, cost savings, and energy savings. Identifying these patterns and determining the correct parameters to maintain requires extensive consumer use analysis and will require ongoing analysis of specific home use patterns as smart systems are installed. This will require a continuous feedback loop between consumers and technology vendors to identify shifts in preferences and behavioral patterns so that systems can appropriately respond to such changes.

1.4 DRIVERS AND CHALLENGES FOR THE CONNECTED HOME ENERGY MARKET

The connected home energy market consists of various systems, connected devices, control hardware, software components, and ecosystem participants. All these market components experience growth or decline based on a variety of factors, ranging from consumer behavior to energy policy direction and energy grid-related factors. Gaining an understanding of the market drivers and restraints is a requirement to be able to estimate the future direction of the industry.

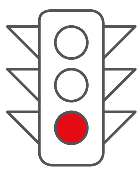
Technological advancements have played a large part in steering the direction of the industry. Advanced control and monitoring infrastructure has enabled new innovation options in product features, business models, and incentive programs for consumers. The ability and willingness to drive incentive programs also depends on regulatory policies or governmental support. Policies and incentives regarding energy efficiency measures can vary from state to state in the United States (US) and from province to province in Canada. There are a number of non-mandatory initiatives with a wide reach that could potentially help standardize energy efficiency evaluations for providing appropriate incentives.

Some key drivers and challenges for the connected home energy market have been highlighted below in Figure 2.



Drivers

- Consumer awareness of benefits
- Mobility of solutions via smartphones
- Energy- and cost-saving opportunities
- Incentives provided for adoption
- Development of wireless networking technologies
- Reduction in the costs of connected devices



Challenges

- Cybersecurity and privacy concerns
- Complex installation and troubleshooting mechanisms
- Initial cost concerns

Some of the primary drivers for the connected home energy market are described below:

Consumer awareness of benefits
The consumer awareness of connected home technology benefits is growing rapidly, as multiple market participants are promoting the opportunities, services, and capabilities of such technology. As such, a connected home is increasingly being treated as a distinct retail category. Consumer awareness regarding utility programs that can be leveraged in conjunction with connected home technologies is another driving factor because it can help build a need for adopting the products/systems.

Mobility of solutions via smartphones
Consumers are increasingly using smartphones to perform a variety of tasks and functions. They have also become more comfortable navigating increasingly sophisticated smartphone functionalities and various applications that are moving to the cloud. This has provided a ready-made control console for home energy solution providers, and the ability to use smartphones is expected to reduce resistance to the adoption of solutions.

Energy- and cost-saving opportunities
Due to the visibility provided by monitoring sensors and the automated control opportunities provided, there are numerous benefits including reducing unwanted energy consumption and delivering cost savings to consumers. For example, heating costs[6], which make up a large portion of the energy consumed in homes, can be reduced by up to 25 percent to 30 percent via intelligent home control. These savings, coupled with detailed analysis of energy consumption across systems, act as desired benefits to drive the adoption of connected home energy technologies.

Incentives provided for adoption
Incentives provided by government bodies and by utilities are also a key driver for the connected home energy market. These incentives might involve rebates for installing systems or devices such as smart thermostats, energy efficient heating/cooling equipment, Energy Star-certified home appliances, or energy efficient lighting. Other incentives could be based on the willingness of consumers to participate in home energy audits, smart metering and demand response programs, and dual energy programs. The possible penetration of energy-as-a-service offerings in the residential sector would also act as an incentive for consumers because these would address their concerns regarding initial investments.

Development of wireless networking technologies
The increasing number of wireless technologies enables communication among devices. This has made centralized control and monitoring of the overall connected home easier in some ways, as an internal home network can be created among the ecosystem of home devices. These technologies include Wi-Fi, Bluetooth Low Energy, Z-Wave, Zigbee, and Thread.

Reduction in the costs of connected devices
The cost of connected devices is continuously decreasing, making them more affordable for consumers. The reduced cost of producing technical products and the rapid technological innovation have increased competition in the marketplace for connected technical products and services, forcing providers to accept lower margins to remain competitive. Although initial costs remain a concern for consumers, the shrinking prices help increase the appeal of the technology.

In addition to these market drivers, there are a number of restraints limiting growth and decelerating adoption rates of the market. These must be effectively addressed by the industry to enable widespread connected home energy technology adoption.

Some of the primary challenges for the connected home energy market are described below:

Cybersecurity and privacy concerns
The emphasis placed on connectivity and convenience in an effort to enrich consumer lifestyle experiences in the connected home has also exposed the connected home environment to an increased incidence of cyber threats. Two broad areas of the connected home are at risk in the event of a cyber-breach: the machine-to-machine (M2M) environment encompassing all devices and systems that can connect and communicate through an IP network; and the data made inseparable from devices through aggregation in the cloud or within the home network. Damage from a breach could permeate all layers of the ecosystem, including users, vendors, service providers, and associated infrastructure. These concerns can be effectively addressed by adopting counter-measures such as adding hardwired capability to devices, advocating strong password etiquette, using bidirectional encryption for data transfer, and enabling automatic firmware updates for connected devices.

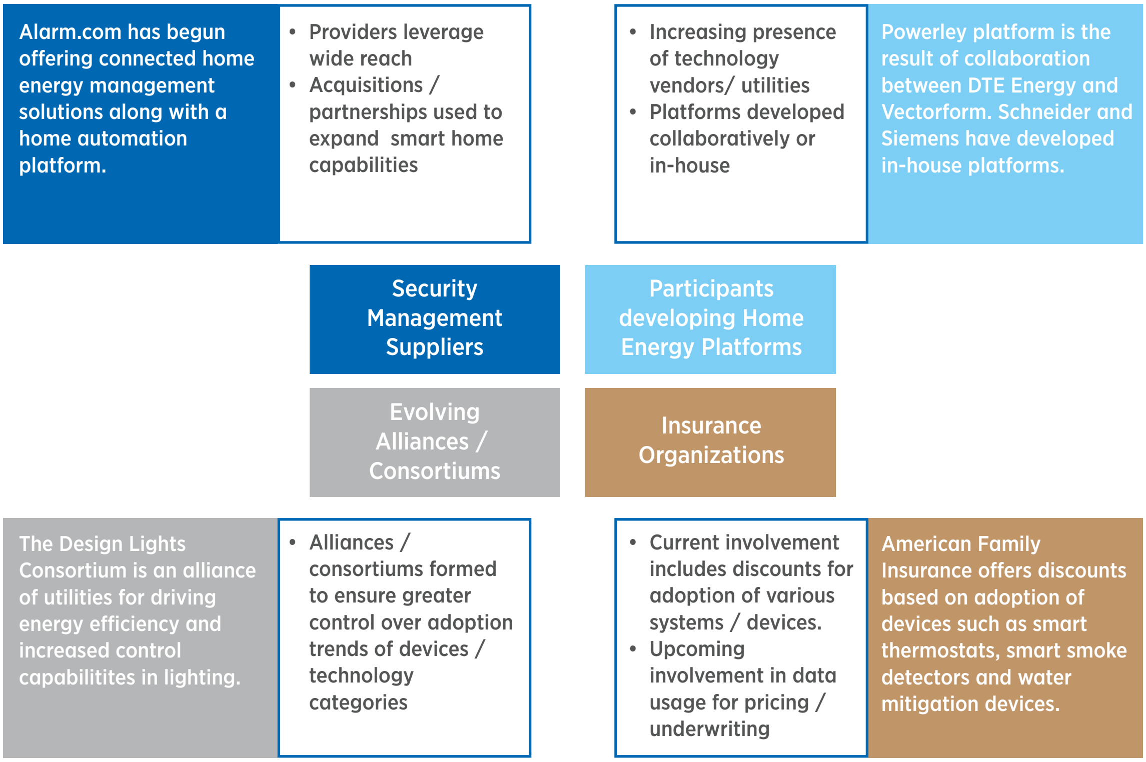
Complex installation and troubleshooting mechanisms
Self-installation is becoming more difficult as consumers integrate an increasing number of connected solutions. Ensuring device compatibility while using limited communication protocols adds to this challenge. Communication hubs/bridges can be utilized to integrate disparate ecosystems of devices, but these add a layer of complexity to the installation and necessitate troubleshooting that consumers prefer to avoid. Increasing widespread adoption requires that this challenge be addressed.

Initial cost concerns
Despite the falling prices of connected devices, many sections of consumers still have concerns regarding the upfront costs needed to upgrade multiple systems in their homes. These concerns are addressed in many ways—such as through rebates and financing support by utilities and other stakeholders—but consumer concerns remain and there is still slow adoption of connected home energy solutions.

1.5 SUPPLEMENTARY ECOSYSTEM PARTICIPANTS IN THE CONNECTED HOME ENERGY MARKET

While a brief overview has been provided of the major connected home energy participant groups in Section 1.1, it is also important to understand some emerging industry participants. These are a result of evolving requirements and evolving business models based on recent industry advancements. Some of these emerging participants are:

Figure 3 Supplementary Ecosystem Participants



Security management suppliers are extending home energy management offerings. Given that connected security has traditionally been an early-adopted connected home technology, a number of security management companies exist in this space. Using their advantage of existing consumer engagement and leveraging acquisitions/partnerships, a number of security companies have started expanding into the connected home energy market. For example, the security services provider Alarm.com has begun offering connected home energy management solutions along with a home automation platform.

Traditional technology vendors/utilities are also developing whole home energy management platforms.

Due to the evolving nature of the market, there is a growing prevalence of non-traditional providers, such as utilities, offering supplemental home energy platforms. Utilities usually engage in collaborations/partnerships with connected home platform providers to offer home energy platforms. This enables a higher degree of control and monitoring to drive energy efficiency and demand side energy management. For example, the Powerley platform was created through collaboration between the utility DTE Energy and Vectorform. It was designed to help drive home automation, reporting, and demand response programs as a result of the enhanced system control provided by the platform.

Technology vendors, like Schneider Electric and Siemens, are also developing in-house home automation platforms. Technology vendors rely on their experience in home systems, such as with device control, to develop home energy management solutions that can effectively address connected home requirements.

Home energy management platforms can act as an effective gateway to enter the connected home energy market and grant a degree of control to organizations that provide customizable platforms. It remains to be seen which platform categories are sustainable in the long term.

Participant group alliances and consortiums are developed to drive the common evolving interests in the connected home energy market.

As the market continues to evolve, various participant groups are expected to have evolving roles. The above example of home energy platform development demonstrates how different participant groups are competing to be the gateway to home automation via platforms. As a result of these evolving roles, participants with common interests have been collaborating together to form alliances or consortiums to ensure common requirements are effectively addressed.

For example, the Design Lights Consortium is an alliance of utilities with the goal of developing approved supplier lists for energy efficient and connected lighting technology. This enables consumers to address utility requirements with products that have discounted incentives or rebates. Another example is the Z-Wave Alliance, which has brought together multiple organizations with products compatible to Z-Wave communication protocol. This enables them to create a simple and interoperable common home automation ecosystem for multiple systems.

Insurance organizations are moving into the connected homes market.

Insurance organizations[7] are entering the connected home market by offering premium discounts for consumers that have adopted partnering connected security systems or other systems/devices such as water leak detectors, smart thermostats, etc. However, this is expected to expand in scope as insurance organizations look to analyze connected home system use data and patterns to appropriately size underwriting and pricing. This could drive insurance organization and industry participant partnerships and collaborations in the coming years.

2. CONSUMER PERCEPTION ANALYSIS

2.1 INTRODUCTION AND METHODOLOGY OF THE SURVEY PROCESS

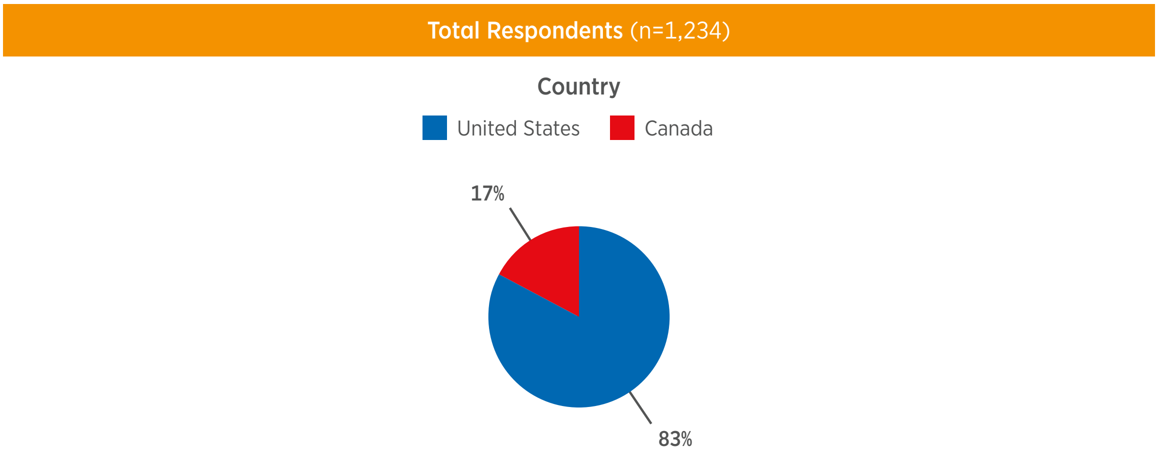
Consumer Research Module
Consumers play a key role in driving various trends in the connected home energy industry. Their perceptions determine the success or failure of various initiatives and innovations in the market. The consumer research module for this research was designed to capture valuable insights regarding energy aspects and adoption trends associated with connected home solutions, while aiding the development of the connected home energy roadmap. The intent of the module is to enrich and externalize data obtained from industry research and secondary sources, and to aid with corroboration and triangulation of industry data. The objectives fulfilled by undertaking the survey are enlisted in the Executive Summary section.

Research Instruments: Discussion Guide Questionnaire
Frost & Sullivan developed the discussion guide for the consumer perception research process in consultation with the steering committee. The approval process and obtaining of data consisted of multiple stages detailed in the methodology section of the Executive Summary of this report. The data from these responses were analyzed using various qualitative and quantitative tools.

2.2 CONSUMER PROFILING

Screening questions were asked as a part of qualification criteria before allowing respondents to proceed with the survey. Respondents not meeting the required criteria were disqualified. Qualifying respondents were further profiled for classification purposes. Please refer to the methodology section of the Executive Summary for further information. The results of the respondent profiling process are illustrated below. Figure 4 shows the country classification of the broad category of respondents.

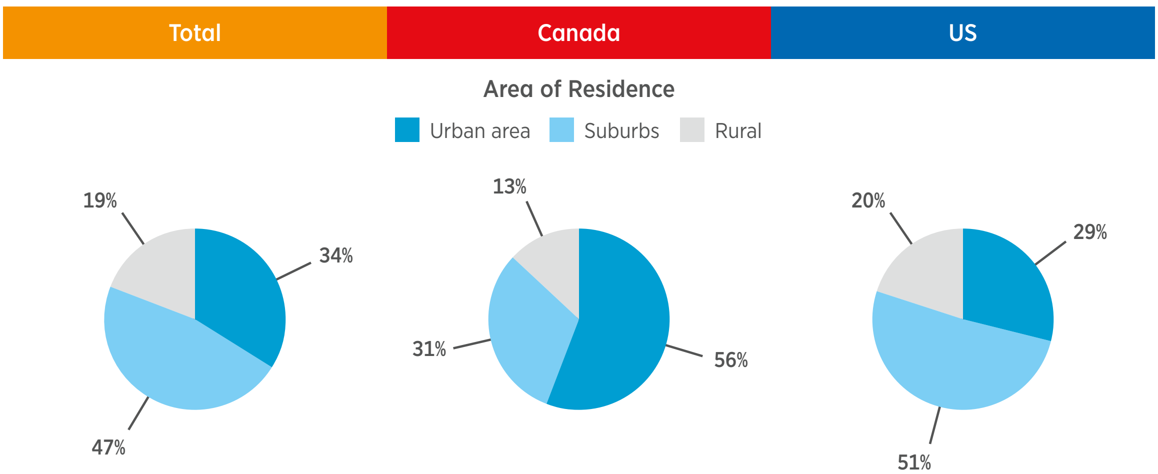
Figure 4 Country Classification within the Category of Respondents



Q: Country of organization

Qualified respondents were geographically categorized for United States (US) and Canada. Eighty-three percent of respondents were from the US, while the remaining 17 percent were from Canada. Of the total sample, 34 percent of respondents resided in urban areas, 47 percent resided in the suburbs, and 19 percent resided in rural areas.

Figure 5 Area of Residence

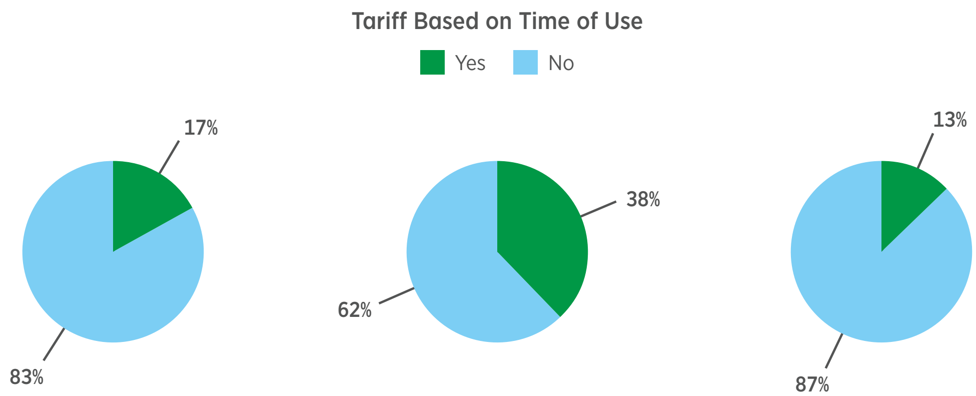


Q: What type of area do you live in?

There was a healthy distribution between respondents having a tariff based on time of use versus the others on fixed rate tariffs. As shown in Figure 6, 17 percent of respondents had a tariff plan based on their time of use as opposed to 83 percent having tariffs that were not time dependent; thus, reflecting the tentative adoption rates of time-of-use programs from utilities.

Figure 6 Respondent and Household Profiles

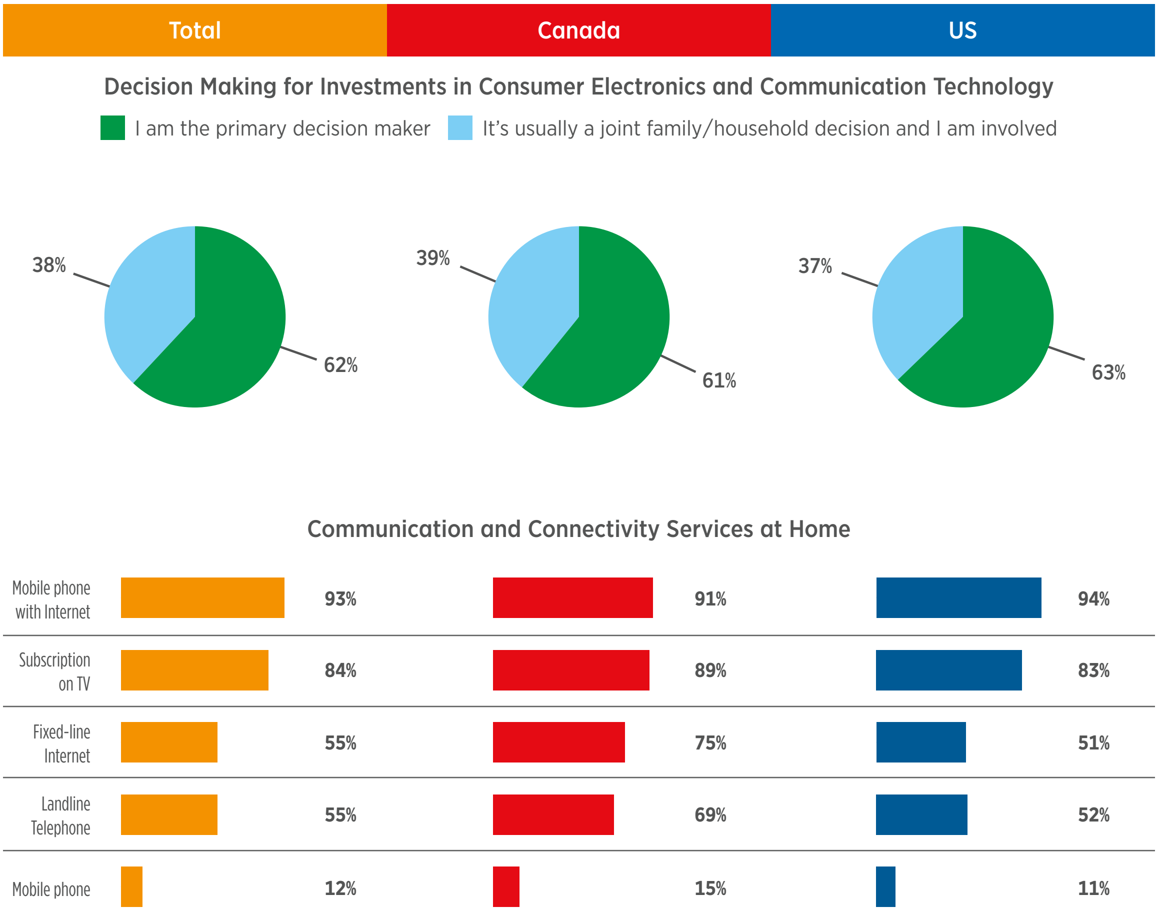
	Total	Canada	US
Average Number of People in Household	3 People	3 People	3 People
Average Gross Household Income Per Year	$84,095	$92,573	$82,297



Q: How many people live in your household, including yourself? What is your gross household income per year, including pensions and other benefits, before tax and other deductions? Do you have a tariff based on time of use?

The influence of respondents in decision making with regard to investments in consumer electronics and communication technology was verified during the screening phase to ensure possible translation of the results into actionable insights for the industry. Of the overall respondents, 62 percent were primary decision makers and 38 percent were involved in the joint family/household decisions regarding these products and technologies (as shown in Figure 7).

Figure 7 Communication and Connectivity Services in Households



Q: How would you describe your role in the decision-making process for investments in consumer electronics and communication technologies? Which of the following communication and connectivity services does your household subscribe to at your home?

2.3 CURRENT ADOPTION TRENDS

The consumer research survey provided important insights into the overall intention and trends for adoption of connected home energy technologies. The questions in this category aimed to understand the perceptions regarding the characteristics of connected homes, key objectives for adoption for energy-saving solutions, current and upcoming adoption trends, brand preferences, and perceptions regarding modes of control for home energy equipment. Figure 8 represents consumer opinions regarding key characteristics of a connected home.

Given the proliferation of multiple solutions[1] offering application-based control of residential systems via cloud systems using the smartphone, 'smartphone/tablet-controlled systems for HVAC, lighting, etc.' is the most popular characteristic, selected by 74 percent of respondents. Respondents' understanding of what constitutes a connected home is closely related to systems driving energy consumption. This is followed by 'Wi-Fi-connected security,' also driven by remote access options, and the simplicity involved in the installation and operation of connected security cameras. Energy savings is also top of mind as illustrated by 49 percent of respondents selecting 'products that reduce electricity bills'.

Figure 8 Perception of Characteristics of Connected Home

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Smartphone/tablet controlled systems for HVAC, Lighting, etc.	74%	73%	80%	70%	75%	75%	73%	75%	75%	77%
WiFi connected security	72%	72%	65%	72%	75%	73%	70%	70%	74%	75%
WiFi connected entertainment systems	68%	71%	75%	72%	69%	67%	64%	65%	68%	70%
WiFi connected appliances	65%	69%	65%	67%	75%	64%	65%	64%	63%	66%
Devices that can be programmed	63%	68%	70%	69%	67%	62%	55%	60%	65%	63%
Products that reduce electricity bills	49%	58%	45%	60%	57%	47%	48%	44%	49%	49%
Centralized hubs like Wink, Amazon Echo etc	49%	45%	40%	43%	51%	50%	45%	54%	48%	52%
Systems enhancing home comfort	47%	48%	55%	47%	48%	47%	42%	48%	47%	50%
Self learning/self adjusting systems	32%	37%	20%	38%	42%	31%	29%	35%	27%	33%

Q: Some people would consider a connected home to be characterized by?

Figure 9 illustrates the primary drivers. Utility/energy/cost savings is the primary driver in both countries.

However, consumer perceptions regarding energy cost savings as a driver are at 78 percent for Canada compared to 68 percent for the US. This is despite relatively lower electricity rates in Canadian provinces stemming from primary use of the hydroelectric power available in surplus in most provinces.

Building on the high percentage of consumer concern regarding utility/energy/cost savings, adoption would entail focusing marketing messaging for specific savings examples or performance characteristics for various technologies in addition to the convenience aspect.

Figure 9 Drivers of Interest in Smart Home/Connected Home Solutions

	Total n=1234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Utility / energy/ cost savings	70%	78%	70%	85%	69%	68%	61%	67%	70%	71%
Convenience	61%	58%	55%	59%	57%	62%	61%	61%	60%	65%
Security	55%	46%	35%	41%	58%	57%	56%	58%	55%	61%
Comfort	48%	47%	35%	53%	40%	48%	46%	49%	45%	52%
Peace of mind	43%	41%	40%	38%	46%	43%	42%	41%	43%	47%
I like tech products	31%	27%	25%	26%	31%	31%	33%	31%	30%	32%
Entertainment	29%	24%	25%	20%	31%	29%	28%	26%	30%	35%
Other	3%	4%	10%	3%	3%	3%	6%	2%	2%	3%

Q: What drives your interest in smart home/connected home solutions?

Frost & Sullivan's research also identified the current adoption trends and those expected in the next 12 months in terms of the types of products adopted.

As corroborated with industry interactions, connected home entertainment was found to currently have the highest adoption rate (as illustrated in Figure 10). This is the most frequently adopted connected product category for both the US and Canada, a result of the relatively higher evolution of entertainment products on the connected scale.

Connected thermostats and connected security followed. Connected thermostats have been part of the next thermostat product development life-cycle after programmable thermostats. Self-learning capabilities are currently only available with a few brands, such as Nest's learning thermostat. Relatively high adoption rates of connected thermostats compared to other connected products, coupled with the increasing abilities of thermostats to control multiple systems in the home, indicates that thermostats could be a viable control gateway for home energy management based on requirements.

A number of connected security cameras are also available. These cameras generally have a proprietary mobile application, allowing users to remotely access video feeds, although there are many installed devices on professionally monitored programs.

Figure 10 Connected Products Already Adopted

	Total n=1234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Connected home entertainment	34%	33%	35%	30%	37%	34%	32%	33%	34%	38%
Connected thermostats	29%	29%	25%	27%	33%	29%	28%	33%	29%	26%
Connected security systems	25%	21%	10%	17%	33%	26%	23%	30%	21%	32%
Connected lighting	20%	20%	20%	18%	22%	21%	23%	22%	18%	22%
Connected smoke alarms	18%	19%	10%	18%	24%	18%	22%	17%	14%	24%
Smart Plugs	14%	12%	15%	11%	12%	15%	17%	15%	11%	18%
Connected air conditioners	12%	11%	10%	14%	7%	12%	13%	14%	11%	12%
Connected small appliances	12%	10%	20%	6%	13%	12%	14%	13%	11%	12%
Connected white goods / major appliances	11%	8%	15%	9%	4%	11%	8%	11%	10%	14%
Connected sprinklers	8%	4%	0%	3%	7%	9%	8%	9%	6%	15%
Connected water heaters	8%	6%	5%	6%	6%	8%	10%	8%	7%	8%
Connected fans	8%	7%	5%	7%	6%	8%	8%	8%	8%	9%
Electric vehicles	6%	6%	0%	7%	4%	6%	8%	7%	3%	9%
Connected air purifiers	6%	5%	0%	5%	6%	6%	10%	7%	4%	5%
Connected pool pumps	4%	2%	5%	2%	1%	4%	5%	4%	4%	5%
None	37%	41%	50%	43%	33%	36%	38%	34%	40%	30%

Q: Which of the following connected products have you adopted?

In reference to the trends of connected products to be adopted in the next 12 months, product group distribution shows changes, such as connected home entertainment with a lower position as the fourth-most popular product group, caused by a relatively higher existing product base across respondents. Additionally, as shown in Figure 11, connected thermostats form the most popular product group. Fifty-one percent of respondents who do not currently possess connected thermostats are planning adoption in the next 12 months. Given the major role HVAC systems play in home energy, this adoption rate assumes a high significance by ensuring a higher degree of monitoring and controllability of such systems through the thermostat.

The next two popular product groups for adoption in the next 12 months are connected lighting at 45 percent and connected security systems at 42 percent. Connected lighting continues to be driven, to a large extent, by the retrofit adoption of LED lighting systems. Connected security systems have witnessed high growth levels in the 'do-it-yourself' security system installation market.

Figure 11 Connected Products to Be Adopted in the Next 12 Months

	Total n=1234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Connected home entertainment	36%	35%	23%	34%	38%	36%	34%	38%	36%	35%
Connected thermostats	51%	54%	20%	60%	51%	50%	49%	52%	48%	54%
Connected security systems	42%	31%	39%	28%	36%	44%	44%	45%	41%	51%
Connected lighting	45%	41%	25%	40%	46%	46%	41%	49%	45%	50%
Connected smoke alarms	33%	30%	17%	33%	29%	34%	33%	34%	35%	33%
Smart Plugs	31%	35%	18%	34%	41%	31%	27%	31%	31%	33%
Connected air conditioners	27%	26%	17%	30%	21%	28%	29%	31%	24%	29%
Connected small appliances	24%	21%	13%	22%	21%	25%	28%	27%	23%	22%
Connected white goods / major appliances	25%	22%	6%	23%	23%	26%	30%	29%	24%	23%
Connected sprinklers	13%	11%	5%	9%	18%	13%	11%	19%	9%	18%
Connected water heaters	20%	20%	11%	20%	22%	21%	23%	19%	19%	23%
Connected fans	20%	12%	16%	10%	13%	21%	21%	25%	19%	22%
Electric vehicles	11%	10%	5%	11%	8%	12%	13%	13%	10%	12%
Connected air purifiers	15%	11%	10%	11%	11%	16%	17%	17%	15%	14%
Connected pool pumps	9%	6%	0%	7%	6%	10%	12%	12%	8%	10%

Q: Which do you plan to adopt in the next 12 months?

Insights were obtained from respondents regarding current brand/ecosystem use. Canadian respondents have a higher concentration in terms of brand preference compared to the US. Brands related to thermostat products and overall home energy management ecosystems were the most popular.

The adoption of home energy solutions was studied in terms of motivating factors across various degrees of influence. Figure 12 and Figure 13 illustrate such factors with various levels of influence for adoption across the overall respondent profiles. Occupancy-based heating/cooling was the most popular factor, followed by time-of-use-based heating or cooling adjustments.

The most popular feature/benefit in Canada was the associated benefit of cost savings with 84 percent of respondents being motivated to a high degree by that benefit. Occupancy-based heating/cooling adjustment was the most popular feature/benefit in the United States having a motivation rate of 75 percent. Energy consumption reporting and real-time energy consumption analysis are other motivating factors that would be preferred add-ons in an energy management system.

Figure 12 Drivers of Adoption of Home Energy Solutions – (1/2)

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Automatic adjustment of heating or cooling, when it senses that there are no occupants	76%	81%	75%	80%	84%	75%	72%	80%	73%	74%
Automatic adjustment of heating or cooling, during peak hours or high cost hours	75%	79%	75%	80%	79%	74%	73%	79%	75%	68%
Ability to realize savings from the use of the various energy saving solutions	73%	84%	95%	84%	82%	71%	70%	68%	73%	69%
Ability to manage energy-consuming home appliances from a single device	69%	69%	85%	66%	70%	69%	66%	73%	69%	64%
A smart system that understands my energy bill, and can break it down into the key high energy	64%	68%	80%	68%	66%	63%	67%	68%	61%	59%
A smart system that advices me on the best ways to save energy in my home	61%	62%	75%	60%	61%	61%	66%	60%	62%	57%
Ability to manage appliances, lights etc. from a single device, display, or smartphone.	61%	60%	70%	55%	66%	62%	65%	72%	58%	53%
Ability to monitor, in real time, the total energy being consumed in the household	58%	67%	75%	67%	66%	56%	55%	59%	56%	53%
Ability to monitor energy consumption of whatever is plugged in specific outlets	57%	58%	70%	56%	58%	57%	60%	60%	56%	53%
Ease of installing / setting up the solution	56%	67%	75%	67%	66%	53%	51%	57%	54%	50%

Q: Which of the following features or benefits will most motivate you to adopt home energy solutions? And which will least motivate you?

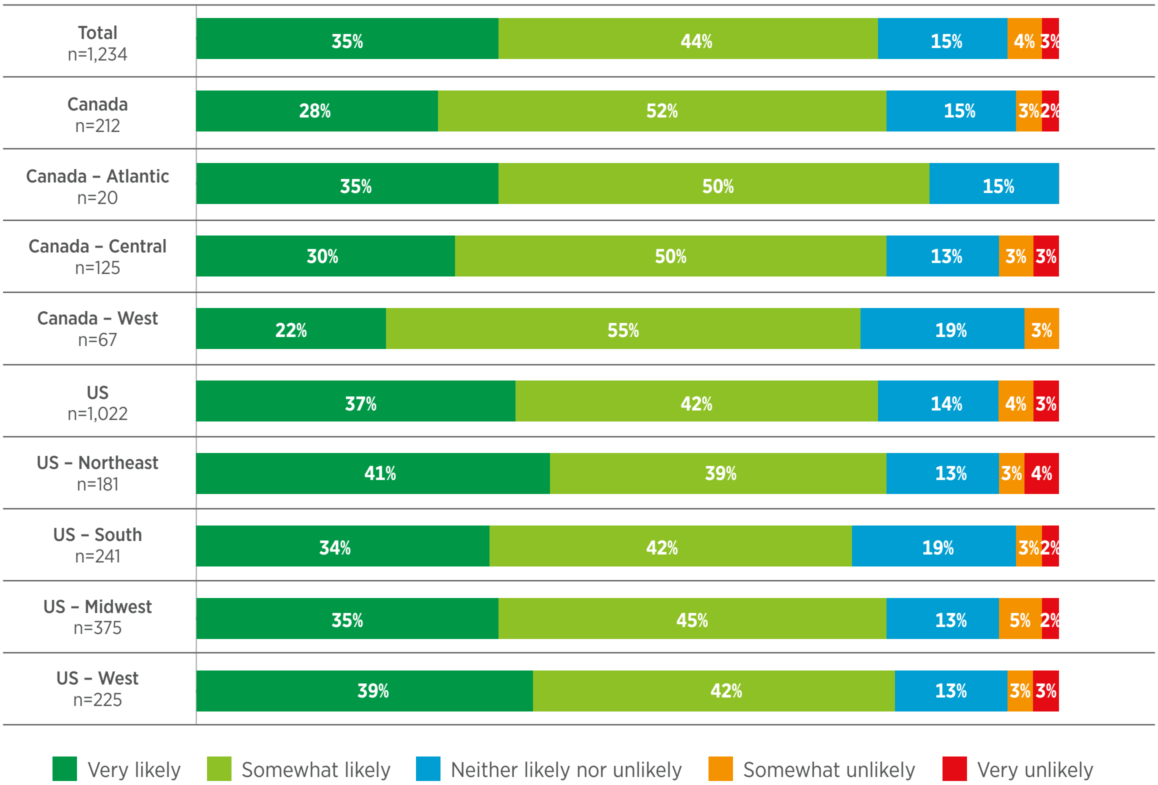
Figure 13 Drivers of Adoption of Home Energy Solutions – (2/2)

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Ability to adjust thermostat remotely using your smartphone	56%	54%	65%	50%	58%	56%	57%	66%	55%	45%
A report or feedback about the estimated cost savings that you have realized for a given period	51%	59%	65%	59%	58%	49%	49%	44%	53%	49%
Ability to manage the energy consumption of home appliances remotely using your smartphone	51%	47%	65%	42%	52%	52%	54%	59%	49%	46%
Ability to switch on/ switch off lights remotely using your smartphone	41%	38%	40%	35%	42%	41%	42%	52%	37%	37%
Display the cost of energy at a particular moment (real time)	39%	46%	65%	46%	39%	37%	38%	38%	36%	38%
Peak hours or high bill warnings	38%	43%	55%	46%	34%	36%	36%	40%	38%	30%
A report or some feedback about the overall consumption pattern of energy	36%	42%	45%	43%	39%	35%	36%	31%	37%	36%

Q: Which of the following features or benefits will most motivate you to adopt home energy solutions? And which will least motivate you?

Multiple features as a part of a solution based on the respective respondent's past selections were provided to evaluate likelihood of actual use of the overall solution, with the results shown in Figure 14. Canada and the US had similar percentages being very likely or somewhat likely to use the solution. Canada had 80 percent for these two categories and the US had 79 percent.

Figure 14 Likelihood of Using Home Energy Solutions

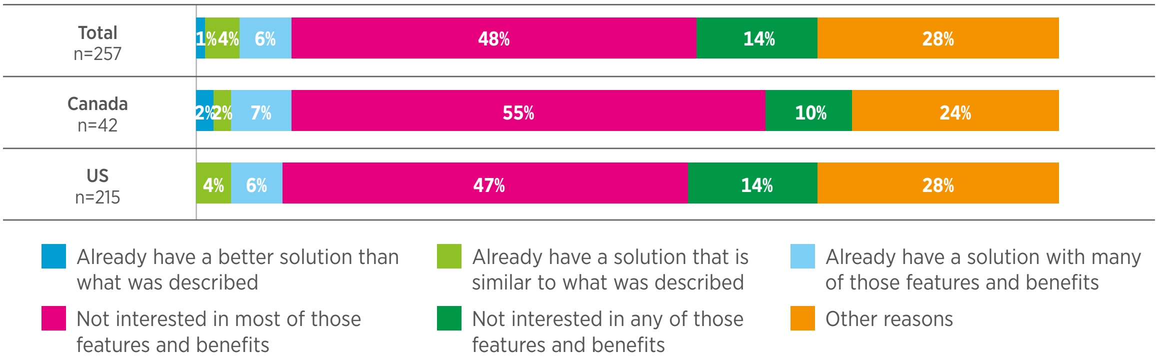


Q: How likely are you to consider using such a solution in your home?

Reasons for unwillingness to adopt the solution were also studied, as illustrated in Figure 15. Approximately 50 percent of respondents who had responded 'somewhat unlikely' or 'very unlikely' did so because they were not interested in most of the features/benefits presented.

These are, however, low numbers compared to the overall sample size as the respondents who were 'somewhat' or 'very unlikely' to adopt the solutions numbered 257 out of an overall sample size of 1,234.

Figure 15 Reasons for Not Being Willing to Use Home Energy Solutions



Q: What is the reason why you are somewhat unlikely/very unlikely to use such a solution?

Respondents were also questioned regarding devices to be used while controlling an overall connected home energy management solution. Figure 16 shows the results when respondents were provided an option to select multiple control possibilities, whereas Figure 17 shows results when respondents were asked to choose their most-preferred control option. Smartphones are the most popular option in both result sets.

Smartphones can be used to integrate systems using a common home energy management application, or systems can have dedicated applications for control and monitoring purposes.

When it comes to the device they most prefer to use, centralized control consoles were the second-most popular option and can also be integrated into the overall system as an additional control mechanism.

Figure 16 Devices Used when Controlling Connected Home Energy Management Solutions

	Total n=1234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Smartphone	52%	49%	50%	42%	60%	53%	48%	0%	54%	55%
Laptop/ Notebook/ PC	10%	12%	5%	15%	7%	10%	14%	11%	8%	9%
Tablet	7%	10%	20%	10%	7%	6%	5%	5%	7%	6%
Centralized control console for all functions	11%	13%	15%	14%	9%	11%	10%	12%	13%	8%
Voice control/smart speaker	7%	5%	5%	4%	6%	7%	6%	8%	7%	9%
Different control devices for different purposes	3%	1%	0%	2%	1%	3%	4%	2%	4%	4%
Wearable device (e.g. Smart watch)	2%	0%	0%	1%	0%	2%	3%	3%	2%	1%
Don't know	8%	10%	5%	12%	9%	8%	10%	7%	6%	8%

Q: Apart from manual control, which of the following devices would you most likely use when controlling your connected home energy management solution (once it is fully installed)?

Figure 17 Most Preferred Devices Used when Controlling Connected Home Energy Management Solution

	Total n=1234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Smartphone	70%	65%	75%	58%	75%	72%	67%	73%	71%	73%
Laptop/ Notebook/ PC	31%	34%	35%	37%	28%	30%	34%	32%	28%	30%
Tablet	29%	31%	40%	32%	27%	28%	29%	24%	26%	34%
Centralized control console for all functions	23%	24%	30%	25%	21%	23%	22%	23%	23%	23%
Voice control/smart speaker	22%	16%	20%	15%	16%	23%	28%	20%	19%	28%
Different control devices for different purposes	9%	5%	0%	6%	4%	10%	14%	9%	10%	9%
Wearable device (e.g. Smart watch)	9%	4%	0%	5%	4%	9%	10%	10%	9%	10%
Don't know	8%	10%	5%	12%	9%	8%	10%	7%	6%	8%

Q: Which of these devices would you most prefer to use?

In terms of current use, electronic timer devices wired to outlets were the most popular control mode for switching on/off of lights in both countries, as shown in Figure 18. Dedicated smartphone apps and smartphone apps that are part of an overall connected home management system are two other popular modes of control for this purpose.

In Canada, dedicated apps for lighting control have a higher acceptance rate compared to overall home smartphone apps, possibly due to an earlier overall adoption of smart lighting.

Figure 18 Devices Used to Program the Switching on/off of Lights

	Total n=648	Canada n=136	US n=548
Electronic timer device wired to the outlet	33%	27%	34%
Smartphone app exclusively for switching lights	23%	27%	22%
Smartphone app that is part of a home energy or smart home management system	22%	16%	23%
Mechanical timer device wired to the outlet	16%	27%	14%
Other	6%	4%	6%

Q: What device do you use to program the switching on/off of lights?

In terms of devices currently used to program or control thermostats, respondents were asked to answer in terms of multiple devices they use for thermostat control (Figure 19) and their most preferred device (Figure 20). The traditional mode of control continues to dominate, with dedicated thermostat consoles being the most popular. However, these consoles have grown in sophistication[2] as seen with the Nest thermostat and touchscreen displays that possess geofencing capabilities and scheduling features. The second-most preferred control option is a dedicated smartphone application for the thermostat. One of the driving factors is that all functionalities can be accessed with a dedicated application as opposed to an overall connected home application in many cases.

Figure 19 Devices Used to Program or Control the Thermostat

	Total n=648	Canada n=136	US n=548
Touchscreen/push button based/other temperature display	74%	76%	73%
Smartphone app that controls only the thermostat	29%	22%	30%
Smartphone app - part of home energy management system or smart home management system	19%	12%	21%
Control console that is part of a home energy or smart home management system	15%	11%	16%
Voice control that is part of a home energy or smart home management system	8%	4%	9%
Other	4%	5%	4%

Q: What device do you use to program or control the thermostat?

Figure 20 Most Preferred Device to Control the Thermostat

	Total n=648	Canada n=136	US n=548
Touchscreen/push button based/other temperature display	59%	70%	57%
Smartphone app that controls only the thermostat	16%	11%	17%
Smartphone app — part of home energy management system or smart home management system	12%	7%	13%
Control console that is part of a home energy or smart home management system	7%	5%	7%
Voice control that is part of a home energy or smart home management system	3%	2%	3%
Other	4%	4%	3%

Q: Which device do you most prefer to use to control the thermostat?

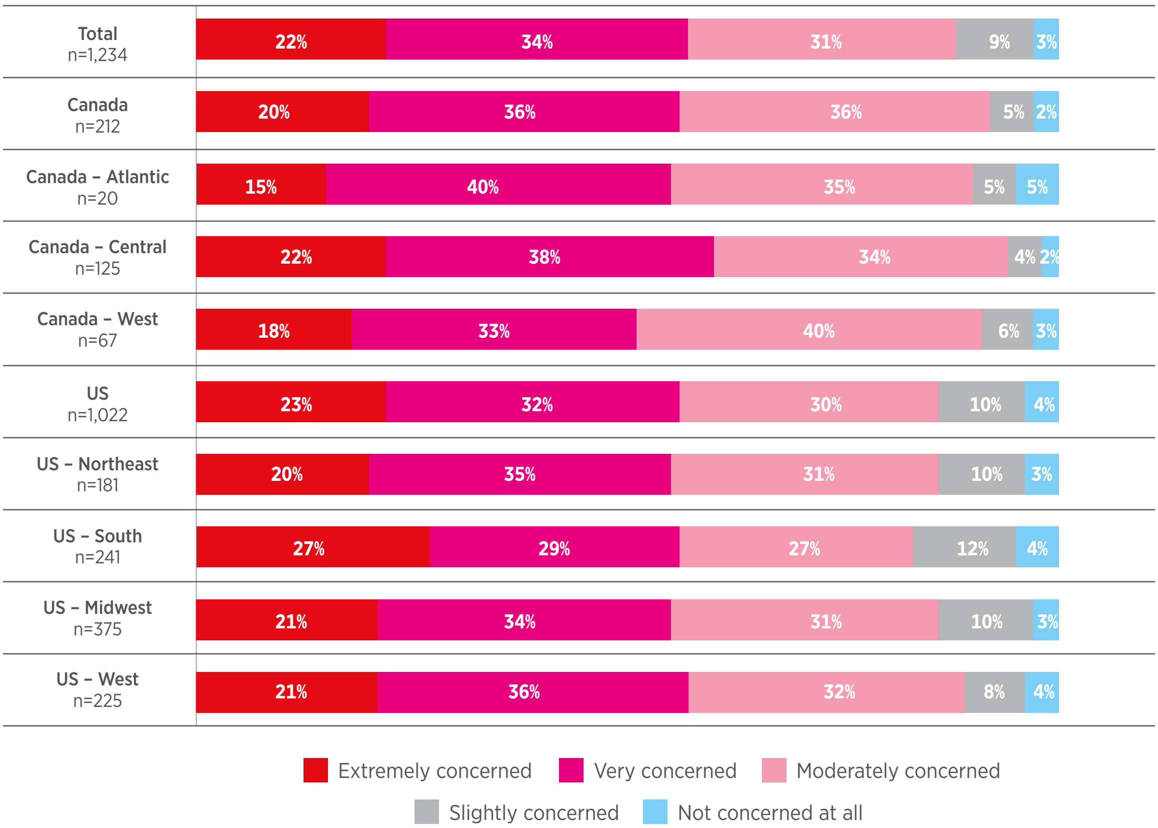
2.4 ENERGY COSTS: TRENDS AND PERCEPTIONS

The impact energy costs and the energy market have on each other are key factors to consider in the connected home energy market. Respondents were asked about concern levels regarding energy costs, cost fluctuation trends, payback criteria, mitigating actions taken, and the perceived impacts of various solutions on costs.

The information in this section provides insights for designing programs to drive adoption of energy efficiency measures, understanding consumer acceptance levels of various methods of controlling energy use, and driving customer efforts to efficiently utilize home energy.

Respondent concerns about energy costs are shown in Figure 21. Those who were ‘slightly concerned’ or ‘not concerned at all’ made up eight percent of Canadian respondents and 14 percent of US respondents, showing the majority of respondents have medium to high levels of concern regarding energy costs.

Figure 21 Level of Concern about Energy Costs

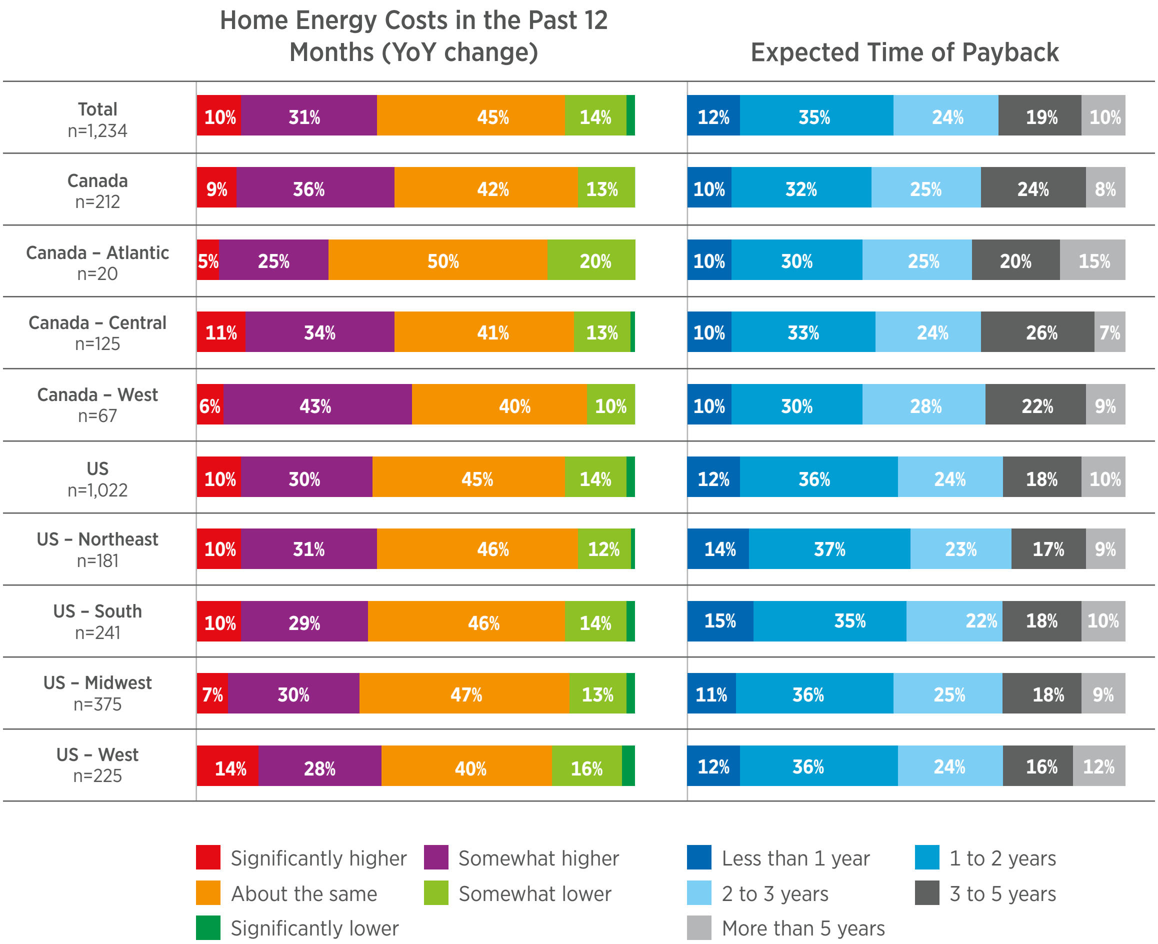


Q: How concerned are you about your home's energy costs?

Respondents' inputs regarding changes in costs associated with home energy consumption over the last 12 months were obtained. As shown in Figure 22, 45 percent of respondents in Canada and 40 percent of respondents in the US had higher overall costs associated with home energy consumption. While the US had similar results across regions, Canada showed increasing costs from the Eastern seaboard moving towards the Western seaboard.

Insights from respondents were also gathered for expected payback time for investments made solely for energy-saving reasons. The most common time period realized was one to two years across both countries, as shown in Figure 22. This can be used to gauge the additional cost-to-energy-saving benefit ratio to ensure viability of upcoming energy-saving solutions.

Figure 22 Home Energy Costs in the Past 12 Months (Y-o-Y change) and Expected Time of Investment Payback

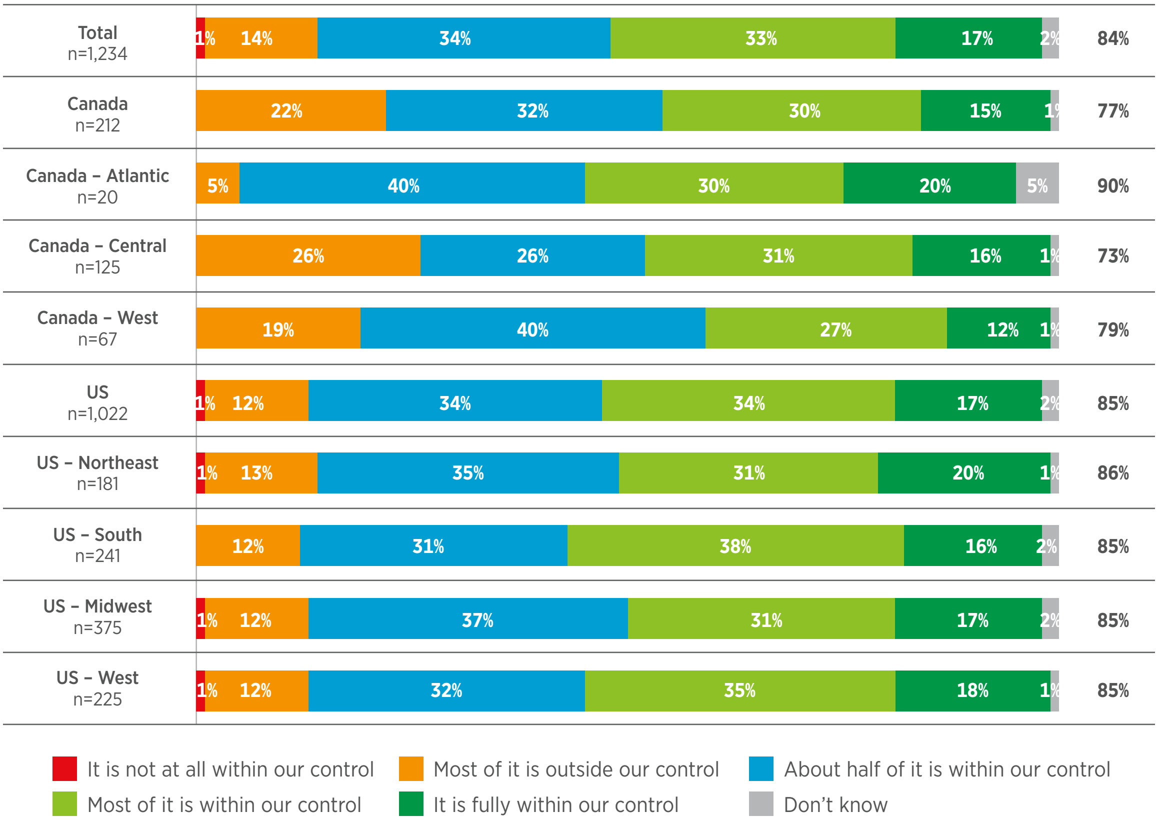


Q: Compared to the previous year, how did your home energy costs in the past 12 months compare? If you invest in a product solely for energy-saving reasons, how many years do you expect savings to payback your initial investment?

The perception of consumer control regarding managing home energy costs was also evaluated to analyze consumer education levels in terms of options/products/practices available to increase home energy efficiency.

As shown in Figure 23, 49 percent of all respondents believe that home energy costs are either not within their control at all or half to most of costs are out of their control. This indicates an urgent need to deploy more effective consumer information programs to ensure possible future implementation of homeowner-driven energy efficiency initiatives.

Figure 23 Belief in Ability to Manage Home Energy Costs



Q: To what extent do you believe that energy costs are something that you, as a home owner or resident, can manage, reduce, and minimize?

Information on consumer actions about energy cost reduction has been provided in Figures 24 and 25. The most popular measure across regions with 76 percent of respondents is upgrading lighting equipment to include LED bulbs. This reflects the recent change across the US and Canada as customers have increasingly adopted LED technology. It has also been supported by incentive programs[3] from utilities that had LED upgrades as a major component.

Energy Star-certified appliances have been another popular measure with 68 percent of respondents having implemented, followed by programmable thermostats (non-communicating) to preset scheduled temperature changes based on use requirements.

In terms of energy savings, the highest percentages for connected technology implementation are for smart power strips and smart thermostats with 29 percent and 25 percent, respectively.

Figure 24 Actions Taken to Manage or Reduce Energy Costs (1/2)

	Total n=1234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Switch to LED light bulbs	76%	81%	95%	83%	72%	76%	73%	71%	75%	83%
Use Energy Star certified appliances	68%	73%	60%	76%	72%	66%	66%	59%	68%	71%
Use a programmable thermostat (non-communicating)	41%	52%	55%	58%	40%	39%	36%	35%	41%	40%
Increasing insulation in the home	35%	36%	60%	40%	21%	35%	38%	26%	40%	36%
Using high efficiency HVAC systems	29%	31%	20%	30%	36%	29%	23%	31%	33%	24%
Use smart power strips	29%	20%	25%	18%	22%	31%	32%	30%	27%	36%
Use a smart thermostat	25%	25%	25%	29%	19%	24%	31%	25%	21%	24%
Program the switching on/off of lights	21%	23%	25%	21%	27%	21%	20%	18%	20%	25%
Shut down the water heater when not needed	18%	17%	15%	10%	33%	18%	19%	19%	17%	19%

Q: Which of the following actions, if any, have you taken to enable you to manage or reduce home energy costs?

Figure 25 Actions Taken to Manage or Reduce Energy Costs (2/2)

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Regularly consult whole home energy usage	16%	17%	25%	14%	19%	16%	16%	16%	16%	16%
Participate in a utility demand-response/ energy saving / other program	16%	9%	10%	12%	4%	17%	19%	14%	17%	18%
Undertaking home energy audits	15%	14%	15%	13%	15%	15%	18%	11%	14%	18%
Use smart plugs or energy monitors	14%	8%	15%	8%	7%	15%	22%	14%	10%	17%
Use motion detectors in home to automatically switch lights on/off	13%	13%	10%	14%	10%	14%	12%	12%	15%	13%
Use a system that controls multiple device types to manage or reduce costs	11%	11%	10%	11%	12%	11%	14%	8%	11%	12%
Electric vehicle charge scheduling	5%	4%	5%	6%	1%	5%	6%	4%	3%	7%
Other	3%	2%	5%	2%	1%	4%	3%	3%	2%	7%
None of the above	3%	2%	0%	1%	4%	3%	5%	5%	2%	1%

Q: Which of the following actions, if any, have you taken to enable you to manage or reduce home energy costs?

After obtaining responses on the actions taken to manage home energy costs, consumers were asked for their perceptions of the impact of the measures in reducing home energy consumption. The results are shown in Figures 26 and 27.

Increased insulation had the highest number of responses, indicating a high impact on driving energy savings, with 57 percent of overall respondents selecting it.

The major role that HVAC efficiency measures can play was reflected in the opinions of 54 percent of respondents, which mentioned using high-efficiency HVAC systems as a solution with a high impact.

Figure 26 Perceived Impact of Various Solutions on Energy Savings (1/2)

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Increasing insulation in the home	57%	59%	60%	60%	57%	57%	52%	57%	60%	54%
Using high efficiency HVAC systems	54%	44%	25%	46%	45%	56%	47%	56%	59%	56%
Use Energy Star certified appliances	52%	52%	50%	57%	45%	52%	54%	46%	55%	52%
Use a smart thermostat	51%	50%	45%	49%	52%	51%	51%	50%	53%	49%
Use a programmable thermostat (non-communicating)	51%	49%	45%	50%	48%	51%	52%	46%	55%	50%
Switch to LED light bulbs	47%	48%	40%	50%	46%	47%	47%	44%	48%	47%
Use a system that controls multiple device types to manage or reduce costs	40%	38%	40%	38%	37%	41%	40%	37%	41%	44%
Use smart power strips	39%	33%	40%	30%	36%	40%	44%	41%	39%	39%
Program the switching on/off of lights	37%	33%	15%	32%	40%	38%	38%	36%	36%	41%

Q: What would be the possible impact of the following measures in reducing your home's energy consumption? If you have fully adopted the measure, please indicate the impact that you believe it has had on your energy consumption. (Top 2 Boxes – Very high impact & High impact)

Figure 27 Perceived Impact of Various Solutions on Energy Savings (2/2)

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Shut down the water heater when not needed	35%	33%	40%	28%	39%	36%	37%	35%	31%	44%
Use smart plugs or energy monitors	35%	31%	30%	30%	33%	36%	38%	36%	35%	36%
Use motion detectors in home to automatically switch lights on/off	34%	28%	30%	26%	31%	35%	31%	34%	35%	37%
Participate in a utility demand-response/ energy saving / other program	33%	32%	30%	35%	27%	34%	32%	32%	34%	36%
Undertaking home energy audits	32%	32%	30%	33%	30%	33%	33%	30%	33%	35%
Regularly consult whole home energy usage	32%	29%	30%	32%	22%	33%	30%	32%	35%	32%
Electric vehicle charge scheduling	21%	20%	25%	22%	13%	22%	25%	24%	18%	21%

Q: What would be the possible impact of the following measures in reducing your home's energy consumption? If you have fully adopted the measure, please indicate the impact that you believe it has had on your energy consumption. (Top 2 Boxes – Very high impact & High impact)

To obtain an understanding of the future intent of consumers with respect to adoption of energy-saving solutions, inputs were sought on which measures they intended to adopt over the next 18 months. The highest responses were for smart thermostat use, with 25 percent of respondents planning adoption as shown in Figure 28.

The next four highest response rates were for technologies with a smart/programmable component included in their offering, such as using smart power strips outlets, smart plugs or energy monitors, programming the switching on/off of lights, and using a programmable thermostat. These smart/connected options indicate an increased upcoming ability to centrally monitor and control home energy use.

Fifteen percent of respondents plan to regularly consult on home energy use and 14 percent are planning thorough home energy audits.

Figure 28 Actions to Reduce Home Energy Costs to Be Taken in the Next 12 to 18 Months

	Total n=1234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Use a smart thermostat	25%	28%	20%	28%	30%	24%	26%	22%	26%	23%
Use smart power strips outlets	24%	27%	25%	27%	28%	23%	25%	18%	26%	23%
Use smart plugs or energy monitors	23%	21%	25%	21%	21%	23%	19%	24%	24%	24%
Program the switching on/off of lights	19%	18%	20%	19%	15%	19%	18%	19%	17%	22%
Use a programmable thermostat	17%	13%	10%	10%	19%	18%	21%	20%	15%	17%
Increasing insulation in the home	16%	12%	15%	14%	9%	16%	14%	21%	17%	12%
Use a system that controls multiple device types	15%	15%	20%	16%	10%	15%	16%	16%	14%	16%
Regularly consult whole home energy usage	15%	17%	5%	21%	15%	14%	14%	12%	14%	17%
Undertaking home energy audits	14%	11%	10%	12%	10%	15%	19%	15%	15%	12%
Use motion detectors	14%	10%	15%	10%	9%	15%	19%	13%	13%	19%
Participate in an utility energy program	14%	17%	10%	19%	16%	14%	15%	12%	15%	12%
Shut down the water heater when not needed	13%	14%	20%	17%	7%	13%	15%	14%	11%	15%
Using high efficiency HVAC systems	10%	8%	15%	7%	9%	10%	10%	10%	9%	12%
Switch to LED light bulbs	9%	8%	0%	8%	12%	9%	9%	8%	11%	6%
Use Energy Star certified appliances	9%	9%	10%	6%	13%	9%	8%	10%	9%	8%
Electric vehicle charge scheduling	5%	4%	5%	3%	4%	5%	7%	8%	3%	5%
None of the above	19%	18%	15%	17%	22%	20%	18%	22%	20%	17%

Q: Which of the following actions do you plan to take in the next 12 to 18 months to reduce home energy costs?

2.5 ROLE OF UTILITY ENERGY PROGRAMS: TRENDS AND PERCEPTIONS

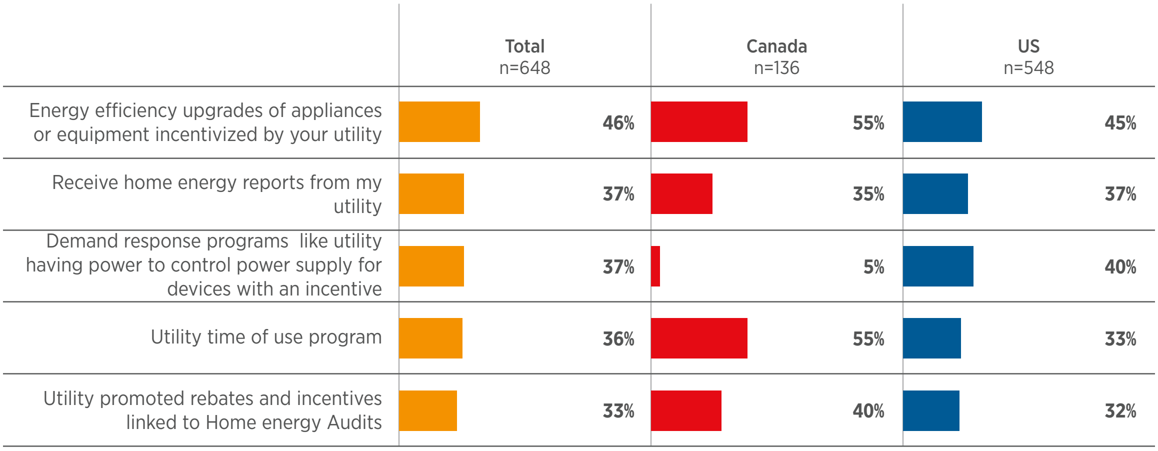
The questions in this category were used to understand the role that utilities can play in the market and the potential for evolution to include further offerings for controlling home energy consumption.

As described in other chapters, a multitude of utility-driven energy programs exist, many times varying by state/province. However, an understanding of various requirements from the end-users can contribute to ensuring the programs can be modified per requirements or can assist technology vendors, service providers, industry associations, or regulators in effectively engaging with utilities and consumers.

Consumers who answered that they have participated in utility energy saving programs (Figure 25) were asked to provide answers regarding participation in utility programs as shown in Figure 29. The highest number of responses was for energy efficiency upgrades of appliances or equipment incentivized by utilities at 46 percent. This was followed by home energy reports and demand response programs with 37 percent each.

Demand response programs, however, were the least popular type of utility programs in Canada. This is caused by reliance on hydropower, energy surplus, and low electricity rates hampering demand for these programs. Reliance on hydropower, for example, ensures an enhanced ability of power generation units to respond to changes in demand from the grid due to the technological aspects. This can affect the level of incentives that utilities provide for demand response programs and drive down consumer interest, coupled with low electricity rates to start with.

Figure 29 Participation in Utility Programs

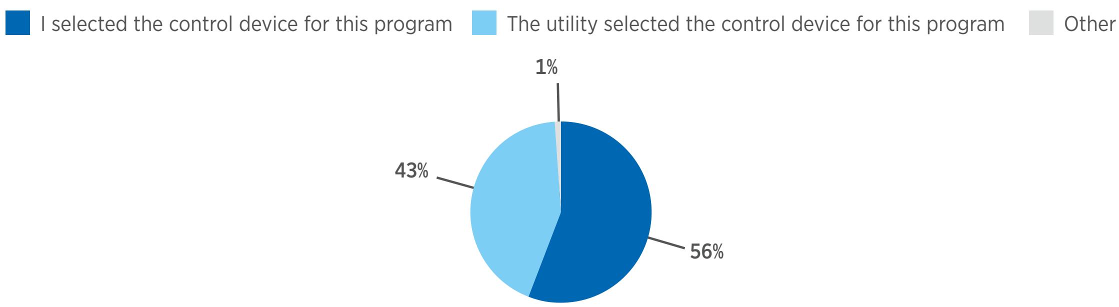


Q: What utility programs did you participate in?

Consumers participating in demand response programs were asked about who selected the control device for the program. As shown in Figure 30, consumers themselves selected the control device 56 percent of the time, compared to utilities at 43 percent.

This is also driven by the proliferation of overall home energy control consoles and smart/connected thermostats, which can then be connected to smart meters to appropriately respond to peak load signals.

Figure 30 Characteristic of Energy-saving or Demand Response Program



Q: Which of the following is characteristic of your energy saving or demand response program?

Consumers were asked about their preference for proposed delivery models for energy management services from utilities, and these results are shown in Figure 31.

The highest number of responses, 71 percent, was from consumers wanting energy management services to be provided directly via utilities. Other popular delivery models were utilities offering to finance the purchase of connected home products through energy bills (66 percent) and utilities providing auxiliary connected home services (65 percent).

Figure 31 Delivery Models for Energy Management Services from Utilities

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
A utility provides energy management services	71%	63%	65%	60%	69%	72%	71%	68%	74%	73%
Utility offers to finance your purchase of smart home products through your utility bill	66%	58%	70%	54%	63%	67%	67%	67%	70%	63%
A utility provides other services that come along with smart home (security/ safety, etc.)	65%	58%	50%	55%	67%	67%	67%	68%	65%	68%
A third party service provider provides utility services and connected services together	47%	44%	45%	42%	48%	47%	41%	49%	46%	52%
A non-utility provides energy management services	42%	37%	30%	34%	43%	43%	40%	40%	42%	49%
Services are contracted independently through separate providers	35%	30%	35%	29%	30%	36%	32%	37%	35%	39%

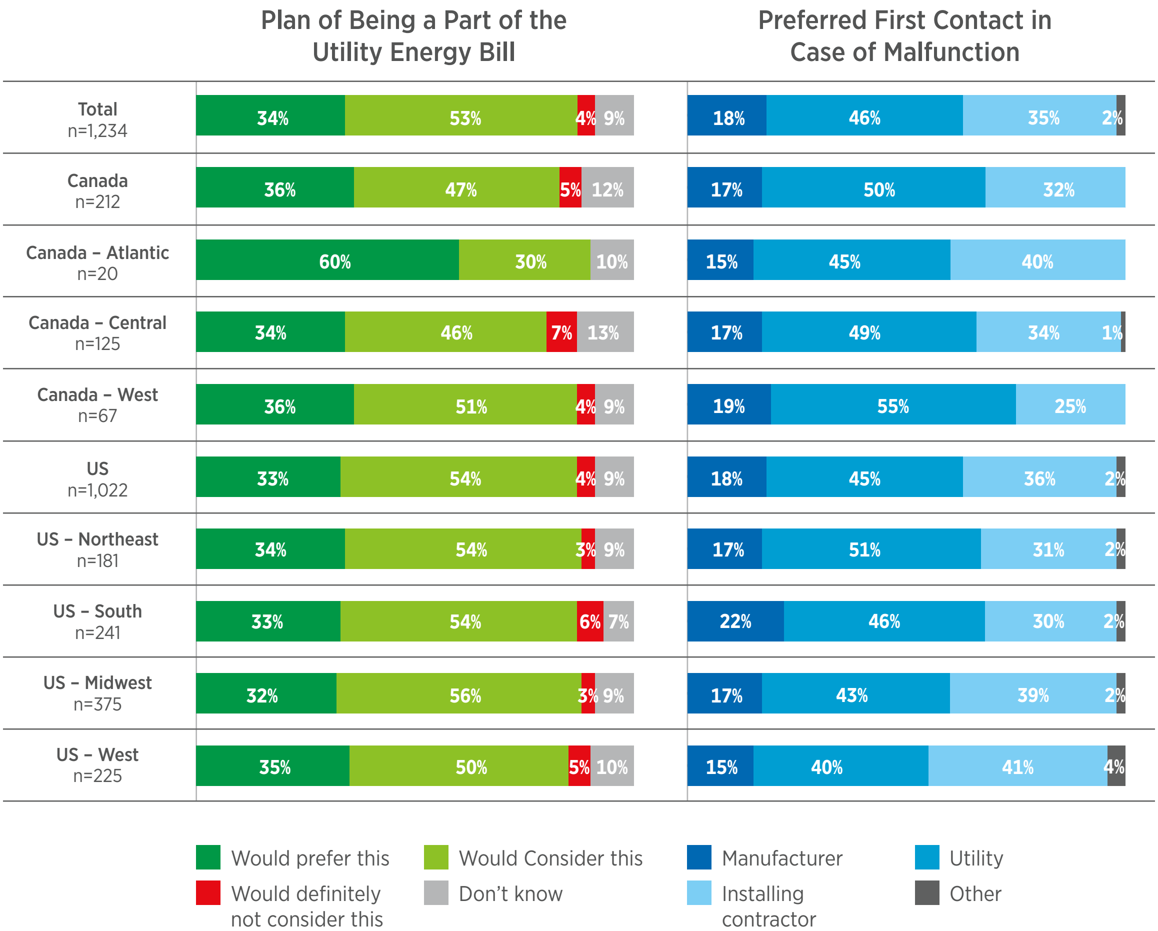
Q: Please provide your opinion of the following possible approaches for delivery models from utilities.

Consumers opting for services to be provided from the utility ('A utility provides energy management services' or 'A utility provides other services that come along with smart home') were asked about the plan being part of the utility energy bill and their preferred point of contact in case of malfunction (Figure 32).

Eighty-seven percent mentioned they would prefer this or consider this option, with 34 percent saying they would prefer this and 53 percent willing to consider it. This was the same across regions except for Canada's Atlantic region where 60 percent of respondents mentioned they would prefer these services to be a part of their energy bill.

With regard to the preferred first point of contact in the case of a malfunction in the system, 46 percent would prefer the utility to be their point of contact that would then coordinate with other vendors to rectify the problem.

Figure 32 Plan Being a Part of the Utility Energy Bill and Preferred First Contact in Case of Malfunction



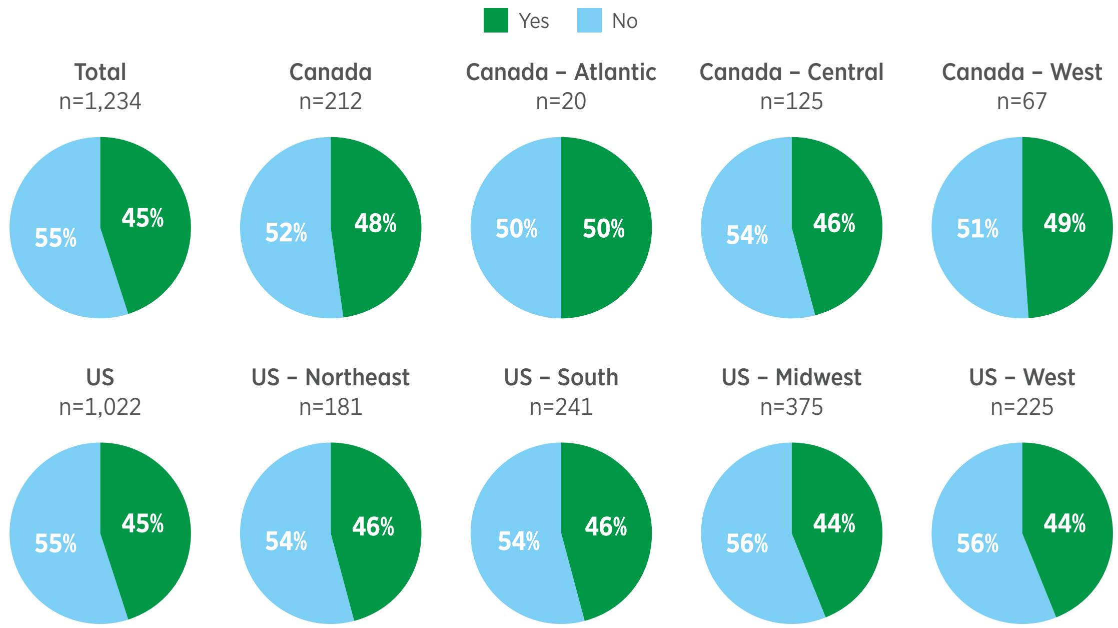
Q: If coordinated by the utility is preferred; please provide your opinion on such a plan being a part of the utility energy bill. In case of malfunction of the above system, who would you prefer as your point of contact?

As a part of demand response programs, consumers were asked about their willingness to allow utilities temporary control of specific home energy-consuming systems so the utilities might be able to curtail demand by powering down/switching off such systems during peak load conditions.

In the results, as shown in Figure 33, 45 percent of consumers were willing to offer that level of control, whereas 55 percent were against. These numbers were similar for both Canada and the US when analyzed separately.

As shown in Figure 34, consumers were then further questioned regarding which connected products they would be willing to offer control to utilities. Cooling in summer, heating in winter, and lighting were the most popular choices, with 44 percent, 42 percent and 36 percent respectively.

Figure 33 Willingness to Opt In to Allow the Utility Company Temporary Control of a Home Energy-consuming System



Q: Would you be willing to opt for a program where the utility is permitted to temporarily interact/control a home energy-consuming system in the house as part of a demand response program?

Figure 34 Connected Products for Which Control Could Be Granted

	Total n=1234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Cooling in summer	44%	43%	35%	46%	42%	45%	40%	47%	46%	42%
Heating in winter	42%	42%	50%	38%	48%	42%	38%	44%	45%	40%
Lighting	36%	38%	35%	39%	37%	36%	38%	38%	37%	31%
Hot water tank heating	35%	37%	50%	34%	37%	35%	36%	38%	34%	32%
Washing machine	28%	27%	20%	27%	28%	28%	29%	33%	27%	25%
Dishwasher	25%	26%	25%	23%	33%	24%	28%	27%	22%	22%
Tumble dryer	24%	25%	25%	24%	28%	24%	26%	28%	21%	22%
De-humidifier	13%	14%	20%	14%	10%	13%	20%	10%	13%	8%
Electric vehicle charging	10%	9%	0%	9%	12%	10%	14%	10%	8%	12%
Other	1%	0%	0%	1%	0%	1%	1%	1%	0%	0%
Don't know	32%	32%	35%	34%	27%	32%	35%	28%	33%	34%

Q: For what connected products would you be willing to offer this control to utilities?

The preferred timing of offering control to utilities for various systems was also broken down by system and region, as shown in Figure 35. The results for ideal timing of control show that time of control can vary widely based on the system/product and that utility demand response programs would be expected to curtail specific systems based on the time of peak load demand reduction requirement.

Figure 35 Preferred Timing of Control

	Total	Canada	Canada - Atlantic	Canada – Central	Canada – West	US	US – Northeast	US – South	US – Midwest	US – West
Cooling in summer	Afternoon (55%)	Afternoon (57%)	Afternoon Night (57%)	Afternoon (58%)	Afternoon (54%)	Afternoon (55%)	Night (48%)	Afternoon (65%)	Afternoon (55%)	Afternoon (55%)
Heating in winter	Night (49%)	Afternoon Night (49%)	Night (70%)	Afternoon (57%)	Morning (59%)	Night (48%)	Night (57%)	Afternoon (46%)	Night (50%)	Night (48%)
Lighting	Morning (39%)	Morning (47%)	Night (57%)	Morning (47%)	Morning (52%)	Afternoon Night (38%)	Morning Night (41%)	Afternoon (42%)	Afternoon (39%)	Evening Night (45%)
Hot water tank heating	Night (50%)	Night (58%)	Night (70%)	Afternoon (56%)	Night (60%)	Night (48%)	Night (54%)	Night (45%)	Night (47%)	Night (49%)
Washing machine	Morning (42%)	Evening (51%)	Afternoon (75%)	Evening (59%)	Morning (63%)	Morning Afternoon (41%)	Afternoon (53%)	Morning Night (41%)	Morning (40%)	Night (51%)
Dishwasher	Evening (40%)	Evening (45%)	Afternoon (40%)	Evening (48%)	Night (45%)	Morning Evening (39%)	Night (45%)	Morning Afternoon Evening (41%)	Morning Evening (40%)	Afternoon Night (45%)
Tumble dryer	Night (43%)	Evening (52%)	Evening 60%)	Evening (53%)	Night (63%)	Night (43%)	Afternoon (53%)	Night (46%)	Morning (49%)	Night (55%)
De-humidifier	Morning (46%)	Morning (48%)	Afternoon (50%)	Morning (50%)	Morning, Afternoon Evening (57%)	Morning (46%)	Night (53%)	Afternoon (53%)	Morning (47%)	Morning Afternoon (47%)
Electric vehicle charging	Night (50%)	Night (63%)	-	Night (64%)	Afternoon Night (63%)	Morning Night (47%)	Evening (48%)	Night (58%)	Morning (57%)	Afternoon (48%)

Q: What time of the day would you prefer to offer control to utilities for equipment?

Expectations regarding rebates to be provided by utilities for taking control of various technology products were also gathered from consumers, as illustrated in Figure 36. The lowest overall rebate expectation was for dehumidifiers at $128 and the highest was for electric car charging at $245.

Figure 36 Rebate Expectations for Program Participants

	Total	Canada	Canada - Atlantic	Canada – Central	Canada – West	US	US – Northeast	US – South	US – Midwest	US – West
Cooling in summer	$196	$170	$164	$171	$168	$201	$229	$189	$193	$208
Heating in winter	$198	$185	$180	$197	$170	$201	$243	$185	$195	$199
Lighting	$144	$125	$121	$122	$132	$149	$180	$150	$130	$153
Hot water tank heating	$154	$146	$140	$150	$140	$156	$200	$148	$140	$156
Washing machine	$144	$128	$100	$109	$168	$147	$177	$146	$138	$136
Dishwasher	$136	$122	$70	$116	$143	$139	$177	$134	$113	$147
Tumble dryer	$139	$134	$150	$120	$153	$140	$160	$138	$128	$144
De-humidifier	$128	$107	$100	$94	$143	$133	$144	$114	$123	$158
Electric vehicle charging	$245	$239	-	$218	$269	$246	$272	$277	$245	$194

Q: Please provide your expectations for rebates for technology products offered for demand response control.

2.6 SATISFACTION WITH CURRENT OFFERINGS AND FUTURE POTENTIAL

This segment of the research module is directed at understanding satisfaction levels with current technologies, concerns regarding the current state of the overall industry, and future overall trends for product/type of provider selection. Understanding the gaps in offerings and consumer perceptions regarding ideal providers form some of the key takeaways of this section.

The results regarding consumer satisfaction levels in regard to the capabilities of technologies in the industry have been provided in Figures 37 and 38. The respondents who are with ‘fully satisfied’ and ‘partly satisfied’ have been included in these charts.

Some of the capabilities/possible capabilities consumers have expressed relatively lower satisfaction levels with include: suggestions from smart systems regarding optimal energy saving techniques as per consumption, the breakdown by energy bills of key high energy-consuming nodes, smartphone control in the context of managing energy consumption, and the switching on/off of lights. Overall energy savings and peak demand-based heating/cooling adjustments have high satisfaction levels among consumers. These points show that the next wave in terms of programs for consumers must satisfy specific requirements that currently might be considered as value-adds to the main solution.

Figure 37 Satisfaction with Capabilities of Technologies (1/2)

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Ability to realize savings from the use of the various energy saving solutions	53%	55%	60%	59%	45%	53%	52%	51%	55%	52%
Automatic adjustment of heating or cooling, during peak hours or high cost hours	53%	57%	40%	63%	49%	52%	51%	54%	51%	52%
A report or some feedback about the overall consumption pattern of energy	51%	54%	65%	57%	45%	50%	49%	50%	51%	49%
Ease of installing / setting up the solution	49%	49%	45%	53%	43%	49%	49%	53%	46%	49%
A report or feedback about the estimated cost savings that you have realized for a given period	47%	50%	50%	54%	42%	47%	49%	47%	45%	47%
Peak hours or high bill warnings	44%	47%	50%	54%	33%	44%	41%	41%	46%	46%
Automatic adjustment of heating or cooling, when it senses that there are no occupants	44%	42%	35%	45%	37%	44%	45%	51%	42%	41%
Ability to manage energy-consuming home appliances from a single device	42%	43%	45%	42%	43%	42%	44%	43%	42%	42%
Ability to monitor, in real time, the total energy being consumed in the household	41%	42%	45%	42%	42%	41%	40%	45%	39%	40%
Ability to adjust thermostat remotely using your smartphone	41%	39%	40%	38%	40%	41%	39%	48%	39%	39%

Q: How satisfied are you with your current home energy solutions' ability to provide the following? (Top two boxes – Fully satisfied & Partly Satisfied)

Figure 38 Satisfaction with Capabilities of Technologies (2/2)

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Ability to monitor energy consumption of whatever is plugged in specific outlets	38%	36%	30%	38%	34%	39%	39%	41%	38%	38%
Ability to manage appliances, lights etc. from a single device, display, or smartphone	38%	39%	35%	43%	33%	38%	37%	42%	36%	40%
Display the cost of energy at a particular moment (real time)	38%	36%	35%	39%	31%	39%	41%	41%	35%	41%
Ability to switch on/ switch off lights remotely using your smartphone	38%	34%	40%	36%	30%	38%	39%	42%	35%	39%
Ability to manage the energy consumption of home appliances remotely using your smartphone	37%	36%	50%	36%	31%	37%	36%	42%	35%	37%
A smart system that understands my energy bill, and can break it down into the key high energy	37%	37%	40%	40%	30%	36%	39%	39%	34%	36%
A smart system that advices me on the best ways to save energy in my home	36%	35%	35%	37%	33%	37%	35%	39%	35%	37%

Q: How satisfied are you with your current home energy solutions' ability to provide the following? (Top two boxes – Fully satisfied & Partly Satisfied)

Consumers were also asked for their brand preferences for adoption in the next 12 to 24 months regarding the overall home energy solutions industry. Compared to current adoption rates, respondents showed a higher distribution in brand preference when it comes to future adoption, indicating increasing acceptability of non-traditional home energy suppliers.

Consumer concerns regarding connected home energy management solutions are shown in Figures 39 and 40. Initial setup costs is the most common concern among consumers, indicating that programs where utilities or other vendors provide options to consumers to stagger payments might meet with high acceptance in the current scenario.

The next two concerns at the top of consumers' minds are also with regard to costs: maintenance costs and concerns regarding cost-to-benefit ratios. These are followed by concerns regarding connectivity/ interoperability of appliances and cybersecurity. These are all being addressed by the industry across technologies.

Figure 39 Concerns about Connected Home Energy Management Solutions (1/2)

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
High initial setup costs	72%	67%	80%	67%	63%	73%	73%	71%	73%	76%
High management / maintenance costs	60%	57%	90%	53%	55%	61%	64%	58%	61%	63%
The costs outweigh the benefits	60%	52%	55%	54%	48%	61%	59%	59%	62%	65%
Technical barriers, I don't think my appliances, are ready to connect	58%	53%	60%	51%	55%	59%	57%	59%	61%	60%
System might be hacked	56%	50%	45%	50%	51%	57%	55%	57%	55%	62%
Effect of power failure on the system	55%	50%	55%	47%	55%	56%	57%	54%	55%	58%
Effect of system failure on the ability to manage the home	53%	47%	50%	44%	52%	54%	57%	54%	53%	52%
Unwanted intrusion of my privacy	52%	48%	50%	48%	46%	53%	51%	53%	50%	58%
Energy savings may not significant	52%	49%	65%	46%	48%	52%	53%	51%	50%	56%
Too complicated to install	48%	41%	55%	41%	36%	49%	48%	47%	48%	54%
More likely to fail than manual systems	47%	45%	55%	42%	48%	47%	50%	45%	46%	48%

Q: To what extent would the following be a concern to you?

Figure 40 Concerns about Connected Home Energy Management Solutions (2/2)

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Ability to monitor energy consumption of whatever is plugged in specific outlets	38%	36%	30%	38%	34%	39%	39%	41%	38%	38%
Ability to manage appliances, lights etc. from a single device, display, or smartphone	38%	39%	35%	43%	33%	38%	37%	42%	36%	40%
Display the cost of energy at a particular moment (real time)	38%	36%	35%	39%	31%	39%	41%	41%	35%	41%
Ability to switch on/ switch off lights remotely using your smartphone	38%	34%	40%	36%	30%	38%	39%	42%	35%	39%
Ability to manage the energy consumption of home appliances remotely using your smartphone	37%	36%	50%	36%	31%	37%	36%	42%	35%	37%
A smart system that understands my energy bill, and can break it down into the key high energy	37%	37%	40%	40%	30%	36%	39%	39%	34%	36%
A smart system that advices me on the best ways to save energy in my home	36%	35%	35%	37%	33%	37%	35%	39%	35%	37%

Q: To what extent would the following be a concern to you?

The instances of product/system malfunction across various connected technologies were also evaluated and the results are presented in Figure 41. Connected home entertainment was found to be the most commonly malfunctioning product/system category with 15 percent of respondents selecting the option. The number of participants in the space and issues arising from integration, coupled with less priority given to quality aspects by some brands, are factors contributing to this perception of connected home entertainment technologies.

Connected thermostats are another concern for consumers due to multiple integration points and issues regarding the controlled equipment. Connected lighting is also a concern, possibly because of the number of nodal points in the system. Solutions such as preset integration of various devices in the cloud, like Z-Wave's Smart Start feature, could help mitigate integration problems, ensure smooth installation, and help prevent issues during system operation.

Figure 41 Most Frequently Experienced Connected Systems Malfunction

	Total n=1234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Connected home entertain	15%	9%	10%	7%	13%	16%	15%	15%	16%	17%
Connected thermostats	9%	9%	10%	8%	12%	8%	9%	10%	8%	7%
Connected security systems	8%	9%	0%	6%	16%	8%	9%	10%	5%	10%
Connected lighting	6%	7%	10%	5%	9%	6%	6%	7%	5%	8%
Connected smoke alarms	4%	3%	0%	2%	6%	5%	8%	4%	3%	5%
Smart Plugs	4%	3%	10%	3%	0%	4%	4%	5%	3%	4%
Connected small appliances	4%	3%	5%	2%	3%	4%	7%	4%	3%	3%
Connected major appliances	3%	4%	10%	5%	0%	3%	2%	3%	4%	4%
Connected air conditioners	2%	2%	0%	3%	0%	3%	3%	2%	3%	2%
Connected water heaters	2%	2%	5%	2%	1%	2%	3%	2%	2%	2%
Connected sprinklers	2%	1%	0%	2%	0%	2%	2%	3%	1%	3%
Electric vehicles	2%	0%	0%	1%	0%	2%	4%	2%	1%	2%
Connected air purifiers	2%	1%	0%	2%	1%	2%	4%	1%	1%	1%
Connected fans	1%	1%	0%	2%	1%	1%	2%	0%	2%	2%
Connected pool pumps	1%	0%	0%	0%	0%	1%	1%	1%	1%	1%
None	57%	60%	80%	64%	48%	56%	59%	54%	59%	50%

Q: Which connected products/systems malfunction most frequently as per your experience?

Given the complications of installation of connected/integrated systems, consumers were asked about particular actions taken for facilitating installation in the case of self-installation.

Results in Figure 42 illustrate that Web services, such as online manuals or installation videos, are the most leveraged by consumers for installation. Ensuring preset compatibility with other devices is another popular option for ensuring ease of installation. The provision of such supplemental information/features by market participants would be met with high levels of acceptability among consumers.

Figure 42 Actions to Facilitate Installation

	Total n=1234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Web services	32%	27%	30%	23%	34%	33%	37%	31%	31%	36%
Compatibility with other devices	27%	23%	25%	22%	25%	28%	29%	30%	27%	25%
If This Then That (IFTTT) protocol	9%	7%	5%	6%	10%	9%	13%	10%	6%	10%
Stringify	2%	1%	0%	1%	3%	2%	4%	1%	2%	1%
Other	1%	0%	0%	0%	1%	1%	2%	1%	1%	1%
Not applicable. I don't install it myself	48%	54%	55%	58%	45%	47%	44%	45%	49%	47%

Q: When you are installing these connected technologies, are you leveraging any of the following to make installation/operation/intercommunication of devices in the home easier?

The preference of consumers for connected home energy management solutions was also evaluated with regard to the types of providers they would prefer for an overall home energy management solution. The results for the providers they would consider are in Figure 43 and their most preferred providers are in Figure 44.

While utilities have the highest number of responses in providers considered, specialized organizations offering connected home energy solutions have the highest number of responses when it comes to the most preferred provider.

Obtaining a home energy solution via their home security solution provider was also a popular option among consumers, which would also be driven by their existing relationship in terms of installation and monitoring/maintenance. This is an opportunity for security solution providers to include the offering in their portfolios.

Figure 43 Considered Providers of Connected Home Energy Management Solutions

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Utility company	49%	48%	60%	45%	51%	49%	44%	48%	53%	48%
Home security service provider	42%	31%	40%	27%	34%	45%	43%	44%	45%	47%
Specialist company offering connected home energy solutions	38%	41%	35%	43%	37%	38%	40%	34%	38%	41%
Internet service provider	38%	36%	60%	33%	34%	38%	35%	37%	38%	42%
Appliance company	31%	25%	35%	24%	24%	32%	37%	31%	35%	27%
HVAC (furnace/ air-conditioning) maintenance company	29%	23%	15%	23%	24%	30%	25%	27%	37%	26%
Device vendor	28%	25%	25%	23%	28%	29%	34%	26%	27%	32%
Cable TV service provider	27%	24%	30%	18%	31%	28%	31%	29%	26%	28%
Telephone / Mobile phone service provider	21%	19%	35%	17%	19%	21%	20%	22%	22%	21%
Electronic store / online	20%	18%	20%	14%	25%	20%	21%	22%	18%	20%
Hot water tank / heater provider / leasing company	13%	14%	20%	14%	10%	13%	13%	12%	13%	15%
Other	3%	3%	5%	2%	3%	3%	3%	2%	2%	3%

Q: Which of the following will you consider as a possible provider of connected home energy management solutions?

Figure 44 Most Preferred Providers of Connected Home Energy Management Solutions

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Utility company	18%	19%	15%	22%	16%	18%	14%	17%	21%	17%
Home security service provider	13%	10%	10%	9%	12%	14%	15%	15%	12%	14%
Specialist company offering connected home energy solutions	22%	26%	20%	26%	28%	21%	20%	20%	21%	24%
Internet service provider	10%	14%	25%	13%	13%	9%	7%	9%	9%	10%
Appliance company	6%	4%	0%	6%	1%	6%	8%	7%	6%	4%
HVAC (furnace/ air-conditioning) maintenance company	6%	3%	0%	5%	0%	7%	6%	5%	9%	4%
Device vendor	9%	8%	10%	6%	10%	9%	12%	11%	7%	9%
Cable TV service provider	5%	4%	0%	4%	6%	6%	8%	5%	6%	4%
Telephone / Mobile phone service provider	3%	4%	5%	3%	4%	3%	1%	2%	3%	4%
Electronic store / online	4%	3%	5%	2%	3%	4%	4%	5%	4%	5%
Hot water tank / heater provider / leasing company	1%	2%	5%	2%	1%	1%	1%	1%	1%	1%
Other	3%	3%	5%	2%	3%	3%	3%	2%	2%	3%

Q: Which of these would yout most prefer?

In terms of the most motivating potential benefits of a connected home energy management solution, three of the top four factors rated by consumers were related to energy savings and improved energy consumption control. This underscores the importance of energy related-aspects in consumer mindsets as evidenced in Figures 45 and 46.

Figure 45 Potential Benefits of Connected Home Energy Management Solutions (1/2)

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Cost savings / greater efficiency	82%	82%	85%	81%	84%	82%	83%	78%	83%	85%
Reduction of energy consumption	79%	82%	95%	80%	81%	79%	77%	74%	81%	80%
Increased security of home	72%	71%	70%	68%	76%	73%	73%	71%	73%	74%
Improved ability to control my energy use	72%	77%	85%	78%	75%	71%	71%	68%	71%	75%
Improved safety for household members	68%	67%	70%	69%	63%	68%	70%	66%	67%	72%
Affordable and scalable level of sophistication increases	68%	65%	55%	70%	58%	68%	69%	66%	66%	73%
Raising the resale value of my house	67%	71%	70%	74%	64%	66%	71%	59%	67%	69%
Better protection from emergencies such as fire and floods, etc.	67%	64%	70%	62%	66%	68%	65%	65%	67%	74%
Ability to monitor activities at home while away	65%	61%	65%	62%	58%	66%	67%	68%	64%	65%
Improvement in the quality of life	63%	61%	55%	63%	60%	64%	66%	59%	63%	69%
Use of greener technologies	61%	66%	70%	66%	66%	60%	60%	56%	61%	61%

Q: To what extent do the following potential benefits of a connected home energy management solution motivate you to adopt the technology?

Figure 46 Potential Benefits of Connected Home Energy Management Solutions (2/2)

	Total n=1,234	Canada n=212	Canada – Atlantic n=20	Canada – Central n=125	Canada – West n=67	US n=1,022	US – Northeast n=181	US – South n=241	US – Midwest n=375	US – West n=225
Greater convenience for household members	61%	58%	50%	62%	55%	61%	60%	60%	60%	66%
Simplification of day to day living	58%	56%	45%	57%	58%	58%	54%	60%	58%	60%
Mark on the product certifying to reduce the possibility of intrusion of your privacy	58%	57%	65%	56%	57%	58%	59%	54%	58%	60%
Ability to take part in an energy management/ savings program.	58%	59%	60%	61%	57%	57%	56%	52%	60%	60%
Simplification of day to day living	57%	52%	50%	52%	52%	58%	58%	60%	56%	61%
Friendlier environment for the elderly	55%	56%	60%	58%	52%	55%	56%	54%	54%	57%
Friendlier environment for young children	48%	43%	55%	44%	39%	49%	49%	47%	49%	49%
Reduction in administrative tasks	46%	47%	50%	52%	37%	46%	48%	46%	44%	49%
Having the most advanced technologies	44%	44%	35%	42%	49%	44%	44%	44%	41%	48%
Brings fun	32%	31%	40%	29%	33%	32%	37%	32%	33%	29%

Q: To what extent do the following potential benefits of a connected home energy management solution motivate you to adopt the technology?

2.7 KEY TAKEAWAYS

The key highlights and observations of the consumer research are discussed below.

Adoption Trends: Current and Future

It was observed that respondents closely related the perception of what constitutes a connected home to systems with high energy consumption. This was followed by systems/devices accessible over Wi-Fi such as connected security, entertainment systems and appliances. The primary drivers of interest in connected homes were observed to be utility/energy/cost savings followed by convenience and security. In terms of currently adopted connected home technologies, entertainment was the most popular. However, for intended adoption in the next 12 months, smart thermostats were found to be the most popular system.

Some additional insights regarding adoption trends have been provided in Figures 47 and 48.

Figure 47 Most Motivating Benefits and Features v/s Current Satisfaction

Most Motivating Benefits and Features of a Home Energy Solution vs. Current Satisfaction
Most Motivating Benefits and Features to Adopt a Home Energy Solution The three most motivating benefits and features of a home energy solution are: • Automatic HVAC adjustment when zero occupancy is sensed (motivating to 76%) • Automatic HVAC adjustment during peak hours (75%) • Ability to realize savings from the use of various energy saving solutions (73%)
Unmet Needs (Most Motivating Benefits with Low Current Satisfaction Levels) The top unmet needs when adopting a home energy solution are: • Automatic HVAC adjustment when zero occupancy is sensed • Single device to control appliances, lights, security, entertainment, etc. • Breaks down energy bill by high energy-using appliances • Single device to control appliances and lights • Advices best way to save energy
Likelihood of Adopting the Ideal Home Energy Solution 8 out of 10 consumers are likely (somewhat/very) to adopt a home energy solution with the most motivating benefits and features.
Reasons for Lack of Interest in the Ideal Home Energy Solution 62% of those who are not interested in the ideal home energy solution are not interest in most, if not all, of the features and benefits.

Figure 48 Energy Solutions Adoption v/s Perceived Impact on Energy Savings

Energy Solutions Adoption vs. Perceived Impact on Energy Savings
Most Adopted Energy Saving Solutions 76% of consumers in North America have switched to LED light bulbs while 68% use Energy Star certified appliances. Both are perceived as high impact solutions.
High Impact Solutions with Low Adoption Rates Increased home insulation, high efficiency HVAC, smart thermostat, programmable non-communicating thermostat, system to control multiple devices, smart power strips, and programmed light switching are perceived as having a high impact on energy savings, but current adoption rates are low. **Future adoption intent** (next 18 months) is highest for smart thermostats (25%), smart power strips (24%), and smart plugs/ energy monitors (23%).

System/Device Control Factors

When it comes to most preferred devices for control of home energy management systems, smartphones are the most popular among respondents with majority preference, followed by centralized control consoles. Voice-based control, which has high growth potential in the market, continues to be in early stages of adoption among respondents.

As a centralized control system that can control multiple energy consuming devices, thermostats form an important part of connected home energy control. In-built dedicated thermostat consoles remain the most preferred mode of thermostat control, followed by a dedicated smartphone application and an overall home energy smartphone application. Voice-based control is in nascent stages when analyzed for thermostats separately too.

Energy Cost Perceptions and Trends

Energy costs are a high concern area for most respondents in both Canada and the US. Energy saving investments made in this regard however, have an expected payback period of one to two years, which was the most popular payback period among respondents. It is required to increase awareness among consumers regarding possible steps that can be taken for making their homes energy efficient. This stems from the observation that close to half of the consumers surveyed believed that home energy costs are either not within their control at all or half to most of costs are out of their control. In terms of most popular energy efficiency measures taken, installation of LED bulbs and Energy Star certified appliances were at the top of consumer minds. However, when considering the perceived impact of multiple energy efficiency measures, the increase of home insulation, adopting high efficiency HVAC equipment and Energy Star certified appliances were the most popular.

Utility-Related Insights

Among utility programs, the most popular among respondents were incentives for home energy efficiency upgrades followed by the provision of reports on home energy consumption and demand response programs. However, it is to be noted that demand response programs were found to be much higher in popularity among US respondents compared to Canadian respondents. This is expected to be due to a combination of multiple factors leading to lower incentives for the adoption of demand response programs in Canada currently.

In the case of consumers who have adopted demand response programs, the majority were found to have selected the control device themselves. This indicates a possible requirement for utilities to collaborate with multiple brand vendors for ensuring seamless communication between utilities, and connected homes for demand response purposes. Incentives could also be offered to consumers for selecting certain control devices. For demand response programs, close to half of respondents interested in such programs would be willing to offer utilities temporary control of a connected system in the home. Top capabilities that consumers would be willing to offer for utility control are cooling in summer, heating in winter, lighting and hot water tank heating.

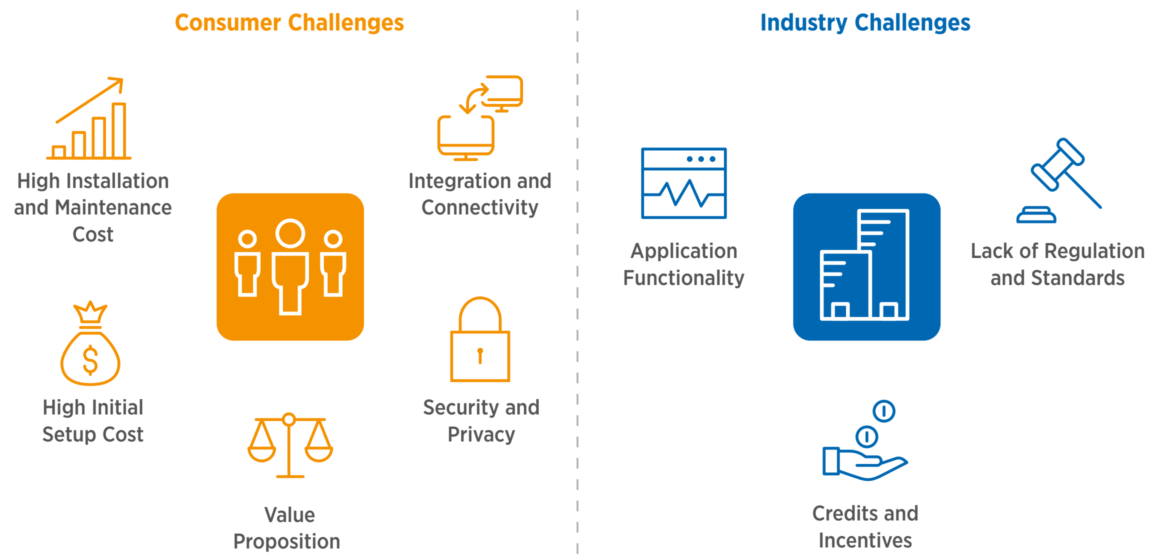
With regard to additional offerings from utilities in the connected home energy space, the majority of respondents stated that they would prefer or consider the business model of a utility providing energy management services for their homes. Other popular potential offerings include utilities assisting with the finance of home energy products through the energy bill and utilities providing supplementary services such as security, safety, etc. Most respondents who opted for connected home services from utilities would prefer to have the services included in their energy bills. In case of system malfunctions under the utility provided services business model, utilities were found to be the most preferred first point of contact for consumers compared to device manufacturers and installing contractors.

3. ADDRESSING KEY CONNECTED HOME ENERGY IOT ADOPTION CHALLENGES

3.1 ADOPTION: CORE ISSUES AND CHALLENGES EVALUATION

Connected home devices and home automation are becoming prevalent parts of the IoT ecosystem. Despite the popularity of smart/connected homes and integrated devices in North America, the majority of homes are still not smart or connected. Currently, the concept of a connected smart home is viewed skeptically and adoption challenges exist [1, 2, 3]. The initial prices of some leading connected home devices and associated services are too high for mass adoption; hence, price is a primary concern. Some of the other crucial issues and challenges in adoption of IoT and smart, integrated devices include high maintenance costs, low perceived benefits, issues associated with the integration of the latest technologies, and growing concern about the security and privacy of personal information. While the number of connected homes is anticipated to slowly increase, it is important to look at the dynamics that challenge and restrain adoption of integrated devices. The challenges can be segmented into two parts: consumer focused and industry focused.

Figure 49 Challenges in the Adoption of Connected IoT Homes



Value Proposition
Generally, consumers are uncertain about the value of connected devices and perceive them as solutions reserved for the tech savvy and the affluent individuals. For the most part, traditional consumers still rely on manual control for adjusting conditions in their homes. This underlines the challenge of moving the adoption rate of connected home technologies past the early adopter phase. To mitigate this challenge, original equipment manufacturers (OEMs) and technology vendors must consider use and affordability when designing and promoting smart devices.

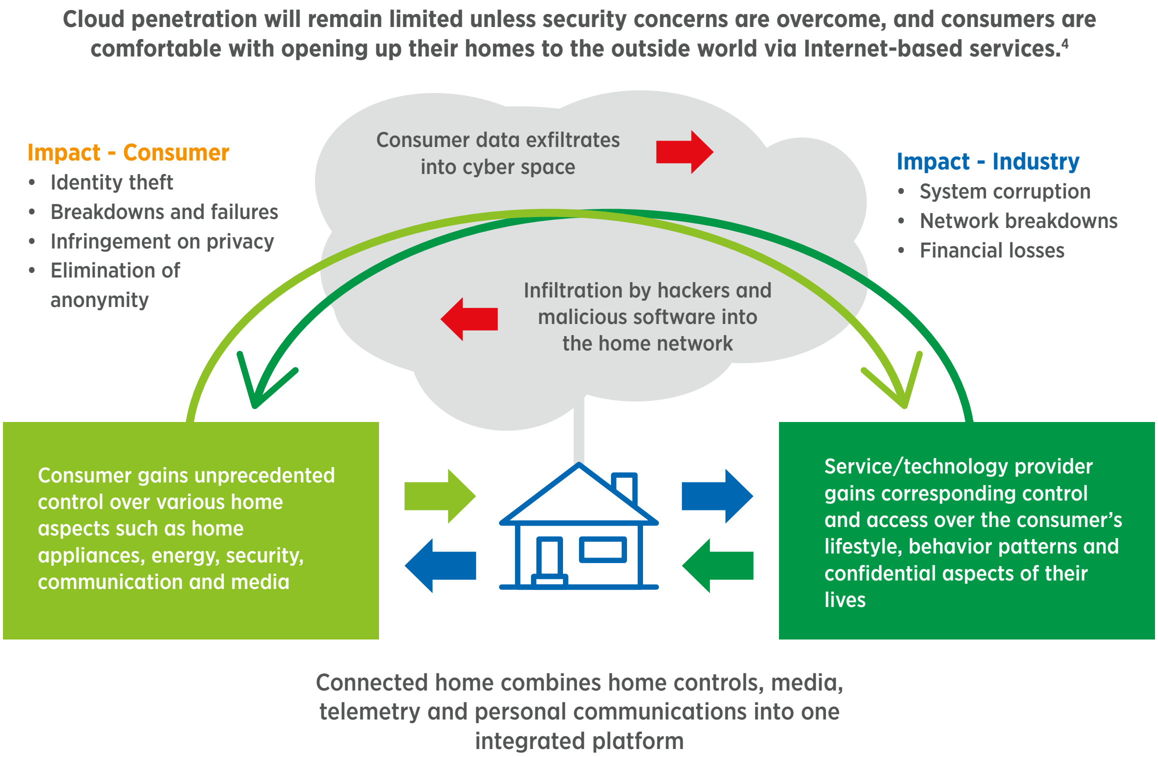
High Initial Setup Cost
The prices of IoT enabled home automation technologies are the primary barrier to adoption. This may indicate that consumer understanding about benefits is still relatively weak. Consumers may be aware of the smart technologies, such as smart thermostat and smart lighting and some of their functionality, but are not aware of the true impact of lowering their energy use and bills. Therefore, to invigorate the connected home device market more needs to be done to educate consumers about the relevance of operational efficiency and benefits of the connected devices.

Installation and Maintenance
Once the connected home technology is chosen, several additional factors must be considered. The number of smart devices to be integrated adds a layer of complexity to the installation processes that consumers would rather avoid. Therefore, some consumers prefer to have a professional install their systems. This results in substantial increases in installation costs, resulting in potential adoption barriers.

In case of system or product malfunctions, many homeowners go with the installing contractor or service contractor as their first point of contact. These contractors might not be fully aware of all the technicalities of the smart home system. Lack of product information and system knowledge creates a gap, negatively impacting the overall maintenance cost and functionality of the system. Thus, a relatively higher fee for maintaining the technology also deters homeowners from adoption of intelligent devices for energy efficient homes. Therefore, ease of installation and maintenance are likely to be key differentiators.

Security and Privacy Issues
Security is a significant challenge facing the connected home ecosystem. The use of IoT in the connected home provides open access and control of devices to operators and service providers, making it vulnerable to cyber threats. The hacking of home devices such as thermostats, baby monitors, smart refrigerators, and cameras is a cybersecurity nightmare. For instance, a smart thermostat that collects data for real-time energy management and energy optimization must be designed to protect information from unauthorized access that could indicate a home is empty or less occupied, making it an ideal target for burglars. Similarly, voice recognition is being integrated into various home devices, which can possibly listen to conversations and monitor activities while it transmits the data to cloud service. The cloud service sometimes involves third-parties, which then exposes the data to unauthorized access and challenges privacy protection[4].

Figure 50 Challenges in Cybersecurity



Convincing potential smart/connected home adoptees that their connected devices will truly be secure can be challenging. Security and privacy concerns have drawn the attention of all the value chain partners from the connected home ecosystem. The Federal Trade Commission (FTC) is taking significant efforts to create an innovative tool that will help protect consumers from security vulnerabilities in connected IoT home devices[5].

Integration and Connectivity Issues

For the effective implementation of IoT in home automation, proper integration and connectivity of devices is critical. Due to various proprietary technologies and sporadic adoption of open protocols, consumers and professional system integrators face an increasingly complex task in ensuring proper integration and communication of various smart devices. Some challenges in home automation IoT connectivity are interoperability, signaling, bandwidth, and power consumption. Generally, homeowners are concerned about the ability of technology to communicate across different systems. The growing acceptance of home hub devices and the rise of services such as "If-This-Then-That" (IFTTT) solve some of this challenge; however, the industry is still some time away from "Plug and Play" devices to ease the level of connectivity.

Data Interpretation

To profit from the disparate information generated by various connected home devices, homeowners need to be able to draw some generalized conclusions from the data. Most homeowners do not understand the data; therefore, there is a need to interpret the local context generated by smart devices as accurately as possible.

Lack of Regulation and Standards

Regulation and standards are important for connected home IoT solutions. Currently, there is no clear regulation and standards to secure data generated during the communication of various connected home devices. There are preferred best practices guidelines, but legislation and transparency about who gets the access to information and how the data is used is lacking and possibly creating a barrier in widespread consumer adoption of IoT home devices. The Electronic Privacy Information Center (EPIC), which focuses on emerging consumer privacy and civil liberties issues, has emphasized the issues of consumer privacy and lack of regulation within this industry[6]. The Federal Trade Commission (FTC) is taking a look at what kind of regulatory steps are necessary for personal and home devices that collect data and transmit over the Internet[5]. Similarly, several ISO[7] and IEEE standards activities are underway to address this challenge. The key standards so far are ISO/IEC 15045, 15067 and 18012.

Credits and Incentives

Financial incentives and rebates are motivating factors for the adoption of smart/connected home devices. However, most consumers feel that the credits and incentives offered by utility companies are limited to relatively smaller gain. Most of the respondents are willing to consider utilities providing the financing option for widespread adoption of connected home technologies. Therefore, utilities should leverage an opportunity to promote the adoption of energy efficiency by encouraging incentives on a much broader scale. For instance, to mitigate the challenge of high initial set-up cost, utilities could provide solutions involving staggered payments. The payment can be made from the cost savings achieved from various energy efficiency measures.

Application Functionality

Many connected home devices have their own unique application to control multiple functionalities of the particular technology. With the rise of hubs and common communication protocols such as Zigbee and Z-Wave, homeowners are able to control everything from one single application for home automation. However, when multiple devices are controlled from a single application, there can be disadvantages since many features of the devices might not be controllable by the application. This can occur due to a reduced level of customization. For example, temperature control of a thermostat might be possible from an overall home application, but additional functionalities such as flexible scheduling or geofencing settings might not be accessible from the overall home application.

Table 2 Connected Home Adoption Issues and Challenges

Issues	Propagated By
Value Proposition	Homeowner
High Initial Setup Cost	Homeowner and technology vendors
High Installation and Maintenance Cost	Homeowners and system integrators
Security and Privacy issues	Homeowner, technology vendors, and system integrators
Integration and Connectivity Issues	Technology vendors and system integrators
Lack of Regulation and Standards	Professional regulatory bodies
Credits and Incentives	Utility companies and administrative bodies
Application Functionality	Technology vendors

Furthermore, the low cost of energy in some states is adding to the challenges for connected home IoT technologies. Customers do not show urgency for implementation of energy efficiency solutions and programs. For instance, the electricity cost in Montreal (Quebec) is approximately 7.07 cents/kwhr, which is much cheaper compared to other provinces in Canada[8].

Table 3 Average Electricity Price[1]

Selected Cities	Average Electricity Price in CAD($) for Cents/kWh
Montreal	7.07
Winnipeg	8.71
Calgary	10.45
Vancouver	11.08
Halifax	16.15
Ottawa	15.21
Toronto	16.32

Also, in the US, the Trump administration's budget cuts for energy policy programs (including Energy Star) could potentially affect the housing industry segment. The proposed budget cuts are anticipated to have a secondary impact on the energy efficiency market. Consequently, value chain participants may become less supportive, ultimately prolonging developments in innovative energy management technologies[8].

For example, when consumers buy a product, they often rely on third-party evaluations to help them make better choices; the Energy Star certification is one such example. Budget cuts to Energy Star would make it difficult for the program to certify new energy-efficient products. This would limit consumer choices and also impact organizations that invest valuable time and resources to make products that qualify for Energy Star.

Similarly, utilities have invested in incentive programs for the adoption of Energy Star products. With budget cuts resulting in a lesser range of products being Energy Star certified, utilities might not be able to continue to offer those incentives/rebates for a larger range. Without those incentives/rebates, a lot of manufacturers could potentially lose motivation to seek Energy Star certification, thus weakening the overall credibility of the program.

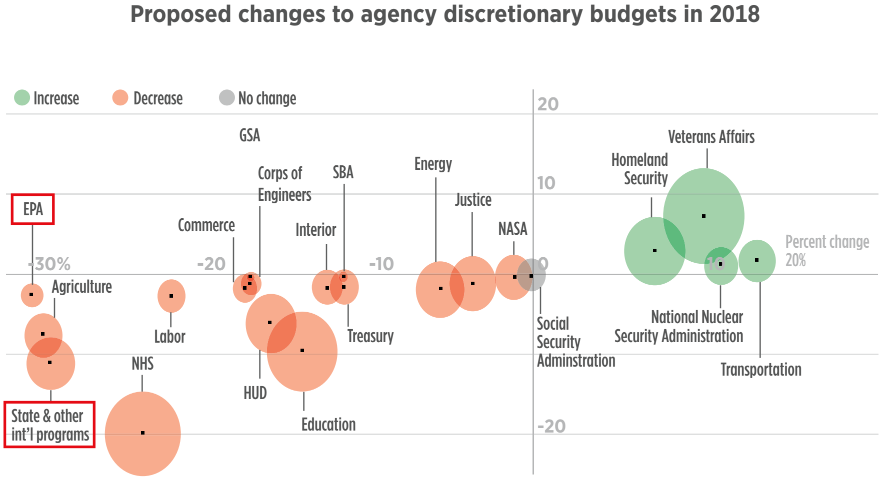
This would be further compounded in the case of a requirement for manufacturers to pay an additional licensing fee (as speculated in various media reports around the topic) over and above the third-party certification fee to get their products Energy Star certified.

Figure 51 Budget Cuts

Energy Programs

EPA
- Clean Power Plan
- **Energy Star**
- Climate change and partnership programs

Energy
- **State Energy Program**
- Innovative Technology Loan Guarantee Program
- Weatherization Assistance Program

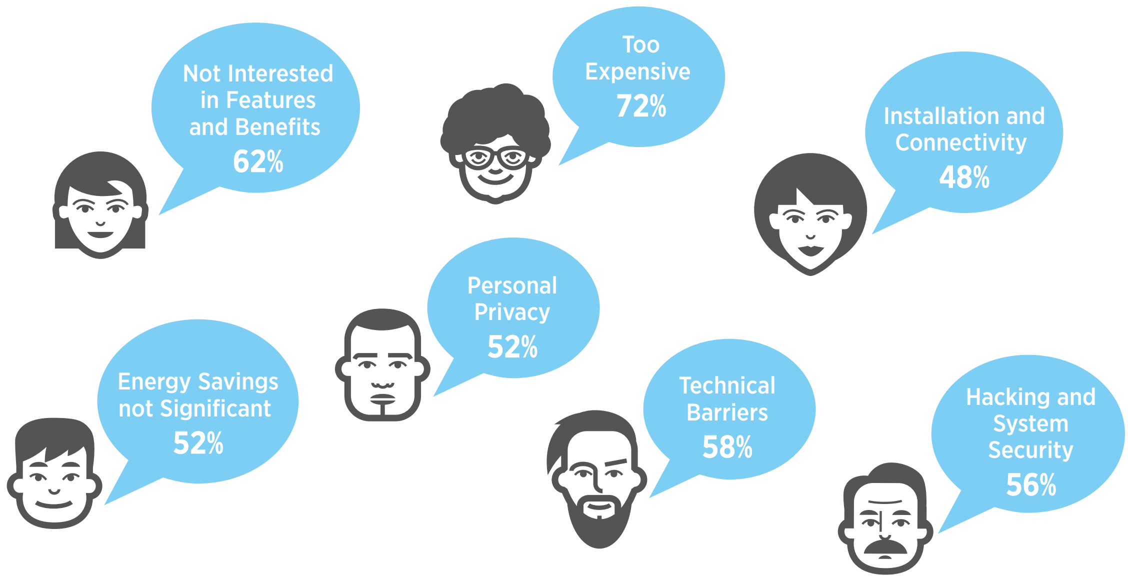


Source: Budget data from Bloomberg

3.2 INDUSTRY CONSENSUS DEVELOPMENT ON CORE ISSUES

The desire for a connected home is motivated by the possibility of effectively managing home energy use by using intelligent commands from connected home devices. Generally, these solutions require high up-front investment in technology from owners, manufacturers, and possible operators, which is why current adoption levels are low for smart/connected home solutions. Apprehension about initial set-up costs was a primary cause identified for low adoption of smart home energy management solutions. Some consumers are more significantly focused on up-front technology cost rather than focusing on and understanding the benefits and financial savings associated with connected IoT home devices. A majority of the respondents from the survey are not keenly interested in most of the features in smart home devices as they consider these to be fringe benefits. Also, renters (non-owners) are less able to make major changes to their houses and appliances; thus, their level of adoption of energy programs and connected home IoT technologies is lower compared to homeowners. This disparity in adoption suggests that opportunities exist to better engage renters in various incentive programs. The figure 52 provides an overview of the primary barriers and contributing factors to low adoption of connected home energy solutions.

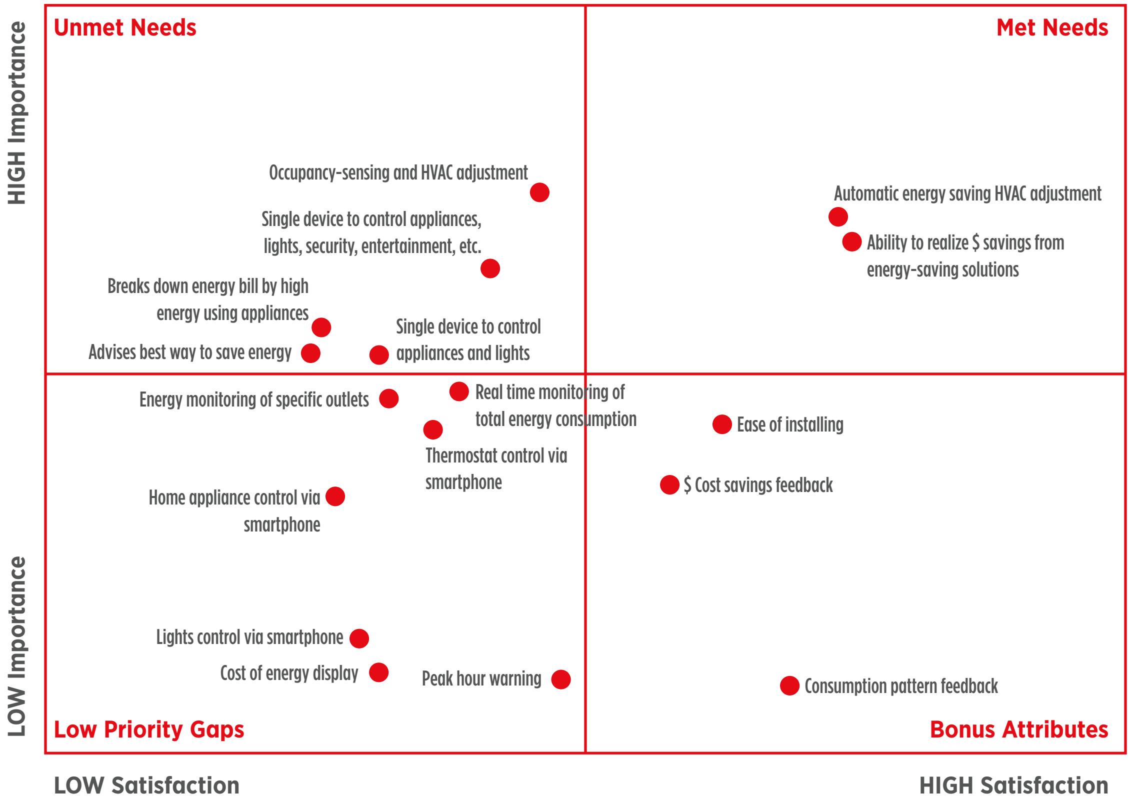
Figure 52 An Overview of Primary Barriers



The challenges start, primarily, with a cost-driven approach by homeowners. Inadequate understanding of benefits and features of connected IoT home device contributes to this challenge. A smart device should satisfy several needs related to security, connectivity, and ease of installation. Selecting the wrong device can trigger increasingly unique and novel challenges associated with personal privacy, cybersecurity, connectivity, or amount of energy savings. This ultimately can lead to poor user experiences that create roadblocks in the adoption of smart home devices.

In addition, the lack of a distinct end-to-end solution for monitoring and controlling all the connected home devices is another fundamental concern and unmet need for homeowners. The indication that consumers would like a breakdown of their energy bills by high energy-using devices[1], as shown in Figure 53, reflects the desire of homeowners to have more understanding and transparency of home energy use.

Figure 53 Unmet Needs of the Consumer

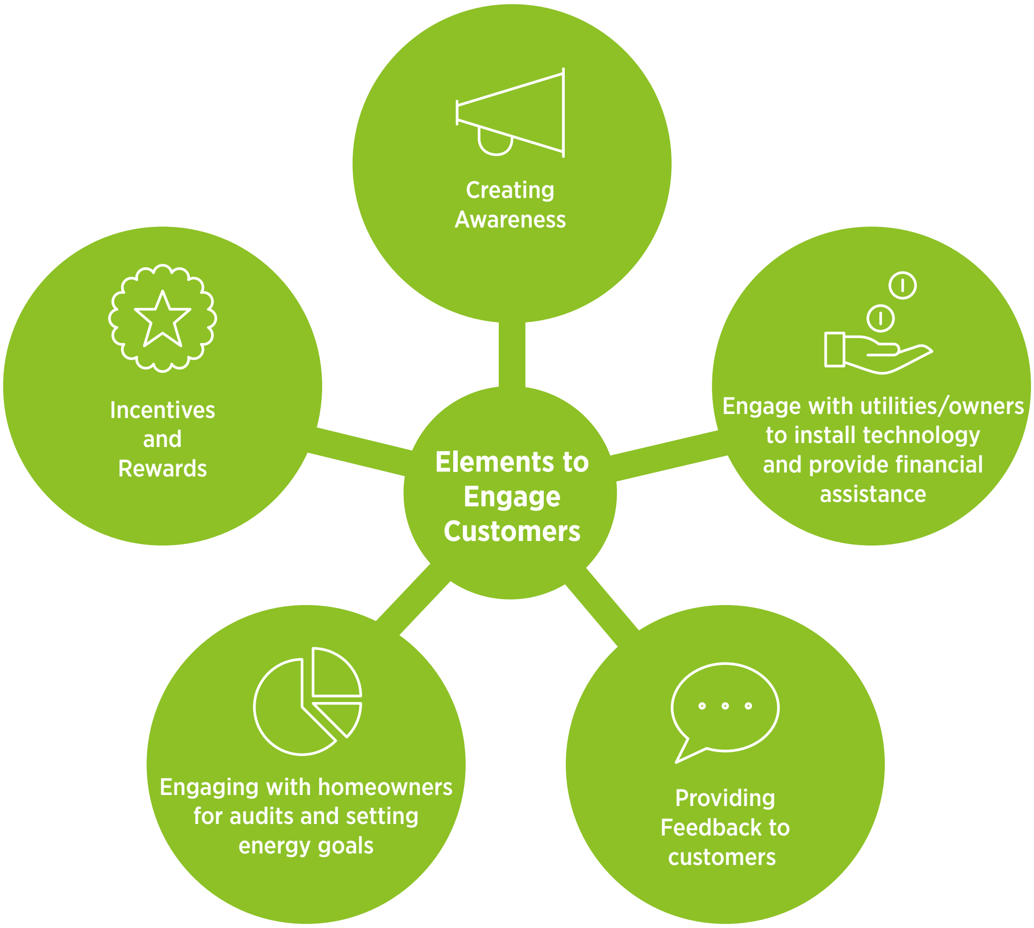


Manufacturers and service providers must understand what motivates homeowners in the adoption of smart devices and then highlight those benefits when educating and marketing to consumers. From a home and energy perspective, the most significant measure as identified by consumers in chapter 2 is the smart thermostat. Therefore, it is the best gateway to engage consumers.

Some cities, such as Austin, Texas, have already set mandates to include smart thermostats as an energy efficiency measure in new home construction. These initiatives will more closely connect the customer to the city's utility and demand management programs.

A greater understanding of the benefits and transparency of energy management solutions will help combat the gap between availability and adoption of connected home IoT technology. The relationship between consumers and providers should become more interactive. For instance, smarter use of energy data can allow utilities to advise customers when it might be the time to invest in more energy efficient equipment/connected home devices. This can be achieved by engaging with all the stakeholders in a connected home ecosystem, including device manufacturers, technology providers, utilities, integrators, and standards bodies. Focus should be expanded from creating a connected home to empowering a consumer through real-time actionable data on energy use.

Figure 54 Customer Engagement



Diverse challenges are present in connected IoT home and efficient energy management solutions. To address consumer challenges and create effective countermeasures, coalitions, partnerships, and alliances are required from all stakeholders in the connected home ecosystem that will dictate the success and evolution of the industry space. Table 4 provides a snapshot of core consumer issues and the activity details associated with each core issues.

Table 4 Core Issues and Activity Details

Core Issues	Activity Details
Consumer Privacy	Connected IoT home systems need improved cybersecurity standards to secure connected home solutions.
Technical Barriers	Industry participants need to create awareness and provide product knowledge to consumers and educate them on the latest technological advancements, features, and associated benefits to promote the adoption of smart/connected home devices.
Visibility of Energy Savings	Currently, most of homeowners cannot see their energy use in tangible format. Real-time energy use information will give greater insights to customers. This will help consumers understand, compare, and take effective measures, including installing smart/connected home devices to reduce energy consumption.

Core Issues	Activity Details
Lack of Regulations	Regulations and standards need to be rectified and enhanced in order for smart/connected home devices to achieve wider adoption.
Connectivity	Currently, plug-and-play compatibility is not available. Therefore, a single system should have an ability to interact with multiple devices.
Installation	Most of the IoT-connected home devices are multipart products that require an installation by licensed professionals. Technology vendors need to work out of the box and have a solution that requires minimal installation and make it easy for third-party vendors or homeowners. Moreover, developing easy-to-install solutions will make it easier for tenants (non-owners) renting an apartment to invest in smart home devices.

3.3 INCENTIVIZING TECHNOLOGY USAGE

Numerous incentive programs in the form of credits and rebates are being offered to generate more consumer interest and accelerate connected home IoT technology penetration. Generally, incentives offset some of the initial capital cost and are tools that sway purchase decisions toward energy-efficient products. With increasing energy costs and growing energy consumption, utilities are offering energy efficiency initiatives that assist customers in implementing suitable energy conservation measures. For customers, these smart home technology incentives and promotions can mean a healthier bottom line as devices continue to evolve.

Rebates for Installing Smart Thermostats

A smart thermostat is one of the key components driving home energy efficiency. Utility companies are offering cash incentives to install smart thermostats because they save energy by maintaining recommended temperatures. Home automation device vendors such as Nest are actively working with utility companies to institute programs that help homeowners migrate to smart thermostats by covering a portion of or the entire cost of the thermostat through instant rebates.

For example, the Pacific Gas and Electric Company (PG&E) provides a cash incentive of $50 for installing a smart thermostat for home energy efficiency improvements[9].

There are other similar programs by US utilities that focus on optimizing energy efficiency by installing smart thermostats. Commonwealth Edison (ComEd) offers instant cash rebates of $100 for installing energy star Ecobee or Nest smart thermostats[10]. National Grid offers a similar system for customers based in Massachusetts that involves a $25 rebate on a seven-day programmable thermostat and $125 rebates on the purchase of Honeywell and Ecobee wireless thermostats. Wireless thermostats from other manufacturers are eligible for a $100 rebate[11].

Rebates on Heating and Cooling Equipment

More than 40 percent of monthly energy consumption bills come from heating and cooling equipment at home. Duke energy offers rebates up to $400 for installing smart heating and cooling equipment, which is programmed through a smart thermostat using a customer's home Wi-Fi network[12]. Similarly, National Grid and ComEd offer rebates up to $500 and $450, respectively, for installing energy efficient central air conditioning units.

Smart Metering and Demand Response Programs

Smart meters are key components for driving utility demand-side management programs. The load data gives customers or customer energy management systems real-time information regarding tariff information and electricity use at home. This enables reduced electrical consumption during peak demand periods after identifying demand response opportunities.

ComEd offers a peak-time saving program for residential customers to earn a credit on electric bills by voluntarily reducing electricity use when it is most in demand[13]. It also offers an hourly pricing program that can help manage electricity costs by running appliances, like the dishwasher, when the price of electricity is lower.

Rebates for Energy Star Home Appliances

There is always an operating cost associated with each and every home appliance. An implementation of Energy Star-certified appliances can help homeowners save money on operating costs by reducing energy use without sacrificing overall performance. Therefore, utilities are offering rebates on purchasing Energy Star-certified appliances.

Here is the select list of utilities that offers rebates on selected Energy Star appliances.

Table 5 Rebates on Selected Energy Star Appliances

Energy Star Appliances	ComEd Rebate Amount (US$)	National Grid Rebate Amount (US$)
Air Purifier	$50	$40
Clothes Washer and Dryer	$50	$50
Refrigerator	$50	$50
Freezer	$25	$50
Room Air Conditioner	$25	$40

Rebates for Efficient Lighting

Because about 30 percent of the electricity use at home is consumed by lighting, significant consumer interest is directed at energy efficient lighting systems. Utilities are offering incentives to implement lighting measures that reduce energy use. Further, custom-based cash incentives are also offered by utilities for overall electric improvements in new homes and retrofits.

National Grid offers a $10 discount for consumers based in Massachusetts who purchase Energy Star LED lighting for their upgrades. Similarly, ComEd offers discounts for LED lighting installations ranging from $10 to $25.

Discounts on the Home Insurance Policy

Various insurance companies are offering discounted rates for homeowners who have installed connected home IoT technologies. This is because a combination of smart home devices and a protective home system can mitigate the risks of burglary, theft, and any kind of system damage.

For example, American Family Insurance offers up to a five percent discount on policies if the homeowner has Internet-connected devices such as a smart home security system, Nest smart thermostat, or other smart home device[14]. Similarly, Farmers Insurance offers many discounts and incentives to homeowners who are smart about protecting their home. Liberty Mutual Insurance actually partnered with Nest to offer smoke detectors to customers free of cost and an additional five percent discount on their insurance policy[15]. Offers like these could speed up the adoption of connected home technology and transform how homes are managed.

Incentives for Solar Technology

Various utility companies offer diverse incentives for installing solar technology. PG&E offers a rebate up to $4,366 and ComEd has a net metering program for a residential customer that provides credits for the excess generated energy that flows into the distribution system. Another factor that may help advance the adoption of connected homes is the availability of various regulatory incentives for homeowners, specifically within the detached single-family segment. Several incentives are available to homeowners for building energy-efficient homes. Households that install solar energy systems can receive a federal income tax credit of up to 30 percent of the cost of such technology.

3.4 OVERVIEW OF BUSINESS MODELS

Several major trends that offer greater value to consumers could influence the future of the smart home industry. With advancements in connected home solutions, there are possibilities to provide supplementary services to homeowners. This will lead to innovative business models being developed and could be the key to deploy particularly cost-effective, sustainable, and smart technologies. Some of these business models are discussed below.

Lighting as a Service (LaaS) Model

Connected lighting technology plays an important role in satisfying the needs and lifestyle demands of consumers regarding energy efficiency and lighting control. With the advent of LED technologies along with connected lighting, the LaaS model is making significant changes in the traditional lighting business; however, is less adopted by homeowners. The current homeowner apprehension with regard to making the initial investments required for installing and/or retrofitting existing lighting systems with connected lighting is one of the factors that could support the growth of the LaaS model in the residential segment. This is because homeowners do not have to pay a lump-sum amount during the installation of lighting equipment in their homes. They can pay for the provision of the lighting equipment and associated services on a subscription basis.

A minimum subscription period would be required to ensure installation and related costs are recovered. A possible entry point could be multi-dwelling apartments, as these can implement LaaS on a larger scale. Partnerships between lighting equipment providers and energy service companies would help successfully execute this business model. Possible rebates from energy providers on adoption of LaaS would play a role in the faster adoption of this model.

Grid Management by Utilities

As opposed to conventional approaches to buying and using energy, a broad approach that could lead to homeowners saving, storing, and producing energy will be a key solution for connected home energy management. Homeowner implementing solar technology is one way of producing, storing, and sharing extra energy during summers. This model is currently in place; however, the adoption rate is low. With more awareness of clean energy and administrative incentives, the adoption rate is likely to increase in coming years. The utility companies could pay homeowners for the extra power generated to effectively manage the demand and supply of their central grid through software- and cloud-based solutions. If done correctly, this model has the potential of helping utilities to wade through energy concerns.

Pay Monthly Subscription-based Services

Bundling smart home packages (hardware and services) might be considered interesting by value chain partners. Supplying smart/connected home gateways, apps, and devices on a monthly pay subscription service could penetrate the connected home market.

Moreover, as discussed in chapter 1, security companies are evolving into the connected home energy market and providing end-to-end solutions to customers. It remains to be seen how this will shape the business landscape in the next five to 10 years.

3.5 STANDARDIZATION INITIATIVES NEEDED

Various standardization initiatives in the connected home market are required to ensure effective operations and cohesion, which are needed to drive the adoption rate of smart home devices. This would possibly reduce the barriers associated with interoperability, compatibility, exchanging, and processing disparate data. Some of the standardization initiatives are needed for cybersecurity, connectivity, data analysis, and methods of evaluating energy performance.

Cybersecurity Standards

Connected home IoT devices raise a myriad of security concerns. There are currently no distinct connected home IoT cybersecurity-related approved standards, and this poses challenges for industry organizations. There are a few prominently used standards and protocols (such as International Society of Automation's ISA 99), but lack of specificity in some standards is a potential contributor to cybersecurity breaches and loss of personal information. Handling data and developing robust cybersecurity mechanisms that will address societal concerns will require the involvement of a connected home ecosystem. Ensuring proper cybersecurity standards improves security and contributes to risk management in numerous ways.

Analyzing Data

Not all the data from smart home IoT applications is collected and analyzed in a standardized format so as to have the correct understanding from it. Most users of smart devices poorly describe and understand the information they gather. A standardized methodology for describing and understanding data will make it easier and more cost-effective for homeowners to analyze, visualize, and derive value from operational information. This can be ensured through the use of certain tools and methods to analyze data; thereby, creating value for consumers.

Connectivity Standards

Because smart home devices are designed by companies that use different standards, technologies, and proprietary platforms, they are often inhibited from connecting with other devices from different companies. There is no common connectivity standard or protocol that is directly compatible with all the smart devices. With the use of a hub that supports multiple protocols, homeowners can reduce this inconvenience. However, there is a need for industry participants to collaborate and create a common connectivity framework to support an open environment. A group of industry consortiums, including AllSeen Alliance and Open Connectivity Foundation (OCF), are attempting to gather the industry to collaboratively develop and use comprehensive specifications that will help realize the promises of connected home IoT devices[4, 16].

Here are the select examples of protocols supported by few connected home platform developers are mentioned in Table 6.

Table 6 Connectivity protocols supported by connected home platform developers

WI-FI	Bluetooth	Thread	Zigbee	Z-Wave
Apple	Apple	Nest	Samsung Smart Things	Samsung Smart Things
Nest	Quirky (Wink)	Samsung Smart Things	IRIS	IRIS
Samsung Smart Things		Quirky (Wink)	Quirky (Wink)	Quirky (Wink)
IRIS			Philips Hue Bridge	Philips Hue Bridge
Quirky(Wink)				Google Home

Evaluating Home Energy Performance

With respect to home scoring, there are various tools such as: Home Energy Rating System (HERS); Energy Performance Score (EPS); or Home Energy Score (HES); which can be used by homeowners. However, a common set of tools and methods should be used to evaluate the overall performance of energy efficiency. Other than smart meters, the energy efficiency score can also be monitored at device level. For instance, states such as Washington, whose administration has directed its commerce department to select and implement an energy performance scoring tool, are currently taking a slow approach. The EPS tool is currently in use in some areas, however, they want more information on how the market responds to various scores such as EPS and HES before choosing one over the other.

Moreover, the Home Energy Score, which is an energy labeling tool developed by the U.S. Department of Energy (DOE), provides homeowners and renters credible information about a home's energy use[17]. Typically, the actual score (e.g., a home is a three out of 10) comes at the end of an overall assessment. However, with a connected home's interface, the ability exists to perform real-time monitoring and offer a homeowner or renter a reminder score and regular feedback. This can help motivate homeowners to invest more in specific IoT home solutions for energy management and demonstrably improve their score to leverage any kind of incentives.

Figure 55 Home Energy Score

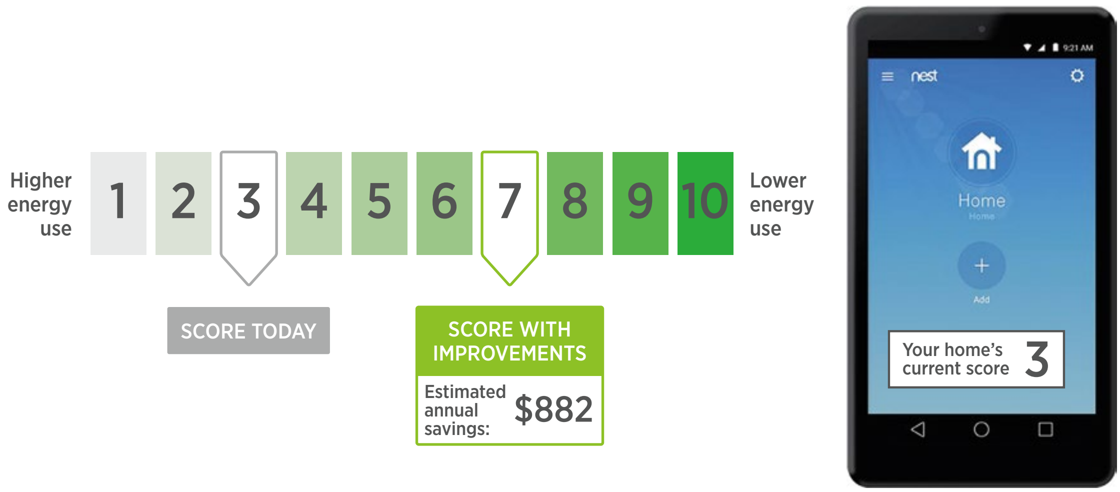
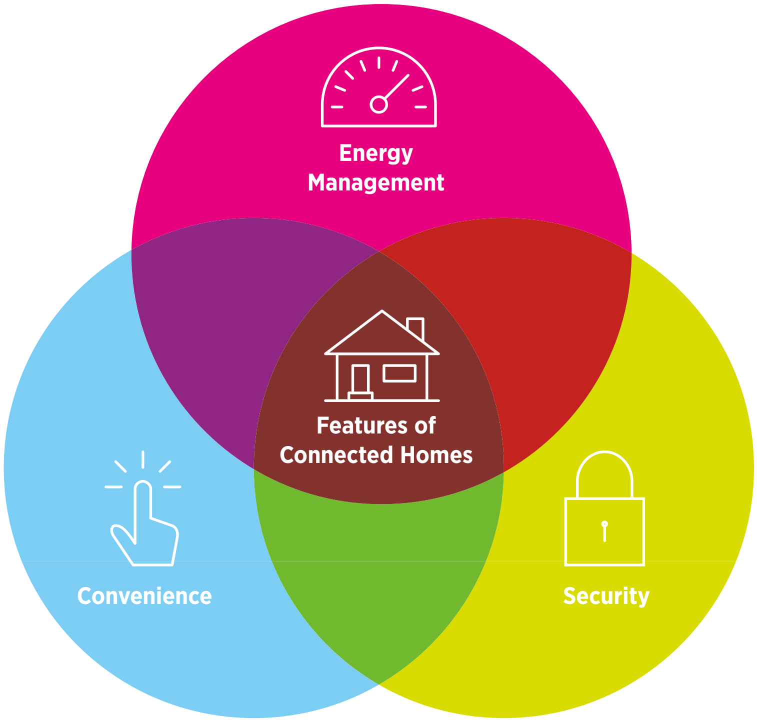


Image Source: US DOE[17], NEEP[18]

Rating Tools for High-Performance Homes

Rating tools for connected homes are developed with the goal of managing energy and optimizing operational performance. Popular rating tools, such as Energy Star-certified homes and Net-zero homes, focus on the energy and sustainability of connected homes as opposed to the features offered by connected home IoT devices, such as overall security and convenience/ease of day-to-day activities. Initiatives to develop such ratings or labels for connected home, in conjunction with energy savings could motivate homeowners and increase the adoption of smart home solutions.

Figure 56 Features of Connected Home



3.6 PROSPECTS FOR COLLABORATIVE PARTNERSHIPS

Due to industry fragmentation, lack of connectivity and security standards, and rapid evolution of connected home IoT solutions, it is necessary for the stakeholders to collaborate and demonstrate value-added services to potential consumers.

Partnership among Technology Vendors
By building partnerships with each other, technology vendors will have the opportunity to leverage complementary strengths to meet client requirements. These partnerships require a high level of integration during the installation of smart systems in order to successfully set up a joint infrastructure for connected networked solutions. This would ensure the smooth integration of smart home solutions and drive the scale of technology adoption.

Partnership with Utility Companies and Device Manufacturers
Utility companies are constantly finding ways to help consumers optimize energy use. The partnerships among various device vendors and utility companies could ensure greater energy saving plans and more ways to offer innovative incentives and rebates. For example, various utility companies have partnered with Nest smart thermostats to obtain energy saving through reward programs. The growing role of such partnerships is inevitable as utilities try to become more viable and competitive. These initiatives will encourage a close connection between homeowners and utility companies through their demand management programs.

Partnership of Technology Vendors with Insurance Companies

Insurance companies are always competing to gain access to precise data to quantify risk on a more granular level. As such, insurers have been testing connected doorbells, occupancy sensors, smoke detectors, and dozens of other smart devices for their risk management capabilities. Some insurers have already introduced initiatives for connected homes. For example, both Liberty Mutual and American Family Insurance and are offering discounts for owners of Nest protect smoke detectors which helps reduce the damage done by fires, and can lower the insurance payouts[19]. Such partnerships between connected home IoT vendors and insurance companies could enhance overall service offerings and give insurance companies an opportunity to reinvent a traditional business model—moving from simply insuring against the risk to actively helping protect customers.

Partnership among Utility Companies

It can be difficult for homeowners to choose an energy management platform because of the numerous available options. Generally, utilities partner with smart home platform providers to offer home energy platforms. However, the utility companies can work together to develop a central home energy management platform and enhance their supplementary value offerings for the residential segment. This could provide homeowners with energy efficiency insights and the ability to recognize the impact of their behaviors on monthly energy bills. This would support decision-making that could lower their energy costs. Moreover, for utilities, this will enable the convergence of behind-the-meter technologies to manage energy efficiency programs (such as demand response programs) and maintaining electrical grid stability.

Partnership among Communication Protocol Developers

Homeowners are bringing more technology into their house and expecting these smart devices to work together seamlessly. The absence of a single end-to-end solution forces consumers to have multiple devices, which creates complications in the installation and troubleshooting processes. Consumers may want to select a protocol that is easy to use with all the connected home devices so he can continue to use it as new products are introduced to the market. To provide homeowners with complete connected IoT solutions, communication protocol companies can work together to develop tailored offerings that combine and integrate the benefits from their individual platforms.

4. DEVELOPMENT OF THE FUTURE ENERGY ROADMAP

4.1 ELEMENTS LEADING TO ROADMAP MILESTONES

As presented in Chapter 3, the industry currently faces a number of challenges. The root causes of these challenges involve technological aspects, challenges due to existing business models/partnerships in the industry, regulatory aspects, and other macroeconomic factors. This chapter develops the future connected home energy roadmap based on the requirements of the industry/consumers and the projected direction of market development. An analysis is provided of the dependencies that can drive execution of the roadmap and the roles of key participants in ensuring successful adherence to the roadmap.

A number of factors are expected to influence the future direction of the industry in terms of specific milestones along the industry development roadmap. For example:

Device compatibility issues

One of the primary characteristics of a connected home is the integration and interoperability of multiple systems/devices. However, device compatibility is a current challenge[1] that results in issues in the installation and operation of overall connected home ecosystems.

The main reason for this incompatibility is the existence of multiple communication protocols in the market that form the layer of communication between devices in the home. In many cases, products of a particular brand are aligned to a particular protocol. This prevents communication between devices and raises the requirement of communication bridges/hubs to act as 'translators' between different protocols. The installation of bridges adds an additional layer of complexity to an already complex network of systems/devices, which can act as a deterrent for consumer adoption and cause issues during future use due to software/firmware updates in the market.

Given that different communication protocols have advantages depending on respective applications, increased collaboration/partnerships between communication protocol providers would be beneficial for the industry at large, especially if the industry does not consolidate towards a particular protocol. Such collaboration could also aid with updates to the protocols to ensure consumers do not have to make frequent infrastructure upgrades.

Monitoring of HVAC Equipment by Utilities

Given the large role that HVAC equipment can play in residential energy consumption, the monitoring of such equipment would be of interest to utilities. This monitoring requirement could be in terms of the energy efficiency aspects of the equipment itself, the control layer that determines energy efficient control of the equipment (including demand response system compatibility), or maintenance of the equipment to ensure energy efficiency levels of the overall system remain within required parameters.

It could be of interest to utilities to form a consortium/association to certify products/installation and maintenance contractors to bring in larger control over the acceptance and maintenance of equipment in homes. Such a consortium could also be developed under the aegis of the Consortium for Energy Efficiency (CEE). Device providers/vendors/contractors could be required to register with the association and gain approval for best practices related to energy efficiency and compatibility with utility-driven programs. Utilities could offer discounts/rebates to consumers on adoption of such products/engagement with such contractors.

The Interest of Insurance Providers in Connected Home Technologies

Home insurance today covers damages due to external and internal factors. Some external factors are robbery and theft, vandalism, and natural disasters and other acts of nature. Internal factors comprise of fire and flooding damage or other damage caused due to accidents or negligent behavior. Having mitigating measures to prevent such events or having information to analyze behaviors that might lead to such events are of high interest to insurance organizations. For example, the increased level of diagnostics available on connected home energy equipment could help detect abnormalities in functioning and communicate any emergencies/anomalies to homeowners so they can take appropriate preventive action. The network of sensors can be cross-utilized to detect break-ins/possible flooding/fires in the home. Information on use activities in the home can be analyzed en-masse by insurance organizations to enable enhanced underwriting and pricing.

This could bring about an increased involvement of insurance organizations in the connected home energy ecosystem as they collaborate with technology vendors, service providers, or utilities.

Increased Diagnostics of Home Energy Equipment

Successful energy efficiency initiatives depend on both the type of equipment installed and the use and maintenance of such equipment. The maintenance aspect is especially of interest in the residential sector given that there are no dedicated/skilled facility managers to monitor equipment health. Maintenance contractors are usually called only when there is a noticeable malfunction in the system. Over time, without timely intervention, equipment in the home can become increasingly inefficient, driving up operating costs and energy demand from the home. One of the advantages of connected home energy technology implementation is an increased level of diagnostics information regarding connected systems. Implementation of enhanced diagnostics features such as an alert to users' smartphones in cases of a required change in air filters, for example, would help increase overall home efficiencies across the grid.

Rebates by utilities for connected home technology use with these features could also help drive adoption and demand for such features; thus, enabling preventive maintenance and real-time equipment diagnostics on a larger scale.

Possibility for Artificial Intelligence (AI)-based Troubleshooting/Customer Service

On increased adoption of home energy management systems, the number of installed systems and extended connected home environments would pose a challenge to service providers/technology vendors in terms of handling consumer queries in cases of malfunctions/other issues in connected homes. As an additional feature in equipment diagnostics, an AI-based solution to self-rectify issues or provide alerts to consumers with guidance on rectifying issues could possibly find traction in the long term. Alerts could be then sent by the system to service providers/vendors in the case of issues not being rectified at the system/user level.

Requirements for Connected Home Evaluation Services

As the market penetration of connected home energy technology increases, requirements for performance evaluation of overall home ecosystems are expected to correspondingly rise. Rebates on the basis of home energy evaluations/audits based on programs[2] such as EnerGuide, Built Green, and Passive House are expected to become more commonplace in coming years.

Apart from home energy audits, overall home cybersecurity audits could also penetrate the market, either as standalone offerings or offerings bundled with home energy audits. While cybersecurity measures might be provided by device manufacturers/platform providers, the installation of such systems would also need to be evaluated for possible breach points, especially in cases of do-it-yourself (DIY) installation.

The Popularization of Energy Services from Utilities

The provision of energy management services from utilities for the residential sector on a large scale is a possibility in future years. The results of our consumer survey also indicate that 71 percent[3] of respondents would prefer or consider the business model of utilities providing energy management services. This could be done by utilities in collaboration with a third-party provider. It would be an advantage for utilities in terms of consumer engagement and better integration with the grid for demand management initiatives. Consumers could also experience increased convenience by working with a single point of contact for a comprehensive home energy solution.

Further Development of Voice-based Control Infrastructure

Current voice-based control mechanisms[4] for connected home energy management are limited in terms of utilizing the full suite of functionalities available for multiple devices/systems in the home. For example, simple functions such as temperature setting are possible, but a higher level of integration in terms of activating schedules for temperature control would depend on collaboration with the HVAC equipment manufacturer. As the collaboration levels between vendors and platform providers increase, voice-based control is expected to further develop in sophistication to include complex control mechanisms for systems and also interaction with utility programs.

Monetization of Energy Usage Data

An increased level of adoption of connected home energy technologies brings with it an increased level of monitoring of systems and their use. Platform providers/energy service providers would be in the position to access use trends and data[5] across a large number of consumers. After complying with consumer acceptance and privacy requirements, these organizations can monetize the use trend data by providing the same to technology vendors/other service providers so they can design innovations based on perceived acceptance from consumers.

Subscription-based Connected Home Energy Products

Given consumer concerns around initial costs for upgrading their infrastructure to make systems connected for energy efficiency purposes, business models for providing such equipment on a subscription basis are expected to find higher acceptance. The equipment provided could include overall connected home infrastructure consisting of products such as communication bridges/hubs, smart thermostats, and other connected devices.

Real-time Energy Usage Tracking

Providing consumers access to real-time energy usage data with information also highlighting high energy-consuming equipment is a future possibility that could leverage initiatives such as the Green Button initiative[6] for energy usage data access. However, this would require upgrades to the existing smart meter infrastructure that commonly uploads energy usage data for extended periods of time in separate packages.

Bundled Connected Home Energy Packages

This offering would apply more to new installations of connected home energy equipment. Collaboration could be made possible to provide bundled connected home energy offerings to consumers requiring the installation of the overall ecosystem. Partnerships between vendors providing different systems to the home could be a possibility, enabling the offer of a complete ecosystem of connected home products that could center on a control hub such as a smart thermostat.

The Proliferation of Residential Distributed Energy Resources

The residential sector is increasingly implementing technology in the distributed energy resources domain. Solar photovoltaic (PV) cells and battery storage are some technologies with rapidly rising implementation levels. The addition of such technologies would also have an impact on utility demand response program dynamics[7] as consumers also start to depend on battery storage options during peak demand periods in addition to utilizing net metering options.

Electric Vehicle (EV) Charge Scheduling

EV is expected to have a high impact on power requirements from the grid with up to five percent of grid power consumption by EVs expected at the end of the next 10 years in the North American market. This will also have an impact on home time-of-use energy consumption for charging points located in the home. Scheduling of EV charging is expected to require interaction with the grid and could be assimilated into residential demand response programs. EV scheduling platforms could also be upgraded to allow for bi-directional charging where vehicles can both get charged from the grid and also discharge power back to the grid as per requirements, thus ensuring higher flexibility for consumers and utilities.

Residential Micro-grid Integration

The development of residential microgrids in the long term could enable cross-utilization of neighborhood battery storage units during peak demand periods; thus, necessitating a localized communications network between individual connected homes. However, due to challenges of current costs, large-scale adoption would be expected only in the long term.

Residential Energy Storage Penetration

The increased adoption of residential battery energy storage is expected to enable/contribute to the connected home IoT energy roadmap milestones of the proliferation of residential distributed energy resources and residential micro-grid integration. Storage batteries can also contribute by being an effective source for meeting peak demand requirements when there is an excess amount of energy drawn from the grid.

Depending on battery life[8], batteries can enable a system with equal or lower overall life-cycle cost even if the capital cost of batteries is higher than the capital cost of a combustion turbine of equal capacity. This is because the batteries enable the use of renewable technologies like wind and solar, which have zero marginal fuel costs. In a modeled situation in which batteries provide four percent of overall system peak net demand (demand minus solar and wind output), a battery with a lifetime of less than 10 years would likely need a capital cost similar to combustion turbines. With a 20-year life, battery capital cost could approach twice that of a combustion turbine.

Increased adoption of residential batteries for energy storage is also driven by various incentives[9] being provided in the market. For example, the Self Generation Incentive Program offered by the California Public Utilities Commission aims to provide subsidies to support the development of behind-the-meter distributed energy resources, including the following technologies: wind turbines, internal combustion engines, micro-turbines, pressure reduction turbines, gas turbines, waste heat to power technologies, fuel cells, and advanced energy storage systems. Another incentive example is the uncapped investment tax credit or Federal ITC, Section 25D of which allows a taxpayer to claim a 30 percent credit for a residential solar energy system that is owned by the homeowner. This was scheduled to expire on 1 January, 2017. ITCs have since been extended to 2019, after which, the credit amount will gradually decrease to 26 percent in 2020, 22 percent in 2021, and 10 percent in 2022. Tax credits represent a dollar-for-dollar reduction on income tax bills. Approximately half of US states also provide an investment or production tax credit above and beyond the Federal ITC.

The role of battery storage in terms of helping to drive other connected energy initiatives can be seen in various industry collaborations involving battery storage organizations. One such collaboration is between Itron and Sonnen for the integration of their products. This is for product integration of the sonnenBatterie eco with Itron's IntelliSOURCE Enterprise demand response management system (DRMS). The integration of the sonnenBatterie would allow Itron to dynamically maximize grid efficiency by storing and releasing energy. This can contribute in allowing utilities to be able to maximize benefits for the grid with the dispatch and coordination of these and other behind-the-meter (BTM) assets. Batteries can be used to supply power to the grid during peak usage periods and also play a role in reducing transmission losses involved in long-range power transmission.

Utilities are increasingly incorporating battery storage aspects in their programs. One such example is Green Mountain Power's Powerwall initiative in Vermont.

Figure 57 Green Mountain Power - Powerwall Initiative

Green Mountain Power – Powerwall Initiative

GREEN MOUNTAIN POWER

Key Participants	Enabling Technologies	Key Aspects
• Tesla • Green Mountain Power • Google Nest	• Solar PV • Tesla Powerwall battery storage • Nest Smart Thermostat • Tesla GridLogic software platform	• Offered within Vermont-for residential users • Current initiative to be offered to as many as 2000 customers • Battery offered on subscription basis/ one time payment

Description

- The program will offer the battery to as many as 2,000 customers for $15 a month over 10 years, or a one-time payment of $1,500.
- The package will include software and a Nest thermostat.
- The utility, using Tesla's software, will be able to call upon the stored energy in the combined batteries to help meet surges in demand, or to sell it on the wholesale market to help balance or smooth out fluctuations within the region.
- There are three broad categories for customer engagement as a part of the program:
  - Customers buy the Powerwalls outright and maintain sole access to the battery for continuous use.
  - Customers include the Powerwalls with new home construction owning the Powerwall outright and give GMP a limited level of access to the Powerwall.
  - Customers do not need to incur the up front cost and accept sharing access with GMP

In the coming years, possible government mandates for adoption of renewable energy solutions in the residential sector could play a role in driving adoption of battery storage. For example, a recent mandate by the government of California would require most new housing units built after Jan 1, 2020 to include a rooftop solar component. The new policy applies to single-family houses and multifamily units that are three stories or less, with some exceptions. This is expected to also drive adoption of residential battery storage technology in the state.

4.2 THE CONNECTED HOME IOT ENERGY ROADMAP

The following charts provide an overview of potential milestones for the connected home energy industry in terms of roadmap milestones. Milestones in the roadmap are provided with needs driving the milestones and supplementary notes elaborating on the same. Milestones are provided with reference to short-, medium-, and long-term timescales on the roadmap.

The first chart provides an overview of a roadmap in an ideal scenario and the second chart provides a roadmap overview in terms of a scenario considering ground realities in the industry and possible delays in/resistance to implementation of initiatives for roadmap adherence.

Figure 58 Connected Home IoT Energy Roadmap Scenario 1

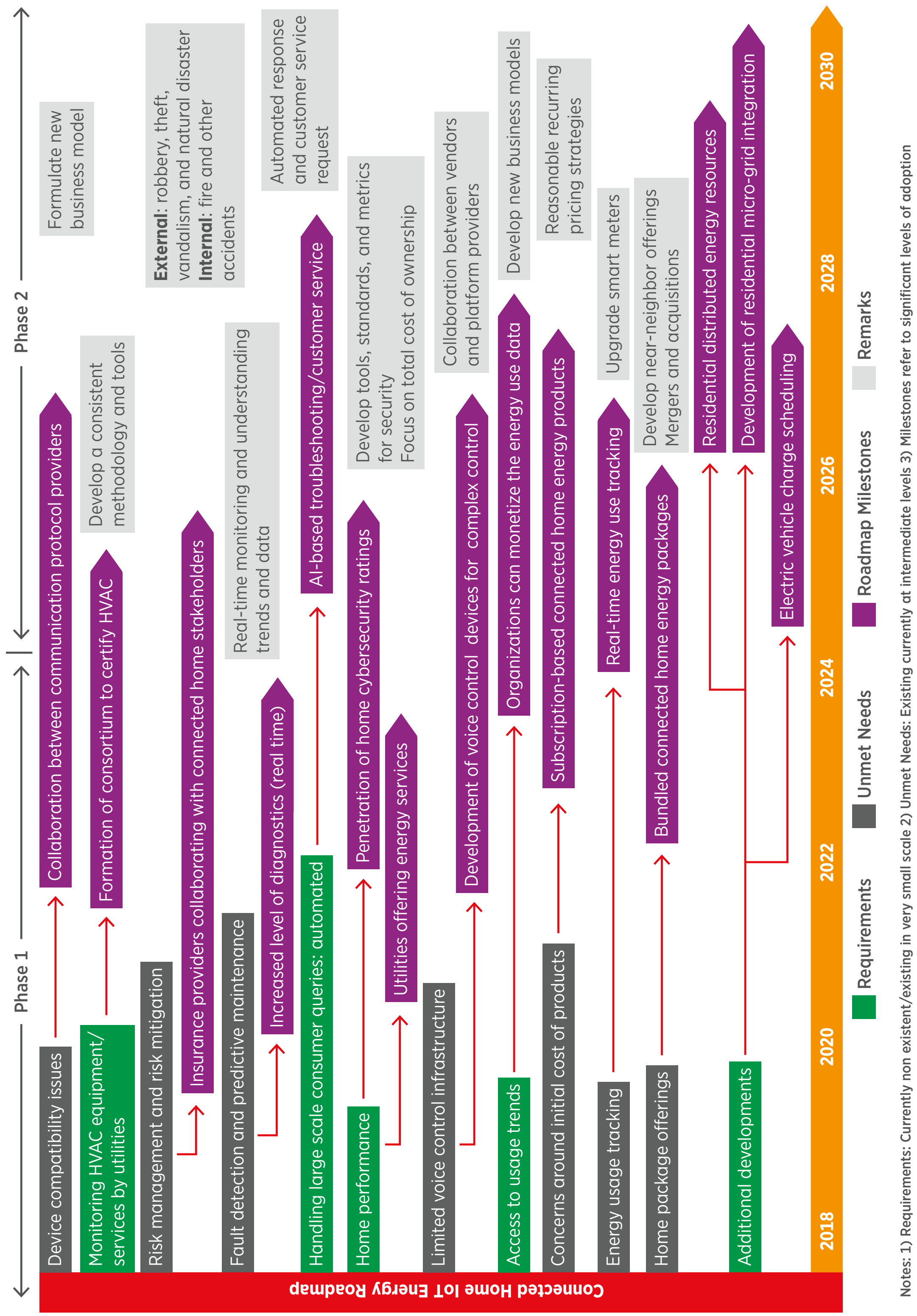
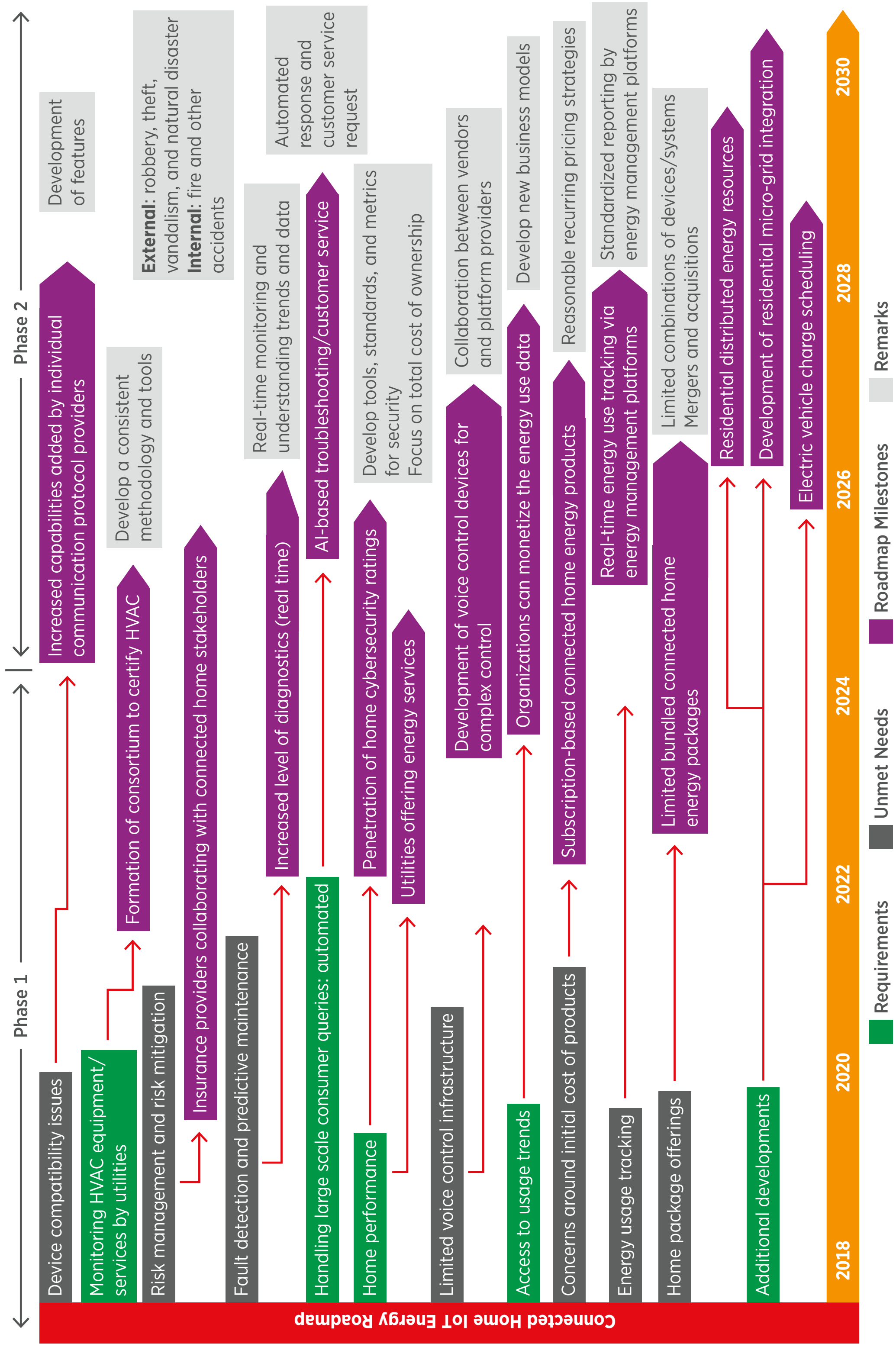


Figure 59 Connected Home IoT Energy Roadmap Scenario 2



Notes: 1) Requirements: Currently non existent/existing in very small scale 2) Unmet Needs: Existing currently at intermediate levels 3) Milestones refer to significant levels of adoption

4.3 DEPENDENCIES FOR DETERMINING ROADMAP ADHERENCE

The roadmap depends on various factors, but generally, the objective is accomplished by effectively managing appropriate activities at different levels. The following section includes a description of key activities to support the elements of a roadmap.

Table 7 Activities for Supporting the Roadmap Elements

Goal	Activities
Optimize Compatibility Issues	• Understand needs of homeowners to identify gaps • Formulate new business models • Collaboration in the area of communication (common standards and protocols) • Standardized communication protocols • Competitive cost of enabling technologies
Monitoring High Energy Equipment	• Develop a consistent methodology and tools to assess • Coherence between state and national tools and methods • Formation of association
Better Risk Management and Risk Mitigation	• Deep customer engagement with insurance companies • Real-time risk analysis to monitor and identify the hazard • Develop customized offerings for the consumer • Complementary partnerships of insurance companies with de-vice/service providers • Differentiated products and allied services by technology vendors
Predictive Maintenance and Fault Detection	• Real-time monitoring • Understanding data analytics • Trend and pattern recognition of equipment • Critical range alerts on smart devices • Schedule maintenance and prevent breakdowns
Improve Home Performance	• Performance evaluation of overall home ecosystems in terms of energy, security, and convenience • Study potential for adoption of cybersecurity ratings • Develop tools, standards, and metrics for virtual security • Evaluate the installation of a system for possible breach • Stakeholders to better engage with customers • Utilities to partner with a third-party for providing energy ser-vices for residential segment • Focus on total cost of ownership by consumer
AI-based Trouble-shooting and Customer Service	• Integrate smart devices to a home automation system • Home automation to understand everyday activities and identify gaps and equipment problems • Prediction trend analysis • Automated troubleshooting and self-rectifying issues • Create automated customer service request and a response • Scheduling maintenance with a service provider if required • Alerts on a smart device for user assistance
Development of Voice Control	• Open standard communication protocol • Setting up the smart products in the central home network • Setting good control mechanism and bandwidth requirements • Technical improvements in voice control for using all the features, including the scheduling of home equipment • Specify cybersecurity standards • Collaboration with technology vendors

Goal	Activities
Monetize Energy Usage Data	• Develop data monetization platform and ways to create value from energy data • Determine trends and customer behavior pattern by real-time data analysis • Establish metrics for data and its privacy • Coordination with value chain participants • Develop new business models to sell data to technology vendors for product enhancement and innovation, and cross-selling of additional products • Develop a business model to sell data to utility companies for grid management • Develop payment mechanism
Subscription-based Model	• Research existing models and identify gaps • Minimize consumers' difficulties by offering smart devices on a subscription model • Reasonable recurring pricing strategies • Develop return policy for devices • Define payment mechanism • Study approach of homeowners on a length of the contract period • Nurture and develop deeper customer relationships
Real-time Energy Usage Tracking	• To install smart meters and smart devices • Develop activity recognition algorithm implemented on the home network • Accurate activity recognition of homeowners daily actions • Develop tool and techniques for data mining/mapping • Generate actionable information and results • Reasonable pricing of the system
Connected Home Energy Packages	• Strategic partnerships between established technology vendors • Mergers and acquisitions of emerging technology vendors (start-ups) • Provide customized solutions • Develop near-neighbor offerings • Build system integrators ecosystem for extended solutions selling • A single app to manage bundled offerings
Residential Distributed Energy Resources (DER)	• Reduce technology cost to localize electricity generation • Install rooftop solar panels, backup generators, and energy storage units • Develop a well-measured approach to integrate DER with smart devices and central grid • Determine and publish the ways to compensate the DER homeowners for the extra electricity they contribute to the grid/system • Specify performance and emission criteria • Supportive administrative policies and regulations on DER
EV Charge Scheduling	• Develop a charging scheduling mechanism • Sizeable high-density vehicle battery • Efficiently coordinating EVs charging activities to avoid stress on the power grid • Coordinate with utility for existing and new programs focusing on EV • Utilities and platform providers to work together with automobile manufacturers • Reduce initial cost of EVs
Residential Micro-grid Integration	• Develop sizable battery for energy storage • To reduce the cost of technology • Set-up community-level networks • Stringent virtual micro-grid security • Develop micro-grid operator requirements • Develop additional standards on a distribution of energy

4.4 KEY PARTICIPANTS IN ENSURING SUCCESSFUL ROADMAP EXECUTION

The successful execution of the connected home energy roadmap depends on multiple industry participants taking various actions. Likewise, each participant group has a variety of roles to play in ensuring that different milestones can be achieved and sustained over a period of time. These roles can vary, including technological development, partnerships with varied stakeholders, lobbying for certain incentives, or developing regulations to enable higher adoption. This section highlights key participant groups and their roles in driving the execution of the roadmap.

Technology Vendors

Technology vendors have a key role to play in ensuring roadmap execution because they are the point of innovation that enables roadmap milestones by making adjustments to their offerings. Some examples of their required role include:

- Enabling partnerships and developing technological aspects to allow for the integration of communication protocols where possible
- Developing sensing/monitoring infrastructure, data storage mechanisms, and analytics to allow for real-time equipment diagnostics, energy use tracking, and data collection/dissemination
- Being involved in the development of standards/protocols for home energy audits and cybersecurity audits
- Gathering input from consumers/service providers and developing AI-based troubleshooting and customer service platforms
- Collaborating with other technology vendors, service providers, and utilities to co-develop voice control mechanisms for leveraging increased device functionalities
- Collaborating with technology vendors to develop bundled offerings
- Developing infrastructure and platform functionality provisions for initiatives like distributed energy resources, EV charge scheduling, and residential microgrid integration

Service Providers

The role of service providers involves collaboration with various stakeholders, input regarding maintenance and operations, and implementations/revised operations that cater to various roadmap milestones. Service providers have traditionally had the responsibility of being the primary industry touchpoint for consumers. Some examples of the role they can play, include:

- Develop familiarization with and driving consumer awareness of integrated communication protocols and their installation processes
- Implement best practices and obtain certifications on energy efficient implementation for contractors
- Coordinate between consumers and other industry participants for initiative implementation
- Provide recommendations to consumers regarding measures to make homes more energy efficient
- Enable energy equipment to operate on subscription-based business models by providing this to both consumers and to allied services

Utilities

Utilities have a large amount of influence in terms of being able to drive initiatives using incentives and leveraging their large consumer bases. Additionally, they have a large stake in the energy ecosystem in terms of the influence of energy efficiency initiatives over the power generation, transmission, and distribution markets. Utilities can perform the following functions to help drive this study's energy roadmap:

- Provide incentives to drive consumer adoption of multiple roadmap milestones for energy efficiency initiatives and demand side energy management
- Form an association targeting the acceptance of connected and energy efficient HVAC equipment
- Develop monitoring and data analytics capabilities to increase the predictability of overall consumer demand and enable collaboration with other participants interested in usage trends
- Develop infrastructure upgrades that enable real-time energy usage tracking
- Upgrade grid infrastructure and platforms to enable initiatives related to distributed energy resources, microgrids, and integrating EV charging provisions

Industry Influencers

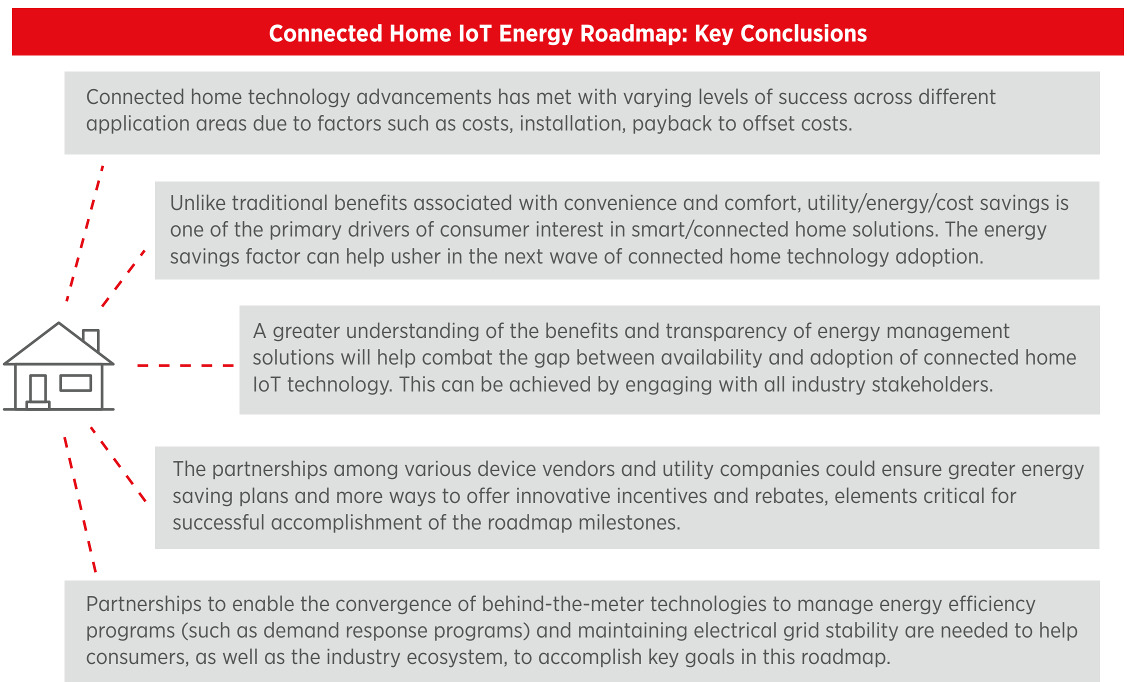
This group—consisting of industry associations, standard and certification bodies, regulatory bodies, and governmental monitoring organizations—has the responsibility of driving industry progress by increasing awareness among participants, providing collaboration platforms for participants, determining standards for industry adherence, and regulating the market. Participants of this group have an overarching role to play in all roadmap milestones for controlling and monitoring the implementation of steps to be taken to achieve these goals.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 KEY CONCLUSIONS

The top findings of this research validate some of the early hypotheses around the opportunities associated with the concept of energy within an IoT enabled connected home environment, and the various dynamics, issues and challenges it presents for both, homeowners, and industry participants. Consumer concern about high energy consumption, expectations regarding connected home energy solutions, challenges associated with adoption of connected home devices for optimizing home energy usage, were juxtaposed against industry issues such as system complexities, ecosystem unification issues, lack of collaboration among various entities, and above all, a lagged development of the utility industry that may challenge accomplishing the identified milestones in this energy roadmap. The key conclusions of this research are summarized in Figure 60.

Figure 60 Connected Home IoT Energy Roadmap: Key Conclusions



Addressing Key Connected Home Energy IoT Adoption Challenges

This research found that the core issues revolve around a wide variety of topics such as costs to cybersecurity, in addition to growing challenges of integration of the latest technologies. Furthermore, the low cost of energy and subsequent budgets cuts to support energy programs in some parts of North America is adding to the challenges for market penetration of connected home IoT technologies. Therefore, it is important for industry participants to address the dynamics that challenge and restrain the adoption of integrated home devices.

Development of the Future Energy Roadmap

A number of factors are expected to influence the future direction of the industry in terms of specific milestones along the industry development roadmap. Addressing these issues, such as device compatibility, monitoring of high energy equipments, third-party collaborations, and increasingly developing AI and voice recognition based capabilities for home energy management solutions can drive implementation of the roadmap and ensure the key participants successfully adherence to delivering the requirements of the roadmap.

Role of Key Participants in Ensuring Successful Roadmap Execution

The successful execution of the connected home energy roadmap depends on multiple industry participants taking various actions. Likewise, each participant group has a variety of roles to play in ensuring that different milestones can be achieved and sustained over a period of time. These roles can vary, including technological development, partnerships with varied stakeholders, lobbying for certain incentives, or developing regulations to enable higher adoption. From technology vendors, utilities, service providers to industry influencers, all participants have clearly demarcated areas to play a crucial role in ensuring the various milestones of this roadmap are accomplished. Taking into consideration the actual pace of development of this industry, Frost & Sullivan projects two scenarios that could potentially manifest: one that takes an optimistic view of various timelines, while the other takes a more conservative view of these timelines.

5.2 RECOMMENDATIONS

The key recommendations of this research are provided in Figure 60. Based on the findings of this research, Frost & Sullivan recommends the following:

Figure 61 Connected Home IoT Energy Roadmap: Key Recommendations

1	Implement best practices to promote connected home certification based on energy savings, comfort, convenience, security and other performance attributes.
2	Develop real-time monitoring and data analytics capabilities to increase predictability of maintenance and consumer usage trends.
3	Develop common standards for open communication protocols for cross-compatibility of products and platforms.
4	Collaborate on connected home industry initiatives, policies and standards, and technology development to ensure interoperability, privacy, security, and transparency.
5	Business model innovation in connected home will become gradually important. It will be one of the primary means of creating customer value.

As an evolving market, the connected home offers tremendous opportunities for further revenue growth and product penetration. Energy is a critical area that offers both, functional advantages as well as inducement to save for homeowners that are considering connected technology adoption. Therefore, there are opportunities for the ecosystem of solution providers and the utility industry participants to cater to this segment, taking into consideration the key pain points and consumer aspirations that emerged from this research.

Improving consumers' visibility of energy metrics and other performance attributes will help them to accurately understand how they consume energy. The use of real-time monitoring to predict consumption trend and an understanding of consumer attitudes will enable service providers and technology vendors to respond to the unmet needs and address key milestones that would be critical to accomplish in the context of the connected home IoT energy roadmap.

The connected home market is very fragmented and there is a lack of interoperability between the diverse smart devices and solutions, resulting in poor end-user experience. Frost & Sullivan recommends developing common standards in order to improve the connectivity of smart devices leading to better end-user experience.

In addition, new go-to-market models and innovative partnership structures are needed to offer consumer centric product and services. Overall, it would be the collective responsibility of the entire ecosystem to help deliver the next wave of growth and dynamism anticipated for this market over the next decade.

APPENDIX A: GLOSSARY

IoT	Internet of Things
CABA	Continental Automated Buildings Association
CHC	Connected Home Council
ESCO	Energy Service Company
IT	Information Technology
HVAC	Heating, Ventilation and Air Conditioning
IP	Internet Protocol
Wi-Fi	Wireless Fidelity
DER	Distributed Energy Resources
EV	Electric Vehicle
EPRI	Electric Power Research Institute
OVGIP	Open Vehicle Grid Integration Project
VGI	Vehicle-Grid Integration
V1G	Unidirectional Power Flow from Grid to Vehicle
V2G	Vehicle to Grid. Bidirectional Power Flow between Vehicle and Grid
DRAM	Demand Response Auction Mechanism
RTM	Real-time Market
DA	Day Ahead Market
AS	Ancillary Service
ISO	International Organization for Standardization

MWh	Megawatt-hour
TOU	Time-of-use
EVSE	Electric Vehicle Supply Equipment
kVA	Kilo-volt-ampere
SAE	Society of Automotive Engineers
LED	Light Emitting Diode
M2M	Machine-to-Machine
OEM	Original Equipment Manufacturer
FTC	Federal Trade Commission
IFTTT	If-This-Then-That
EPIC	Electronic Privacy Information Center
IEEE	Institute of Electrical and Electronics Engineers
PG&E	Pacific Gas and Electric Company
LaaS	Lighting as a Service
DoE	Department of Energy
NEEP	Northeast Energy Efficiency Partnerships
CEE	Consortium for Energy Efficiency
AI	Artificial Intelligence
PV	Photovoltaic

APPENDIX B: REFERENCES

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APPENDIX C: CONSUMER RESEARCH QUESTIONNAIRE

2017 CHER QUESTIONNAIRE DECEMBER 21, 2017

NOTE: CAPITALIZED TEXT IS PROGRAMMER NOTES AND WILL NOT BE SEEN BY RESPONDENTS.

DISCONTINUATION SCREEN
We are sorry, but you do not meet the criteria needed to be able to answer questions for this particular study. We thank you for your time, and look forward to your par-ticipation in future surveys.

COMPLETION SCREEN
Thank you for taking the time to participate in this survey.

INTRODUCTION SCREEN
We know that your time is valuable and we appreciate your participation in this sur-vey. This study aims to understand your opinions and preferences with regards to en-ergy management solutions for the home. Your perceptions are important to us and your responses will contribute to the development of future products and services that we hope will better satisfy your needs.

Your individual responses will be kept strictly confidential and will not be revealed to any company. Only summary data and statistics will be presented to convey the re-sults of this study.

Firstly, we will begin by seeing if your participation is appropriate for this specific sur-vey.

PROGRAMMING NOTES, ETC. ARE CAPITALIZED AND WILL NOT BE DISPLAYED ON WEB SURVEY SCREEN.

QUOTAS: REQUIRE TOTAL N=1,000 TO 1,200 INTERVIEWS.

RESPONDENT QUALIFICATIONS

- OCCUPANT/ HOMEOWNER IN US AND CANADA
- 18 YEARS OR OLDER
- WITH HOME INTERNET ACCESS (CONNECTED)

SAMPLE DISTRIBUTION

- AGE: SOFT QUOTAS ON AGE DISTRIBUTION.
- GENDER: ENSURE A GOOD SPLIT BETWEEN GENDERS. 50/50 PREFERRED. DO NOT ALLOW SAMPLE TO EXCEED 55/45.
- AREA: ENSURE A GOOD SPLIT BETWEEN TYPES OF AREAS, NO FIXED QUOTA BUT MONITOR

RESULTS. PREFER 40% URBAN, 40% SUBURBS, AND 20% RURAL EACH.

SECTION ONE: SCREENING

S1. Please select the country you live/reside in. (ONE ANSWER ONLY.)

United States 1
Canada....... 2
Other .... 3 ➔ DISCONTINUE

S1A. Please select the [IF US] 'state' [IF CANADA] 'province/territory' you currently live/reside in. (ONE ANSWER ONLY)
(INCLUDE LIST OF STATES FOR U.S, LIST OF PROVINCES/TERR. CANADA)

S2. Please select your age range ... (SINGLE RESPONSE)

17 or younger .... 1 ➔ DISCONTINUE
18 to 25 2
26 to 35 3
36 to 45 4
46 to 55 5
56 to 65 6
66 or older 7

SOFT QUOTA:
ENSURE A GOOD SPLIT BETWEEN AGE RANGES.

S3. How would you describe your role in the decision making process for investments in consumer electronics and communication technologies (e.g., computer, telephone system, TV, and security systems, etc.)?

I am the primary decision maker....... 1
It's usually a joint family/ household decision and I am involved....... 2
Some other person in my family/ household usually decides .... 3 ➔ DISCONTINUE
Don't know .... 99 ➔ DISCONTINUE

S4. Which of the following communication and connectivity services does your household subscribe to at your home? Select all that apply.

Landline telephone....... 1
Mobile phone with Internet access 2
Mobile phone without Internet access 3
Subscription television (e.g., cable, satellite, or web-based TV) 4
Fixed-line Internet access 5
Other (Specify:___________)....... 6
None .... 7 ➔ DISCONTINUE

DISCONTINUE IF NOT AT LEAST ONE OUT OF [2] OR [5] IS SELECTED

S5. And are you ... (SINGLE RESPONSE)

Male 1
Female 2

SOFT QUOTA: **ENSURE A GOOD SPLIT BETWEEN GENDERS. 50/50 PREFERRED. DO NOT ALLOW SAMPLE TO EXCEED 55/45.**

S6. What type of area do you live in? (SINGLE RESPONSE)

Urban Area (city, town, etc.)...1
Suburbs (area surrounding a city or town)..............2
Rural (live in the country) 3

SOFT QUOTA: **ENSURE A GOOD SPLIT BETWEEN TYPES OF AREAS, NO FIXED QUOTA BUT MONITOR RESULTS. PREFER 40% URBAN, 40% SUBURBS, AND 20% RURAL EACH.**

S7.a Do you (or your family) own or rent your home (SINGLE RESPONSE)

Own 1
Rent 2
other (e.g., live with relatives, etc.) ....6 DISCONTINUE

S8. What type of home do you have? (SINGLE RESPONSE)

Apartment..1
Condominium 2
Single family home /detached home* 3
Duplex / multiplex /semi-detached home...............4
Townhouse..5
Other (Specify :___________).....................................6
*Canadian terminology

SOFT QUOTA: **ENSURE A MINIMUM OF 50% DETACHED HOUSES** **ENSURE A MINIMUM OF 30% HOME TYPES OTHER THAN DETACHED HOMES**

SECTION TWO: HOME ENERGY SOLUTION ADOPTION – CURRENT

You have qualified to participate in this survey on technologies for the home.

There are many products today that help home owners and occupants better manage their home's utility costs (such as electricity or gas usage). These products include smart devices; smart thermostats and home energy displays provided by utility companies that help you monitor your energy usage or help you avoid high cost peak periods. Some of these smart devices allow you to control your products remotely through a mobile app.

This survey seeks to understand the extent that you have adopted (or not adopted) any of these types of technologies, what is motivating or preventing your adoption of those, and your overall experience and opinion related to these technologies. This survey will take approximately 20 to 25 minutes to complete.

POINT OF VIEW ON WHAT CONSTITUTES A CONNECTED HOME

Q1. Some people would consider a connected home to be characterized by: SELECT AS MANY

Devices that can be programmed................................1
WiFi connected appliances..2
Smartphone/tablet controlled systems for HVAC,
Lighting, etc. 3
Centralized hubs like Wink, Amazon Echo, etc. 4
Self-learning/self-adjusting systems........................5
Systems enhancing home comfort.............................6
WiFi connected security..7
WiFi connected entertainment systems..................8
Products that reduce electricity bills 9
What other 2-3 must-have features and technologies come to your mind thinking about the connected home? ______________________________________.

LEVEL OF CONCERN ABOUT ENERGY COSTS

Q2.a) How concerned are you about your home's energy costs? SELECT ONE

Extremely concerned 5
Very concerned..4
Moderately concerned..3
Slightly concerned 2
Not concerned at all..1

ADOPTION TRENDS

Q3. Do you use or intend to adopt any smart home/connected home technologies (Yes/No)

Q4. What drives your interest in Smart Home/Connected Home solutions? SELECT ALL APPLICABLE

Comfort................................. 1
Entertainment 2
Convenience......................... 3
Peace of mind...................... 4
Utility / energy/ cost savings...... 5
I like tech products................ 6
Security.................................. 7
Other (Please Specify)................ 9

Q5. a) Which of the following connected products have you adopted? (Connected products refer to prod-ucts connected through the internet/WiFi and/or that can be controlled remotely with smartphones/tablets/other mechanisms)?
b) Which do you plan to adopt in the next 12 months?

	Connected Products – all control-lable remotely (Includes smart home solutions, connected products/ solutions, energy saving products/ solutions,	Already Adopted/ Using	Likely to Adopt in the Next 12 Months	No Plan to Adopt in the Next 12 Months
	Connected white goods / major appliances (dishwasher, refrigera-tors, stoves, etc.)			
	Connected small appliances			
	Connected security systems			
	Connected smoke alarms			
	Connected thermostats			
	Connected fans			
	Connected lighting			
	Connected water heaters			
	Connected air conditioners			
	Connected air purifiers			
	Electric vehicles			
	Connected pool pumps			
	Smart Plugs			
	Connected sprinklers			
	Connected home entertainment (TV/Speakers, etc.)			
	Other (please specify)			

OBSERVED ENERGY COST TREND

Q7. Compared to the previous year, how did your home energy costs in the past 12 months compare? SELECT ONE

Our home energy costs these past 12 months is....

Significantly higher than the previous year 5
Somewhat higher than the previous year................4
About the same 3
Somewhat lower than the previous year..................2
Significantly lower than the previous year................1

Q8. If you invest in a product solely for energy saving reasons, how many years do you expect savings to payback your initial investment?

I expect savings to payback my initial investment after....

Less than 1 year..5
1 to 2 years..4
2 to 3 years..3
3 to 5 years..2
More than 5 years 1

BELIEF IN ABILITY TO MANAGE HOME ENERGY COSTS

Additional Frost & Sullivan Note: This also important to the back-end statistical analysis. We can check if those who perceive an inability to control costs will be less willing to adopted connected technologies.

Q9. To what extent do you believe that energy costs is something that you, as a home owner or resident, can manage, reduce, and minimize? SELECT ONE

It is fully within our control...5
Most of it is within our control.......................................4
About half of it is within our control 3
Most of it is outside our control....................................2
It is not at all within our control 1
Don't know 0

CURRENT ENERGY SAVING SOLUTIONS: STEPS TAKEN TO MANAGE OR REDUCE HOME ENERGY COSTS

Q10. Which of the following actions, if any, have you taken to enable you to manage or reduce home ener-gy costs? SELECT AS MANY

Switch to LED light bulbs...1
Program the switching on/off of lights 2
Ask Q11.a)
Use motion detectors inside the home to automatically switch some lights on/off (exclude those used outside the house for security purposes) 3
Use Energy Star certified appliances...4
Participate in a utility demand-response/ energy saving program/other utility energy program .... 5 Ask Q11.b)

Use a programmable thermostat (non-communicating) to set the desired temperature or to turn on/off at specific hours of the day 6Ask Q11.c)
Use a smart thermostat (can include features like the automatic adjustment of temperature settings as per high energy cost hours or when it detects that there are no occupants, scheduling of temperature setting made possible as per usage, remotely operated features)........ 7 Ask Q11.c)
Use a system that controls multiple device types (e.g., HVAC and lighting) as a step to manage or reduce energy cost ....9 Ask Q11.c)
Use smart power strips (prevents computers, printers, TVs, etc. from drawing 'phantom power' even when they are not in use, by automatically shutting down specific outlets when the equipment goes on standby mode) 10
Use smart plugs or energy monitors (devices that plug into outlets to monitor the energy consumption of appliances that are plugged into them)........ 11
Regularly consult whole home energy usage 12
Shut down the water heater when not needed 13
Electric vehicle charge scheduling 14
Increasing insulation in the home........15
Undertaking home energy audits........16
Using high efficiency HVAC systems 17
Other (please specify) 88
NONE OF THE ABOVE........99

CLARIFICATION OF TECHNOLOGIES
IF Q10.2 (Program the switching on/off of lights = SELECTED)

Q11.a) What device do you use to program the switching on/off of lights?

Smartphone app exclusively for switching lights........1
Smartphone app that is part of a home energy or smart home management system.......2
Electronic timer device wired to the outlet 3
Mechanical timer device wired to the outlet........4
Other (SPECIFY)........9

UTILITY ENERGY PROGRAM DETAILS
IF Q10.5 (Participate in an energy saving program = SELECTED)

Q11.b.1) What utility program did you participate in?

[ ] Demand response programs such as to utility having power to control power supply for some devices with an incentive
[ ] Utility promoted rebates and incentives linked to Home energy Audits
[ ] Energy efficiency upgrades of appliances or equipment incentivized by your utility
[ ] Utility time of use program
[ ] Receive home energy reports from my utility'
[ ] Other (Specify)

IF DEMAND-RESPONSE=YES

Q11.b.3 Which of the following is characteristic of your energy saving or demand response program?

[ ] I selected the control device for this program
[ ] The utility selected the control device for this program
.... [ ] Other (Specify)

CONTROL DEVICE DETAILS

IF Q10 – IF AT ANY OF ITEMS 6,7,8,9 = SELECTED (Thermostat programming, smart thermostat, home energy management system, smart home management system)

Q11.c.1 What device do you use to program or control your thermostat? SELECT AS MANY

Q11.c.2 Which device do you most prefer to use to control the thermostat? SELECT ONE

Touchscreen/push button based/other temperature display (usually wall-mounted)..................1
Smartphone app that controls only the thermostat.. 2
Smartphone app that is part of a home energy management system or smart home management system which can control other appliances like smoke detectors, lights, fans, etc., if fully set-up.. 3
Control console that is part of a home energy or smart home management system which can control other appliances like smoke detectors, lights, fans, etc., if fully set-up..............................4
Voice control that is part of a home energy or smart home management system which can control other appliances like smoke detectors, lights, fans, etc., if fully set-up............................. 5
Other (SPECIFY).. 9

BRANDS OF DEVICES AND SYSTEMS IN USE

Q12. What of the following brands of home energy solutions (includes home energy management devices, systems and smart home management system) do you use? SELECT AS MANY

RANDOMIZE LIST

NEST (Google) 1
OhmConnect.. 2
EcoFactor... 3
iControl 4
Opower... 5
Tendril 6
Vivint..7
ADT Pulse (thermostat, lighting, appliance control or NEST interface)... 8
Alarm.com energy management solutions... 9
Google Home..10
Siri/Homekit 11
Alexa 12
Samsung Smarthings..13
Stringify..14
Honeywell...15
Sinope..16
Stelpro 17
Caleo..18
Wink...19

Vera 20
TED Pro Home energy monitoring system 21
Digi XBee Smart Meter 22
Power Cost system (Blue Line Innovations) 23
Elgato Eve energy monitoring system 24
Other (SPECIFY) [Note: unbranded or white labeled items can be described here] 80
NONE of the above 90
Don't Know 99

SATISFACTION WITH CAPABILITIES OF TECHNOLOGIES

Q13. How satisfied are you with your current home energy solutions' ability to provide the following?

RANDOMIZE. ENSURE SAME LIST OF ITEMS USED IN THE MAXDIFF EXERCISE

		Fully Satisfied	Partly Satisfied	Not Satisfied	Not Available	Don't Know
1	Display the cost of energy at a particular moment (real time)	☐	☐	☐	☐	☐
2	Peak hours or high bill warnings	☐	☐	☐	☐	☐
3	Automatic adjustment of heating or cooling, during peak hours or high cost hours, to consume less or no energy	☐	☐	☐	☐	☐
4	Automatic adjustment of heating or cooling, when it senses that there are no occupants, to consume less or no energy.	☐	☐	☐	☐	☐
5	Ability to adjust thermostat remotely using your smartphone.	☐	☐	☐	☐	☐
6	Ability to switch on / switch off lights remotely using your smartphone	☐	☐	☐	☐	☐
7	Ability to monitor the energy consumption of whatever is plugged in specific outlets in the house	☐	☐	☐	☐	☐
8	Ability to monitor, in real time, the total energy being consumed in the household	☐	☐	☐	☐	☐
9	Ability to manage the energy consumption of home appliances remotely using your smartphone	☐	☐	☐	☐	☐

10	A report or some feedback about the estimated $ cost savings that you have realized for a given period	☐	☐	☐	☐	☐
11	A report or some feedback about the overall consumption pattern of energy	☐	☐	☐	☐	☐
12	Ability to manage appliances, lights and other devices, from a single device, display, or smartphone.	☐	☐	☐	☐	☐
13	Ability to manage energy-consuming home appliances, lights, security devices, home entertainment devices (music/video/etc) from a single device, display, smartphone or thermostat	☐	☐	☐	☐	☐
14	Ability to realize $ savings from the use of the various energy saving solutions we've adopted	☐	☐	☐	☐	☐
15	Ease of installing / setting up the solution	☐	☐	☐	☐	☐
16	A smart system that advices me on the best ways to save energy in my home	☐	☐	☐	☐	☐
17	A smart system that understands my energy bill, and can break it down into the key high energy using appliances/ devices.	☐	☐	☐	☐	☐

PERCEIVED IMPACT OF VARIOUS SOLUTIONS ON ENERGY SAVINGS

Q14. In your opinion, what would be the possible impact of the following measures in reducing your home's energy consumption (assuming you fully adopt the measure, if you haven't done so)? If you have fully adopted the measure, please indicate the impact that you believe it has had on your energy consumption?

	Very High Impact	High Impact	Moderate Impact	Low Impact	No Impact at All	Don't Know
	Change all household lights to LED	☐	☐	☐	☐	☐
	Program the switching on/off of lights	☐	☐	☐	☐	☐
	Etc. USE SAME ITEMS IN Q10	☐	☐	☐	☐	☐

SECTION THREE: HOME ENERGY SOLUTION ADOPTION – FUTURE

FUTURE PLANS – TECHNOLOGIES

DISPLAY ONLY ITEMS NOT SELECTED IN Q10. Current Home Energy Solutions

Q15. Which of the following actions do you plan to take in the next 12 to 18 months to reduce home energy costs? SEE Q10 ITEMS

RELATIVE IMPORTANCE OF VARIOUS FEATURES AND BENEFITS

ANCHORED MAXDIFF

You will be presented with sets of features or benefits that you may or may not consider motivating when adopting home energy solutions. There will be four features or benefits in each set. For each set, you will be asked which of those four will be most motivating to you. Some features or benefits may appear in more than one set, but will be in combination with other features or benefits.

16. Which of the following features or benefits will most motivate you to adopt home energy solutions? And which will least motivate you?

MOST MOTIVATING		LEAST MOTIVATING
1	Feature/ Benefit 1	1
2	Feature/ Benefit 2	2
3	Feature/ Benefit 3	3
4	Feature/ Benefit 4	4

NOTE: THIS QUESTION IS REPEATED MULTIPLE TIMES TO COVER THE COMBINATIONS OF FEATURES OR BENEFITS.

	FEATURES OR BENEFITS TO EVALUATE
1	Display the cost of energy at a particular moment (real time)
2	Peak hours or high bill warnings
	Etc. USE SAME ITEMS IN Q13

CONCEPT TEST USING THE 10 HIGHEST RATED FEATURES/ BENEFITS IN MAXDIFF

You will now be presented with a description of a home energy solution that may or may not be currently available. You will then be asked a few questions related to that solution.

Imagine that you were offered a home energy solution that had the following features or benefits:

LIST TOP 10 FROM THE MAXDIFF RESPONSES

- Feature / Benefit 1
- Feature / Benefit 2
- Feature / Benefit 3
- Feature / Benefit 4
- Feature / Benefit 5
- Feature / Benefit 6
- Feature / Benefit 7
- Feature / Benefit 8
- Feature / Benefit 9
- Feature / Benefit 10

Q17. How likely are you to consider using such a solution in your home?

Very likely 5
Somewhat likely 4
Neither likely nor unlikely 3
Somewhat unlikely 2
Very unlikely 1

IF PREVIOUS QUESTION < 4 (Unlikely or Neither)

Q18. What is the reason why you are {TEXT OF RESPONSE IN Q17} to use such a solution?

Already have a better solution than what was described 1
Already have a solution that is similar to what was described 2
Already have a solution with many of those features and benefits 3
Not interested in most of those features and benefits 4
Not interested in any of those features and benefits 5
Other reasons (SPECIFY) 6

FUTURE BRANDS OF DEVICES AND MANAGEMENT SYSTEM TO USE

Q19. a) If you were to adopt new home energy solutions (includes home energy management devices, systems and smart home management system) in the next 12 to 24 months, which of the following brands will you consider? SELECT AS MANY
b) Which of these brands would you most prefer? SELECT ONE

USE SAME BRAND LIST IN Q12

CONCERNS

Q21. Imagine that you have decided to seriously consider adopting the latest connected home energy management solution. A system connected to the internet/other devices/other systems which can be remotely controlled. Example: smart lighting, connected energy efficient water heating, connected energy efficient and self-regulating HVAC, etc.

To what extent would the following be a concern to you?

			VERY HIGH CONCERN	HIGH CONCERN	MODERATE CONCERN	SLIGHT CONCERN	NOT A CONCERN AT ALL
1	☐	Personal loss of control	5	4	3	2	1
2	☐	More likely to fail than manual systems	5	4	3	2	1
3	☐	High initial setup costs	5	4	3	2	1
4	☐	High management / maintenance costs	5	4	3	2	1
5	☐	Too complicated to install	5	4	3	2	1
6	☐	Too complicated to use or control	5	4	3	2	1
7	☐	It's not a proven technology yet	5	4	3	2	1
8	☐	Effect of power failure on the system	5	4	3	2	1
9	☐	Over-dependence on the system	5	4	3	2	1
10	☐	Effect of system failure on the ability to manage the home	5	4	3	2	1
11	☐	Technical barriers, I don't think my appliances,HVAC, lights, etc. are ready to connect	5	4	3	2	1
12	☐	Automated settings may be result in discomfort (e.g., too hot, too humid, or too cold for occupants)	5	4	3	2	1
13	☐	System might be hacked	5	4	3	2	1
14	☐	I will need to adjust my lifestyle / habits at home	5	4	3	2	1
15	☐	Using the system will be time-consuming	5	4	3	2	1
16	☐	I don't really need most of the features	5	4	3	2	1
17	☐	The costs outweigh the benefits	5	4	3	2	1
18	☐	Convincing my partner/ spouse that it's a good use of money/ time/ etc.	5	4	3	2	1
19	☐	Redundant with other solutions that we are already using	5	4	3	2	1
20	☐	Energy savings may not be significant	5	4	3	2	1
21	☐	Unwanted intrusion of my privacy	5	4	3	2	1

MOTIVATION FOR ADOPTION

Q22. To what extent do the following potential benefits of a connected home energy management solution motivate you to adopt the technology?

			EXTREMELY MOTIVATING				NOT MOTIVATING AT ALL
1	☐	Reduction of energy consumption	5	4	3	2	1
2	☐	Use of greener technologies	5	4	3	2	1
3	☐	Greater convenience for household members	5	4	3	2	1
4	☐	Cost savings / greater efficiency	5	4	3	2	1
5	☐	Friendlier (safer/ more convenient) environment for the elderly	5	4	3	2	1
6	☐	Friendlier (safer/ more convenient) environment for young children	5	4	3	2	1
7	☐	Simplification of day to day living	5	4	3	2	1
8	☐	Reduction in administrative tasks (e.g., reading meter, setting thermostat, etc.)	5	4	3	2	1
9	☐	Simplification of day to day living	5	4	3	2	1
10	☐	Raising the resale value of my house	5	4	3	2	1
11	☐	Ability to monitor activities at home while away	5	4	3	2	1
12	☐	Better protection from emergencies such as fire and floods, etc.	5	4	3	2	1
13	☐	Having the most advanced technologies	5	4	3	2	1
14	☐	Brings fun	5	4	3	2	1
15	☐	Improvement in the quality of life	5	4	3	2	1
16	☐	Affordable and scalable (you can start with a small system that you can expand and upgrade as your needs or desired level of sophistication increases	5	4	3	2	1
17	☐	Increased security of home	5	4	3	2	1
18	☐	Improved safety for household members	5	4	3	2	1
19	☐	Mark on the product certifying that it has been tested to reducethe possibility of intrusion of your privacy	5	4	3	2	1
20	☐	Ability to take part in an energy management/ savings program.	5	4	3	2	1
21	☐	Improved ability to control my energy use	5	4	3	2	1

TROUBLESHOOTING MECHANISMS

Q23. a) In case of connected product/system malfunction who do you approach as a first point of contact?

Installing contractor 1
Manufacturer 2
Service/repair contractor 3
Retailer 4
Utility 5
Other (Specify) 9

Installing: contractor who originally installed the system v/s service/repair: a contractor called for repairs who did not originally install the system

b) What are the typical types of connected product/system malfunctions you encounter?

Mechanical failure............ 1
Software issues............ 2
Malware............ 3
Connectivity issues............ 4
Home internet service issues............ 5
Other (Specify) 9

c) Which connected products/systems malfunction most frequently as per your experience? DISPLAY ONLY TECHNOLOGIES ALREADY ADOPTED

d) When you are installing these connected technologies, are you leveraging any of the following to make installation/operation/intercommunication of devices, in the home, easier?

Web services (e.g., YouTube installation videos)...... 1
If This Then That (IFTTT) protocol 2
Compatibility with other devices............ 3
Stringify............ 4
Other (Specify) 5
Not applicable. I don't install it myself 9

PROVIDERS

Q24. a) Which of the following will you consider as a possible provider of connected home energy manage-ment solutions? SELECT AS MANY

b) Which of these would you most prefer? SELECT ONE

RANDOMIZE ITEMS 1 TO 9	a) WILL CONSIDER	b) MOST PREFER
Home security service provider (ADT, Alarm.com, etc.)	1	1
Utility company (e.g., electricity, gas, water, etc.)	2	2
Telephone / Mobile phone service provider	3	3
Internet service provider	4	4
Cable TV service provider	5	5
Electronic store / online	6	6
Specialist company offering connected home energy solutions	7	7
Device vendor (e.g., Apple, Samsung, Sony, etc.)	8	8
Appliance company (e.g., GE, LG, Samsung, etc.)	9	9
Hot water tank / heater provider / leasing company	10	10
HVAC (furnace/ air-conditioning) maintenance company	11	11
Other (specify)	12	12

	Approach	Willingness to Consider or Prefer				Reasons
1	A utility provides energy manage-ment services	Would Prefer This	Would Consider This	Would Definitely Not Con-sider This	Don't Know	
2	A non-utility provides energy man-agement services	Same scale above				
3	A utility provides other services that come along with smart home (secu-rity/ safety, etc.)	Same scale above				
4	A third party service provider pro-vides utility services and connected services together.	Same scale above				
5	Services are contracted indepen-dently through separate providers.	Same scale above				
6	Utility offers to finance your pur-chase of smart home products through your utility bill (through some form of on-bill payment)	Same scale above				

PREFERRED CONTROL DEVICE

Q25.1 Apart from manual control, which of the following devices would you most likely use when con-trolling your connected home energy management solution (once it is fully installed)? SELECT AS MANY

Q25.2 Which of these devices would you most prefer to use? SELECT ONE

Smartphone 1
Tablet...2
Laptop/ Notebook/ PC 3
Different control devices for different purposes...4
Centralized control console for all functions..5
Wearable device (e.g., Smart watch)...........................6
Voice control/smart speaker 7
Don't know 99

RESPONSE TO PROPOSED DELIVERY MODELS FROM UTILITIES

Q26. a) Please provide your opinion of the following possible approaches:

b) If coordinated by the utility is preferred [WOULD CONSIDER OR PREFER Q26a.3,a.1]; please provide your opinion on such a scheme being a part of the utility energy bill (For/ Against/Don't know)

- Would Prefer This
- Would Consider This
- Would Definitely Not Consider This
- Don't Know

c) In case of malfunction of the above system, whom would you prefer as your point of contact?

- Manufacturer
- Utility
- Installing contractor
- Other (Specify)

Q27. Please provide your opinion of the following: Would you be willing to opt for a program where the utility is permitted to temporarily interact/control a home energy consuming system in the house as part of a demand response program? What incentive/rebate would you expect from the utility in turn? [YES / NO]

Q28. a) For what connected products would you be willing to offer this control to utilities?

b) What time of the day would you prefer to offer control to utilities for the following?

c) Please provide your expectations for rebates by technology:

	Systems/ Products	[1] Willing [0] Not willing	Rebates expected per year ($0-100, $100-200, $200-300, $300-400, $400-500, $500+)
	De-humidifier		
	Lighting		
	Heating in winter		
	Cooling in summer		
	Dishwasher		
	Hot water tank heating		
	Electric vehicle charging		
	Washing machine		
	Tumble dryer		
	Other (Please specify)		

PROFILE QUESTIONS

And finally we would just like to ask some questions for classification purposes.

C1. Which of the following currently apply to your status? Select as all applicable (MULTIPLE RESPONSE, UNLESS C1=6 WHERE NO OTHER ITEM SHOULD BE SELECTED)

Married 1
Separated....................2
Divorced 3
Re-Married....................4
Widow....................5
None of the above....................6

C2. How many people live in your household, including yourself? (SELECT ONE)

One....................1
Two 2
Three 3
Four....................4
Five....................5
Six 6
Seven 7
Eight 8
More than 8 people....................9

C3. What is your gross household income in [IF U.S.] U.S$ [IF CANADA] C$ per year, including pensions and other benefits, before tax and other deductions? (SINGLE RESPONSE) LOCAL CURRENCY HERE US$ / C$ BY COUNTRY

Less than $20,000....................1
$20,001 to $40,000....................2
$40,001 to $60,000....................3
$60,001 to $80,000....................4
$80,001 to $100,000....................5
$100,001 to $150,000 6
More than $150,000.................... 7
Prefer not to answer....................8

C4. Which of the following best describes your level of education or training? (SINGLE RESPONSE)

Less than high school 1
High school graduate (or equivalency)....................2
Trade or technical training 3
Some college/university 4
Bachelor's degree....................5
Advanced degree (Master's, Doctorate,
Law, etc.)....................6
Prefer not to answer.................... 7

C5. What is your current occupation? (Please select the best choice) (SINGLE RESPONSE)

Employed full-time 1
Employed part-time 2
Unemployed 3
Homemaker 4
Student 5
Retired 6
Other (SPECIFY:)____________ 7
Prefer not to answer 8

C7. Do you have a tariff based on time of use (rate changes depending on time of day or day of week)?

[YES/ NO]

GO TO COMPLETION SCREEN

Connected Home IoT Energy Roadmap

LANDMARK RESEARCH REPORT

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