CABA™

Connected Home IoT Energy Roadmap

LANDMARK RESEARCH REPORT

EXECUTIVE SUMMARY

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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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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.

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

Figure ES 2 Respondent Profile

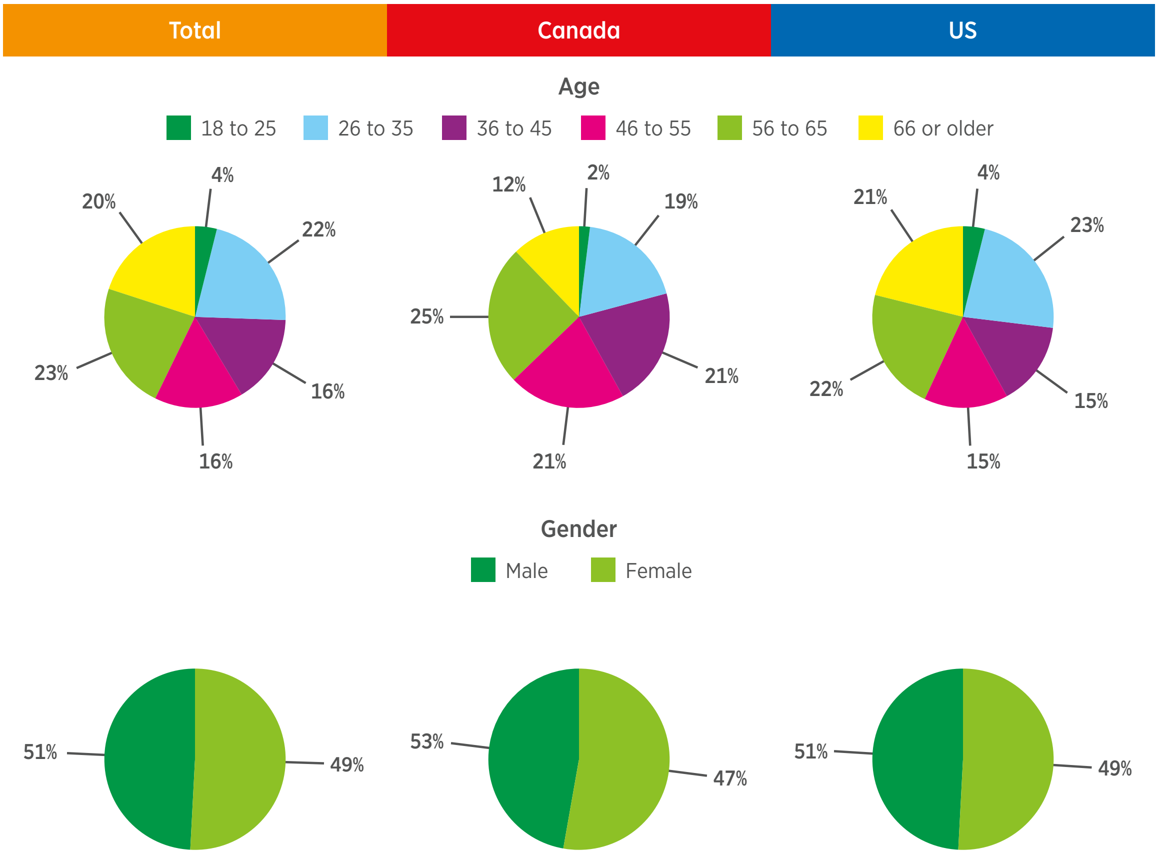
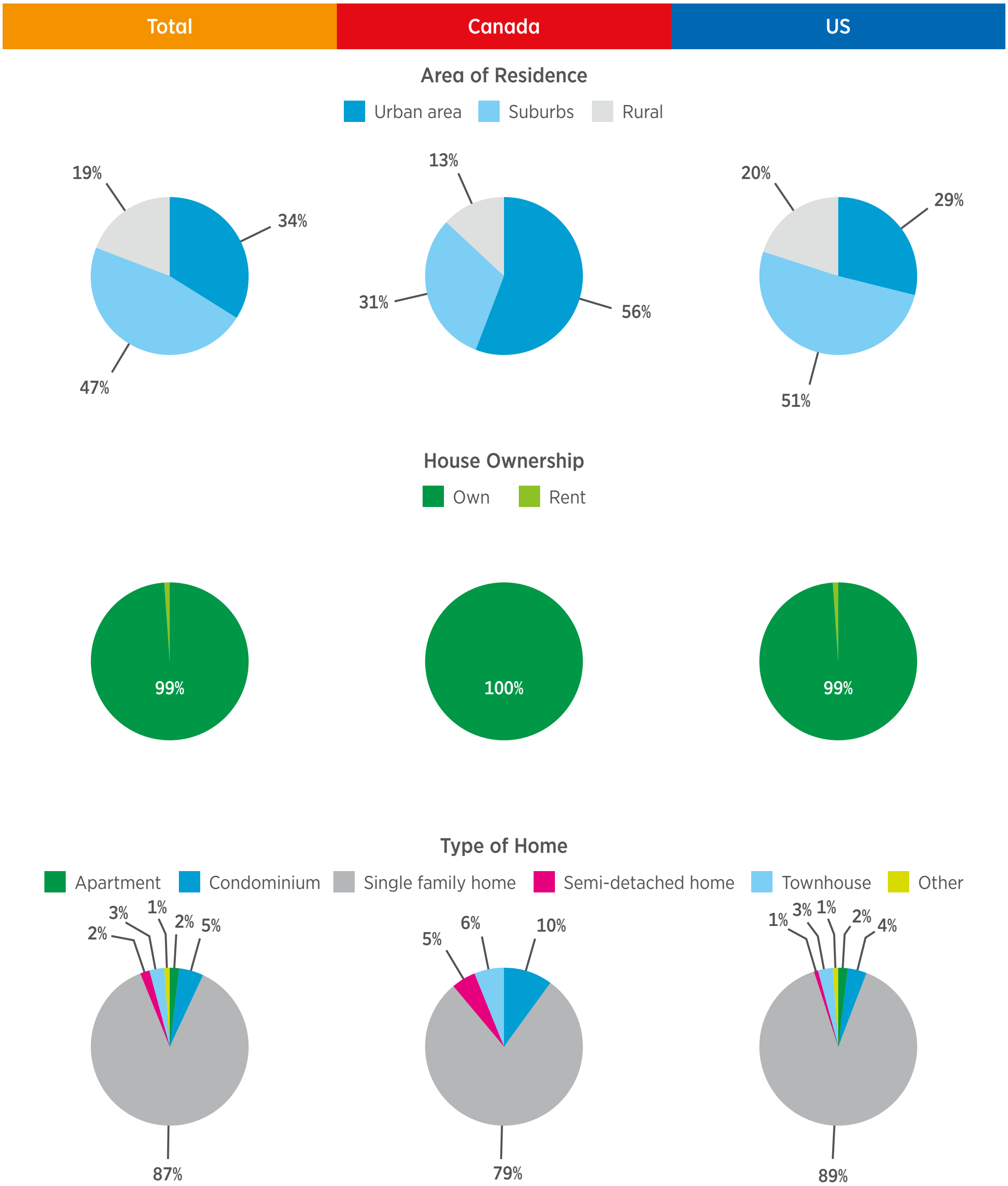


Figure ES 3 Area of Residence and Type of Home of the Sample



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

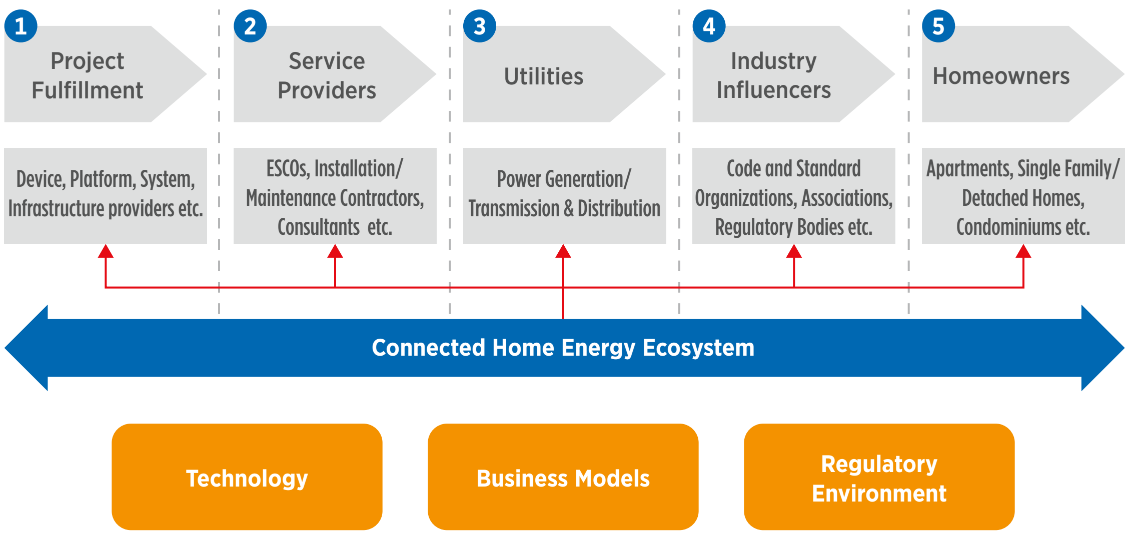
Energy management is one of the key functions performed by integrated connected homes. As the market continues to evolve, the requirement for energy management will continue to grow because the consumption of energy is a key aspect of connected home technologies and plays a key role in overall home costs. 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.

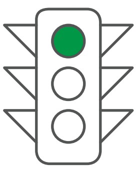
Table ES 3 Adoption by Application Category

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

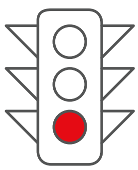
Some key drivers and challenges for the connected home energy market have been highlighted below in Figure ES 5.

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.

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

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

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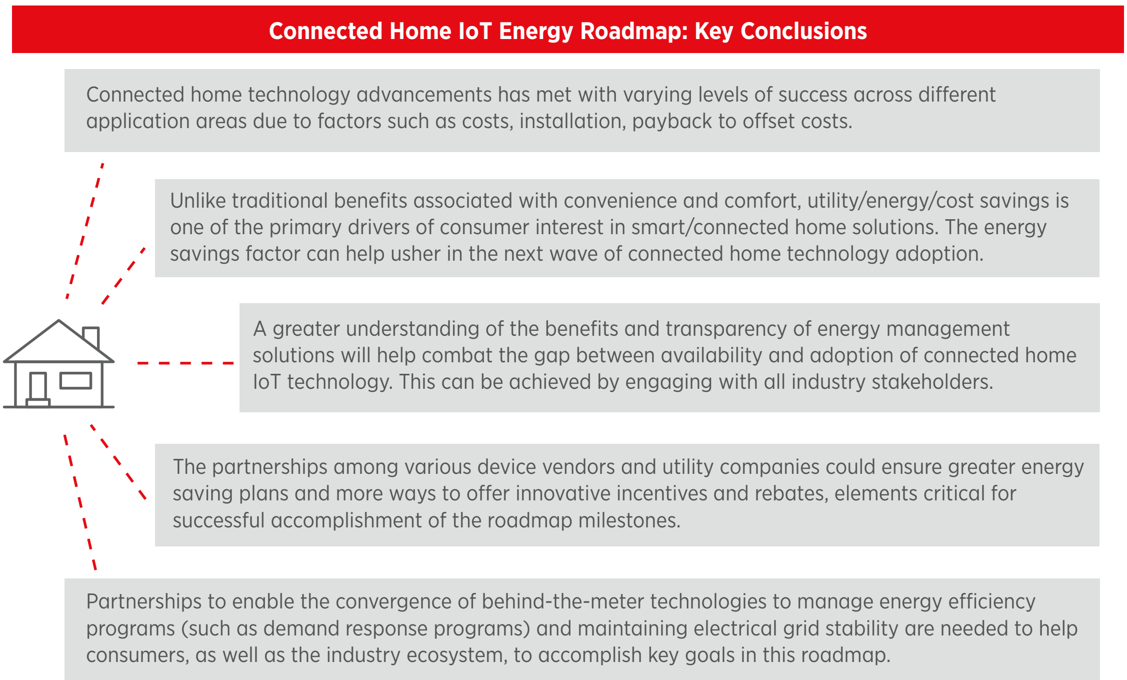
Considering the high impact that EV power demand is expected to have on the overall grid, analyzing initiatives taken in this regard is necessary to determine specific requirements for achieving the milestone of successful EV integration with the overall grid. The following case study provides valuable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

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)

EXECUTIVE SUMMARY

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.

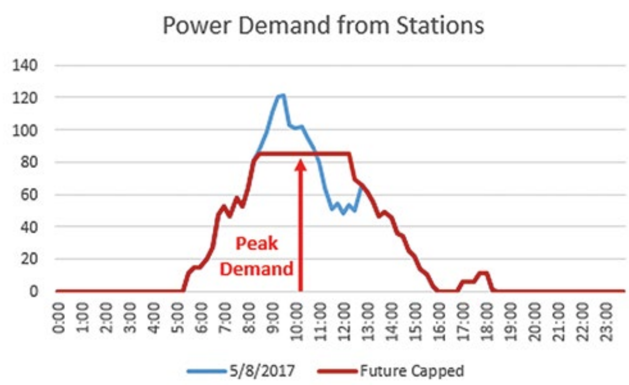
In general, vehicles would stop charging when wholesale prices are high, and resume when prices have lowered. If prices go very low, such as during excess production of renewables, vehicles could start charging in order to absorb the excess, low cost, low carbon electricity. Ancillary service dispatches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

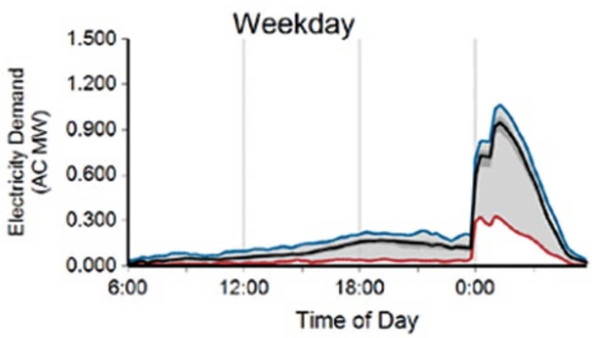
The ability of EVs to adjust charging schedules can be used to synchronize charging with excess renewable energy production. In March and April of 2017, the California ISO curtailed 160,000 MWh – an amount that could power approximately 560 million miles of driving. The energy curtailed was primarily 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.

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.



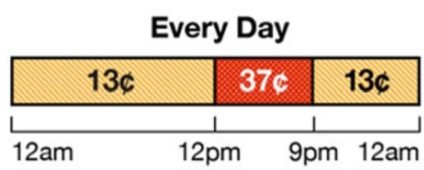
Source: Idaho National Labs Report

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.

EXECUTIVE SUMMARY

CABA™

Connected Home IoT Energy Roadmap

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