CABA™

Connected Multi-Dwelling Units and the Internet of Things

LANDMARK RESEARCH PROJECT

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Connected Multi-Dwelling Units and Internet of Things

This report was prepared for CABA by Harbor Research

Harbor Research

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ES.1 RESEARCH BACKGROUND & INTRODUCTION

This executive summary presents key findings from the Continental Automated Buildings Association's (CABA) "Connected Multi-Dwelling Units and the Internet of Things" Landmark Study conducted by Harbor Research. The report summarized in this executive summary is based on a survey and interviews of 1,500 stakeholders, including developers, owners, operators and property managers, residents, technology providers, original equipment manufacturers, and service providers associated with multi-dwelling units across Canada and the United States.

Harbor Research and CABA would like to acknowledge and sincerely thank the following organizations for funding, guiding and participating in this research:

Figure ES.1 Landmark Study Funders

Role of the Steering Committee

This report the was prepared by Harbor Research for CABA's Connected Home Council (CHC). The two councils within CABA, the Connected Home Council (CHC) and the Intelligent Buildings Council (IBC) focus on expanding connected technology in residential and larger commercial buildings, respectively. Each council produces one collaborative "Landmark Research" project per year which is fully funded by CABA members.

Each Landmark Research project is directed by a Steering Committee made up of the project funders. The Steering Committee provides feedback and input throughout the course of the research to help define the scope, direction, and methodology. CABA and the project's Steering Committee commission a research firm to conduct the research while CABA provides project management and leadership.

Figure ES.2 Connected Multi-Dwelling Units and the Internet of Things Steering Committee Members

The connected home market is a fast-evolving industry segment that is being influenced by a number of emerging industry trends and pressing "hot button" issues. The CHC participated in several research ideation sessions to generate themes and select this CHC Landmark Research project topic. Of the many excellent ideas generated, the top three topics were voted on by CABA members and "Connected Multi-Dwelling Units and the Internet of Things" was selected. Having selected the topic, CABA released a Request for Proposal (RFP) and, after narrowing applicants down to two finalists, commissioned Harbor Research to conduct the research.

About CABA

The Continental Automated Buildings Association (CABA) is an international not-for-profit industry association, founded in 1988, composed of over 360+ major private and public technology organizations dedicated to the advancement of connected home and building technologies. These organizations include private firms involved in the design, manufacture, installation and retailing of products, as well as public utilities and governments responsible for regulations and incentives that affect home and building automation. CABA is a leader in developing collaborative research across buildings stakeholder types and encourages the development of standards that accelerate market development.
Please visit http://www.caba.org for more information.

About Harbor Research

Founded in 1984, Harbor Research Inc. has more than 25 years of experience in providing strategic consulting and research services that enable our clients to understand and capitalize on emergent and disruptive opportunities driven by information and communications technology. The firm has established a unique competence in developing business models and strategy for Smart Systems and the Internet of Things.

Harbor Research works with leading technology innovators and developers, product manufacturers and service providers. The firm brings together a unique combination of domain knowledge, facilitation processes and an extended community of partners and expertise that enables our clients to discover, design and develop smart systems and services.
Please visit http://harborresearch.com for more information.

Research Goals

The goal of this research is to examine in depth the impact of "Internet of Things" (IoT) technologies and the services that they will enable in the multi-dwelling unit (MDU) buildings market segment. This report will provide actionable insights and data as well as develop business cases that will identify barriers to adoption, and will identify new revenue opportunities for organizations in the MDU value chain, as well as potential entrants. This research examined the opportunities provided by IoT for MDU

stakeholders, including: building occupants, owner/operators and property managers, builders and developers, integrators and installers, technology manufacturers, equipment manufacturers, and service providers, including insurance companies, net service providers and utility companies.

To meet these goals, a detailed analysis concerning the future state of the MDU marketplace was conducted, encompassing the identification and evaluation of key trends, buying behaviors, technology challenges and opportunities. Case studies of IoT technologies and applications that highlight current adoption patterns in the MDU marketplace have been identified and the innovative players driving successful solutions highlighted. Top applications for IoT technologies in MDUs have been examined in business cases, examining the technical makeup of solutions and value proposition to various market participants. Within each business case, go-to-market/channel requirements were developed to highlight the role of different stakeholder types in these solutions and recommendations were made for how firms should organize to capture new value from smart, connected offerings.

Research Methods

The methodology for defining, identifying, and analyzing IoT technical and business opportunities followed the procedure below:

Review Existing MDU and IoT Research: Review and analyze existing CABA and Harbor industry research on connected home, IoT technologies, building management systems and the MDU market.

Conduct Secondary Market Research: Conduct supplementary secondary research to identify additional relevant trends, market forces, new building systems technologies and players.

Conduct Interviews with Thought Leaders: Identify and organize a list of key stakeholders and conduct interviews with industry thought leaders and steering committee members.

Develop A Framework to Identify Opportunities: Develop a market application map that identifies key requirements, business opportunities and enabling technologies/key technical requirements.

Identify Pain Points, Opportunities and Current Solutions: Develop an initial set of customer use cases, pain points and barriers to adoption to be validated or disproved by survey participants.

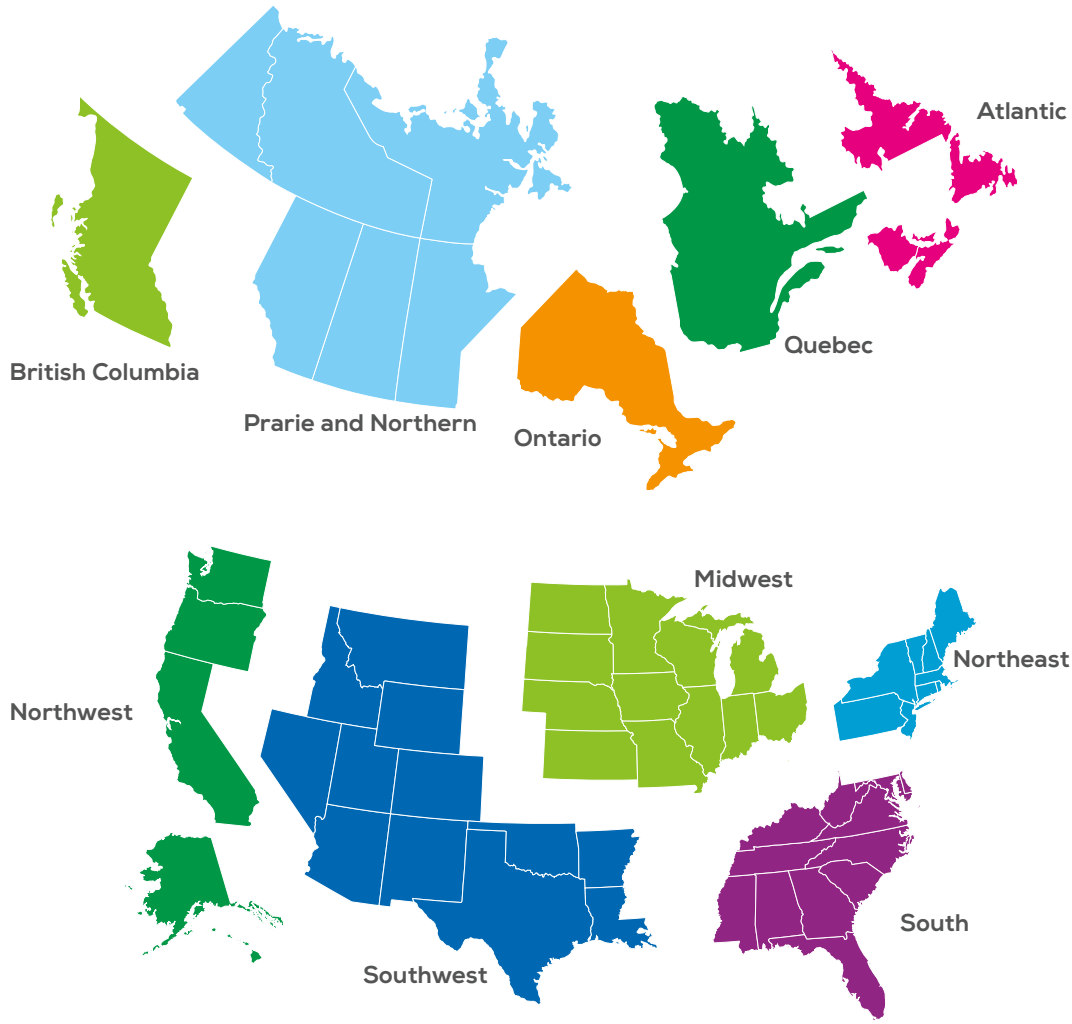
Having identified and framed the opportunities via the above detailed process, parallel quantitative and qualitative primary analysis was conducted alongside supplementary market research and analysis. A market survey was developed and administered across 1,500 respondents representing all identified stakeholder segments from the United States and Canada. For the purposes of this research, the United States was segmented into five regions:

- "Northeast", including CT, ME, MA, NH, RI, VT, NJ, NY, and PA;
- "Midwest", including IL, IN, MI, OH, WI, IA, KS, MN, MO, NE, ND, and SD;
- "South", including DE, DC, FL, GA, MD, NC, SC, VA, WV, AL, KY, MS, and TE;
- "Southwest", including AR, LS, OK, TX, AZ, CO, ID, MT, NV, NM, UT, and WY; and
- "Northwest", including CA, OR, WA, AK and HI.

Canada has been similarly divided into five regions:

- British Columbia;
- "Prairie and Northern", including MB, SK, AB, YT, NT, and NU;
- Ontario;
- Quebec; and
- "Atlantic", including NB, NS, PE, and NL.

Figure ES.3 Regional Breakdown of Canada & United States



The results of this survey were utilized to identify the current state of the market from an adoption standpoint, uncover the most prevalent technical barriers, adoption challenges and opportunities, reveal which IoT applications are driving the most adoption today, and learn about each stakeholder groups' view on needs and requirements such as analytics, physical security and data privacy and ownership.

This research included direct interviews with over 50 MDU participants to understand their role in the spec and decision-making process for IoT technologies, preferences based on usage or tenant demographics, retrofit vs. new build approaches, knowledge of tools available for analytics, energy efficiency and remote monitoring. Additional interviews with recognized thought leaders, experts, industry associations and other sources were then conducted to verify, balance coverage and test findings in a Delphi-style approach.

In addition, this research leveraged previous work that Harbor and CABA have independently performed to identify key trends, players, IoT application evolution and requirements for IoT platform architecture for connected MDUs. Case studies from real-world implementations were developed to address market direction and provide quantitative opportunity sizing for the identified applications.

Report Structure

Chapter One provides context for the development of Smart Systems in MDUs by examining the trends and forces driving the development of Smart Systems and the adoption of IoT technology across a range of markets. Chapter Two then explores the opportunities for Smart Systems across the Buildings Venue, with the key trends and forces driving development of offerings in the Commercial and Single-Family Residential venues examined.

Chapter Three begins our examination into the MDU market, including how to frame opportunities based on building structure, property manager types, and occupant personas. Trends and forces shaping development and adoption of connected devices and services in this market are examined across technology, competitor, customer, and socioeconomic realms. Here we also highlight the underlying elements common to all IoT solutions and point to the overall scale of Smart Systems opportunities within the MDU market.

Having set up the opportunity in MDUs, Chapter Four then investigates the business case for the largest Smart Systems applications. These are broken down by stakeholders involved, trends and forces affecting the application, identified success factors, and case studies of real world implementations. Channels to market, conclusions and implications for various stakeholders involved in the application, and recommendations by stakeholder type are presented.

Chapter Five concludes the report with key opportunities for various types of equipment manufacturers and service providers to target, technological and strategy success factors, and future implications of current developments for which suppliers must begin preparing.

ES.2 SUMMARY OF KEY FINDINGS

The Internet of Things in Smart Systems - Chapter 1

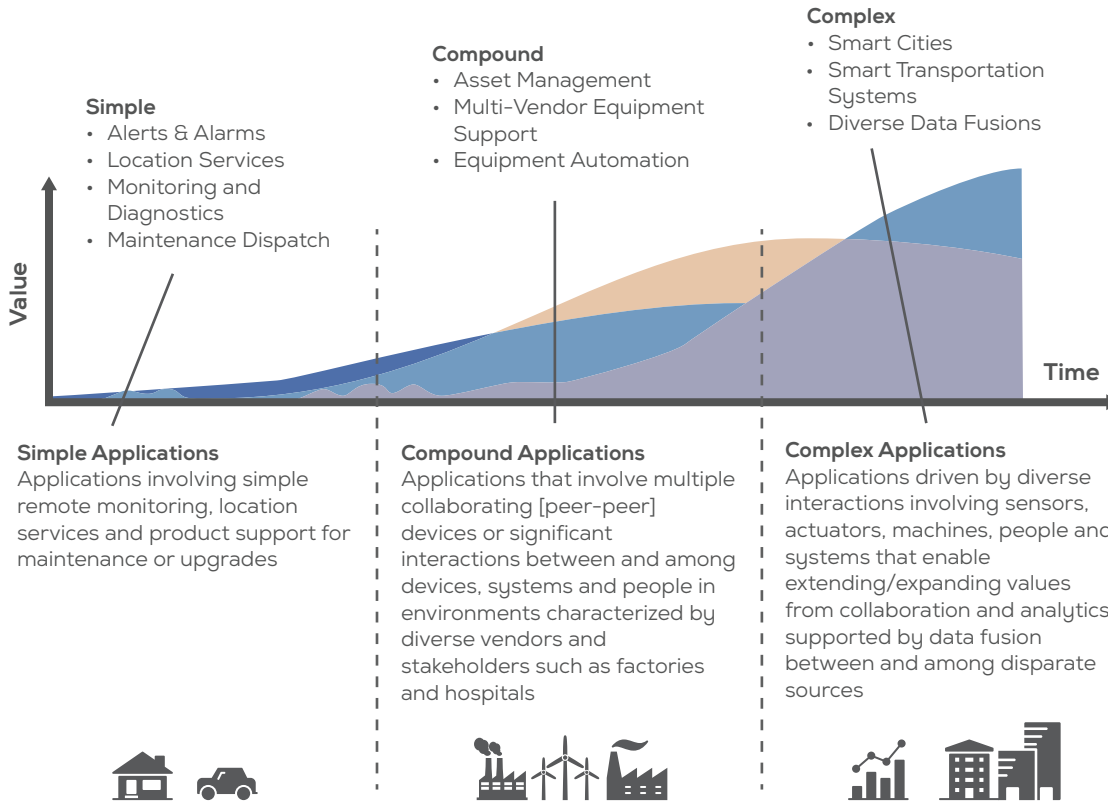
For quite a few years now, much research and consulting has been conducted to understand the impact of the convergence of embedded computing with the packet-switching "network of networks" called the Internet. These days, many people refer to this technological evolution as the "Internet of Things" (IoT) or "M2M," which usually stands for "machine-to-machine." A more accurate and encompassing term for these networks is "Smart Systems," because it begins to capture the profound enormity of the phenomenon, something much greater in scope than just machine connectivity.

Whatever we choose to call it – "Smart Systems" or "Pervasive Computing" or the "Internet of Things" – we are referring to digital microprocessors and sensors embedded in everyday objects relaying information over agile global networks. These networks could comfortably scale to trillions of nodes - some of them hardware, some software, some purely data, many of them coming into and out of existence or changing location constantly.

Increasing analytic capabilities, combined with connectivity, data storage, and processing advances are enabling use cases to become more complex, creating more value for a wider variety of stakeholders. Smart Systems have traditionally focused on "simple" applications involving a single device used in monitoring and alerting cases. Interoperability and increasing capabilities are enabling "compound" applications, in which a simple application is coordinated with other such apps, sharing data and orchestrating device actions. "Complex" applications, which drive interactions across many devices, systems and people, are no longer predominantly held back by technology, but rather by business models. Without the structures in place to develop and capture value from multi-vendor solutions, these applications will remain elusive.

Smart Systems that connect people, devices, business processes, and content to enable collective awareness will drive a multi-year wave of growth based on the convergence of the virtual and physical worlds. The Internet of Interactions, between and among "things" and "people," requires much more than simple incremental improvements in today's technologies to be fully realized. The challenge is much more than a simple patch, Band-Aid, or new flavor of what we already do.

Figure ES.4 The Value of Smart Systems in Increasingly Complex Applications



What's required is a true shift in thinking about how devices, people and physical systems will be integrated and how they will interact. We need an approach that is not about leveraging aging IT technology into a new application context; it's about looking forward to a single, unified architecture for the nearly infinite interactions to which any person or thing can contribute.

Innovations across the technology stack, from networking to applications, are enabling increasingly complex applications across many industries. Realizing this new mode of interaction requires shifting the focus from simple device monitoring to a model where device data is aggregated into increasingly complex applications to achieve true systems intelligence. It's a shift from knowing "what happened" to knowing "what is happening" all the time, with systems autonomously reacting to that knowledge to optimize their operations in real-time.

While some companies will always choose to stay with the status quo, leading product OEMs will vigorously embrace the power that lies within self-initiated communities. Though their business models are intermingling today, all the major categories of traditional solution suppliers have historically operated within well-established business models that reflected the distinctive competencies that each group believed to be at its core. The advent of Smart Systems is blurring these legacy business models and redrawing the competitive landscape, forcing major suppliers to re-think their strategies.

Smart Systems in Buildings - Chapter 2

Smart Building Systems provide a distributed control and information system that enables the control and maintenance of a building environment, leveraging a network of intelligent devices to monitor and control the mechanical and related systems in a building. In this context, our use of the term "Smart Systems" is analogous to what is commonly referred to as "building management systems" (BMSs). The two terms are often used interchangeably, but within this report there is a distinction, and it is one that

reflects the key changes affecting the market: our use of the term Smart Building Systems encompasses a broader set of control and information devices and systems.

Simply put, an intelligent building is a structure in which sensors, switches and systems contained within the building's infrastructure are networked and can communicate with each other and with a human operator through a monitoring or control interface. While this may seem relatively straight-forward, like most things, it is far more complex when put into practice.

A dominant trend in the Buildings Venue is the increased operator awareness of and interest in Smart Systems that provide greater asset visibility and management. Meanwhile, continued interest in energy management among building operators is driven by socioeconomic pressures as well as the availability of interoperable solutions arising from the proliferation of available networked products. These factors are driving operators to adopt solutions that prioritize overcoming integration and security issues.

This analysis highlights diverse challenges to firms seeking significant and sustainable success in offering Smart Systems across the Buildings Venue, including:

- Difficulty adopting new business models and justifying the business case within a fixed time horizon;
- Complex services and solution-delivery ecosystems that require businesses to relate in new and different ways;
- Anticipation of new product, service and systems innovation modes that are not widely adopted today;
- A fragmented IoT and Smart Systems vendor landscape that is not yet well aligned with the larger IT infrastructure and carrier players; and
- Requirements for vertically-focused solutions from a supply-side world that has historically been far more horizontally driven.

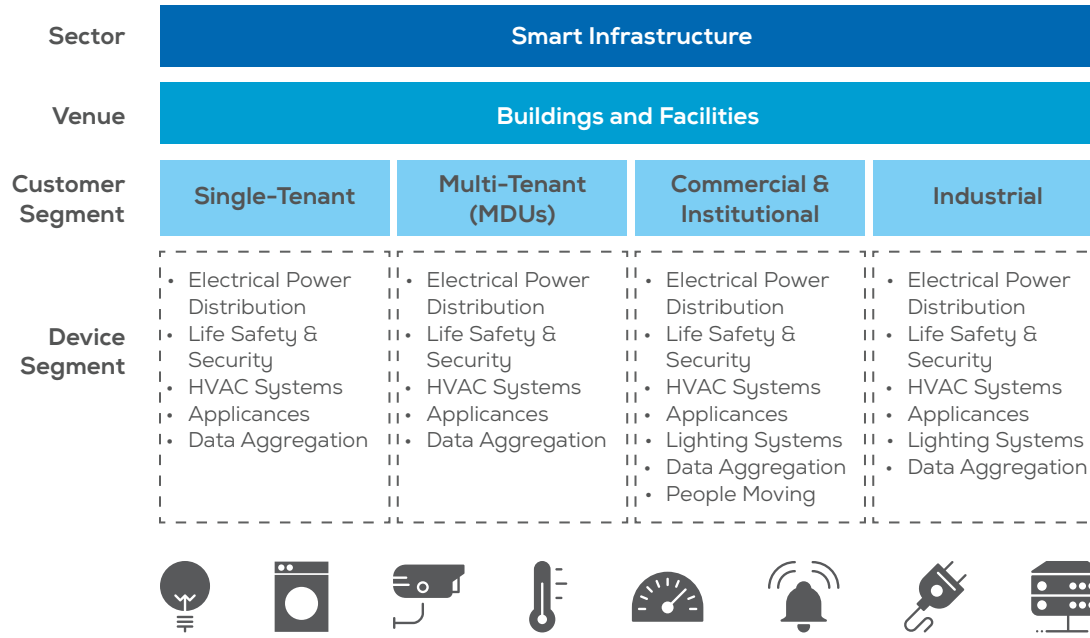
Buildings Venue Segmentation

The opportunities for the Internet of Things are segmented into five economic sectors that encompass eight distinct venues. Within the eight venues, there are 29 customer segments with over 400 distinct connected product segments that Harbor Research analyzes and forecasts. The Buildings Venue resides within the Smart Infrastructure sector and consists of systems that are either part of the building's internal systems (e.g., HVAC, lighting, electrical power distribution) or devices that are installed on or within buildings that are not meant to be moved regularly (e.g., appliances, security and life safety equipment).

The four customer segments within the Buildings Venue are organized in the following manner:

- Commercial and Institutional, including: big box retail, specialty retail, malls, office buildings and related commercial real estate;
- Industrial, including: factories, labs, distribution centers, etc.;
- Single-Tenant Residential Homes; and
- Multi-Tenant (MDU) Buildings, including: multiplexes, townhomes, low-rise, mid-rise, and high-rise condo or apartments.

Figure ES.5 Smart Buildings Market Map



This report focuses on the opportunities for Smart Systems in MDU buildings specifically, a market that has traditionally been served not by a dedicated set of suppliers but rather by those focused primarily either on commercial buildings or single family homes. The physical structures and centralized building systems of MDU buildings share characteristics with commercial buildings, as do the needs of building operators and property managers (which are interchangeable stakeholders for our intents and purposes) with regard to building and equipment management across these customer segments.[1] However, the presence of occupants means that individual units and common areas must operate more like single-family homes, prioritizing the comfort, convenience, and peace-of-mind of occupants. Suppliers coming from both angles, commercial and single-family, have failed to adequately meet the unique needs of this market.

Smart Systems in Multi-Dwelling Units - Chapter 3

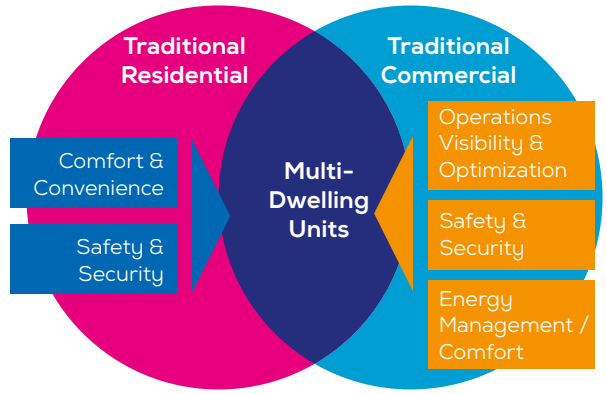
MDUs sit at the intersection of single-family homes and commercial buildings, sharing characteristics of each. Responsible for decision-making around central building offerings as well as installed devices within units, owners and operators (including third-party managers, owner/managers, and owner/occupants) have two unique needs which must be met to justify adoption of connected offerings. First, they must retain an appropriate level of service control, which does not impinge on occupant privacy but provides the ability for the manager to manage services during turnover and ensure that terms of the lease are maintained.[2] Second, they must realize an attractive ROI from connected offerings, which can be captured in several ways.

Operating margins can be increased by reducing ongoing expenses with the adoption of devices and services that increase the efficiency of building systems and management processes. Operating expenses are also decreased by reducing vacancy and occupant turnover, both of which can be accomplished with adoption of offerings that increase occupant satisfaction.[3] Such offerings also grow the top line by differentiating the property and enhancing customer acquisition in competitive markets.[4]

Figure ES.6 MDU Requirements Represent a Blend of Residential & Commercial Needs

Residential
Technology in residential settings has always focused on two applications: comfort & convenience and safety & security. As such, traditional suppliers have tended to target a specific application. While the line between the two groups of suppliers is blurring, these consumer-oriented companies are rarely geared towards commercial applications.

Due to the fragmented user-base and fickle nature of consumers, new entrants are coming from all angles and some are experiencing mild success as the race for consumer acceptance (and data) continues.



Multi-Dwelling Units
MDUs are characterized by two groups of stakeholders: occupants and owner/operators. The structures themselves are closer to commercial buildings in terms of size and more centralized systems, however, the needs of individual unit occupants must be considered.

Commercial
Technology in commercial buildings has traditionally focused on operations visibility and optimization and safety and security. These buildings are characterized by more centralized systems, and due to the size of these buildings, they incur high operations costs (e.g., energy, maintenance, etc.).

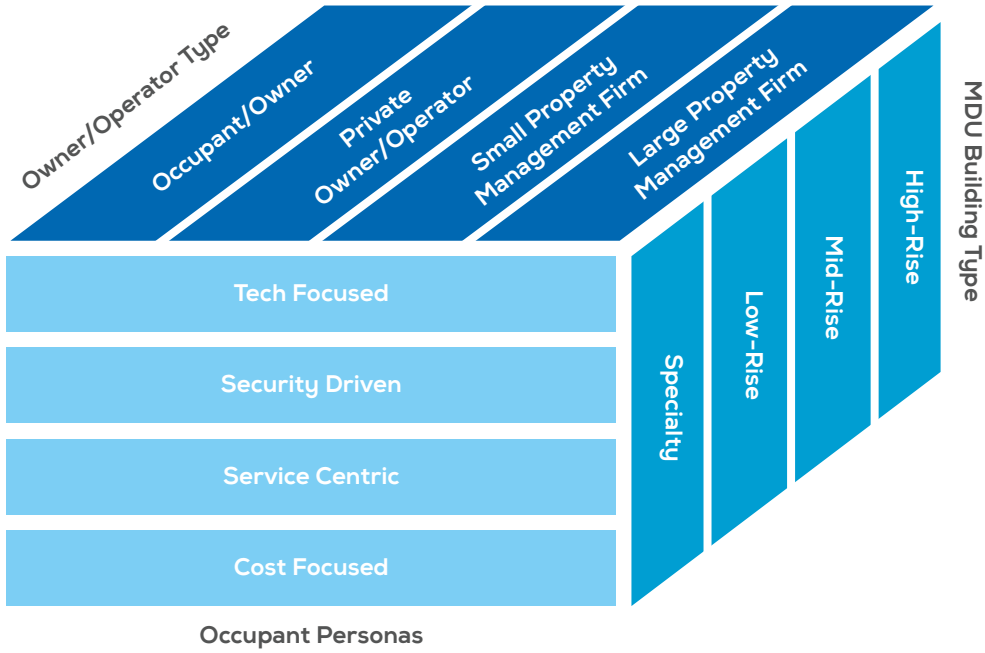
Larger IT companies and equipment manufacturers have controlled much of this market in the past. These traditional suppliers have acquired new software and application platforms to provide better services to their customers, and are entrenched in their market-leading positions.

The inability of both commercial and home automation players to organize successful offerings for this market has left the door open for agile startups to create solutions tailored to the unique needs of MDU building stakeholders.

Market Organizing Principles

The opportunities for IoT technology-enabled use cases in MDUs are shaped primarily by three factors: building structure, property manager persona, and occupant persona. Factors across these three dimensions combine in any and every manner, leading to a very complex and fragmented set of adoption characteristics. The combination of these factors for a given MDU determines which use cases are most desired, the technical capabilities of those use cases, the stakeholder who captures value from adoption, the stakeholder who makes decisions regarding adoption, and the suppliers who are best positioned to deliver solutions.

Figure ES.7 Framing the Smart Systems Opportunity in MDUs

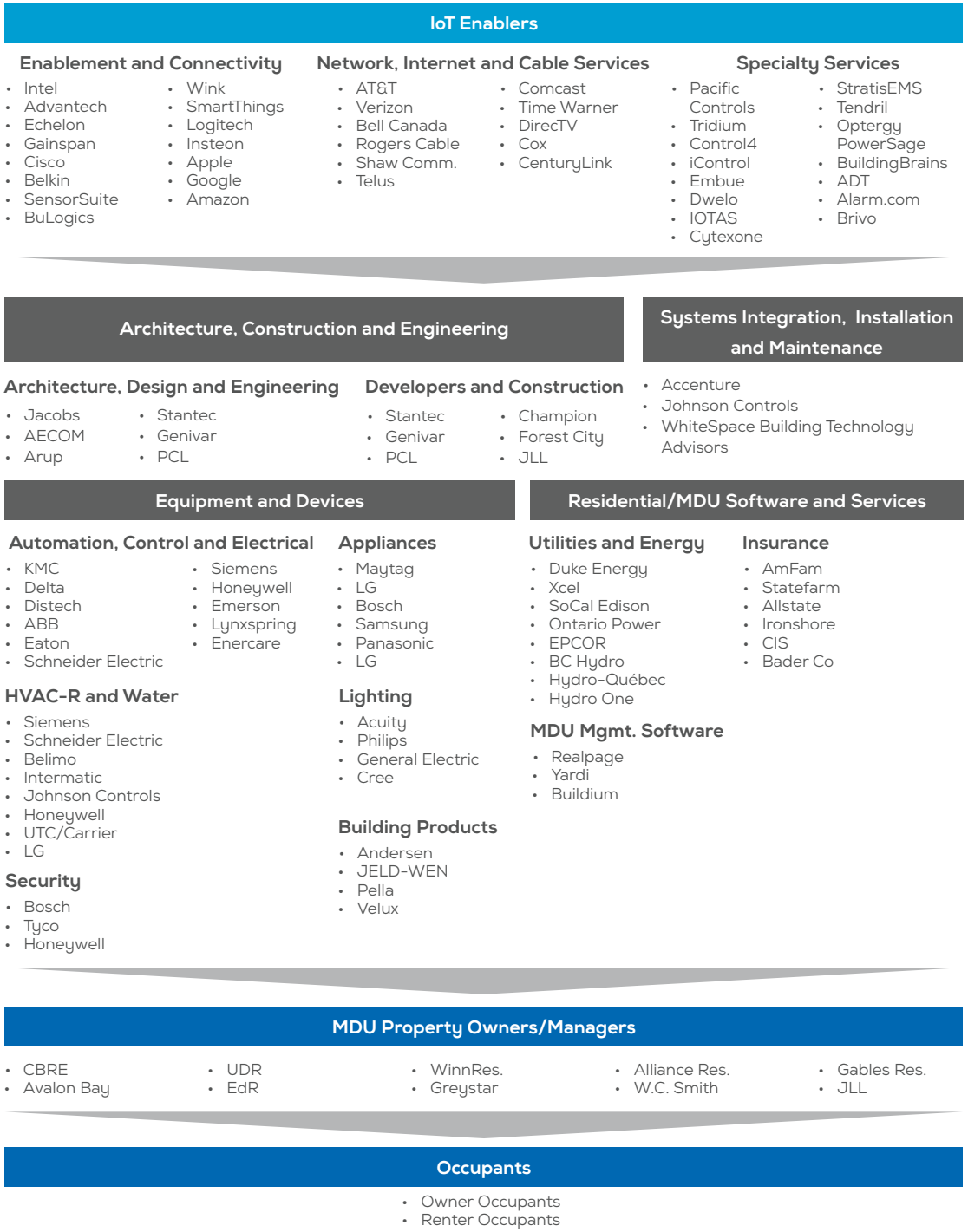


This complexity requires suppliers to have flexible offerings and delivery mechanisms in order to meet the needs of different MDU structures, manager types, and occupant personas. Traditional suppliers of building automation systems to commercial buildings have focused on scale rather than addressing the complexity posed by the three dimensions of MDU opportunities and the needs of particular structure/manager/occupant combinations. Further, our discussions with managers have indicated that the willingness-to-pay for automation solutions in MDUs is considerably smaller than that in commercial buildings, challenging the cost structure of traditional building automation suppliers.[5]

Meanwhile, smart home suppliers who have attempted to scale their offerings out of single family residential and into MDUs have been challenged by the requirement to meet the needs not only of building occupants but also of property managers. Our research confirms that consumer adoption of connected devices that they bring with them, including lightbulbs, speakers, TVs, cameras and motion detectors, is on the rise among tech focused occupants, enhancing in-unit comfort, convenience, and peace-of-mind. However, without coordination with devices and systems that unit owner/operators install, including thermostats, major appliances, HVAC-R equipment, air and water distribution systems, and the building network backbone itself, the ability to create value within the unit is limited.

IoT enablers have emerged to disrupt traditional building system providers by offering more technologically advanced, open solutions. These players are all over the market, working with OEMs, service providers, and even directly with end-users. Their sensors and hardware may be embedded into an OEM's products during the manufacturing process, or a systems integrator may be responsible for building a network that includes hardware from multiple enablement vendors. Sensing an untapped, growing market, specialty IoT platform and service providers have recently cropped up, targeting the MDU market specifically. Players such as IOTAS, Embue, Optergy, StratIS and Dwelo have taken the challenges of this market head on, and stand to benefit greatly from the inaction of traditional buildings suppliers.

Figure ES.8 MDU Competitive Structure



EXECUTIVE SUMMARY

Scale of Smart MDU Opportunity

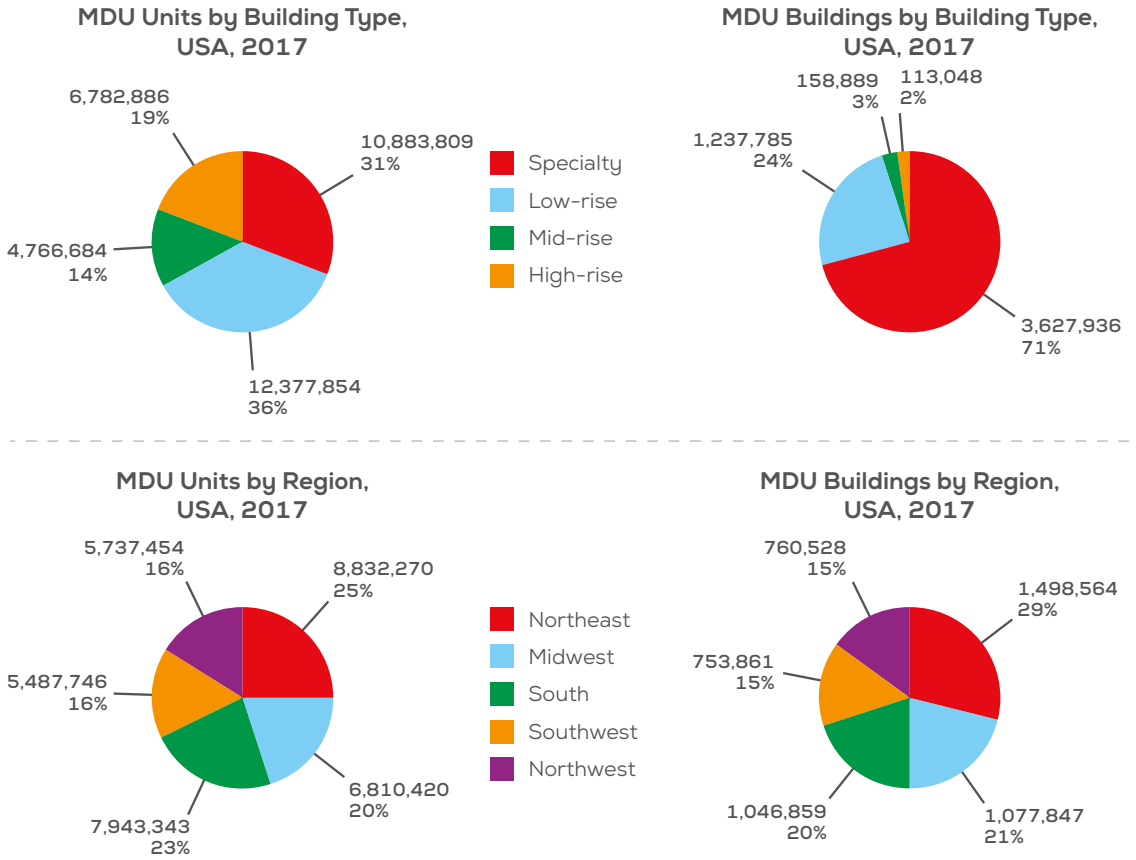
The margins per building may be small, but the addressable market is anything but, with greater than 6 million MDU buildings across the US and Canada housing over 40 million individual units.[6] Further, as the percentage of renters continues to increase, driven by the perceived risks of ownership following the 2008 recession and the flexibility and freedom desired by millennials, who make up the largest portion

of both renters and the general population,[7] connected offerings for rental units will be increasingly desirable.

Over 85 percent of all MDU units and buildings between Canada and the US are in the US, with the Northeast, South and Midwest regions all individually containing more units and buildings than all of Canada. In Canada, Ontario and Quebec account for over 68 percent of all units (3.9 million) and 66 percent of all MDU buildings (0.58 million)

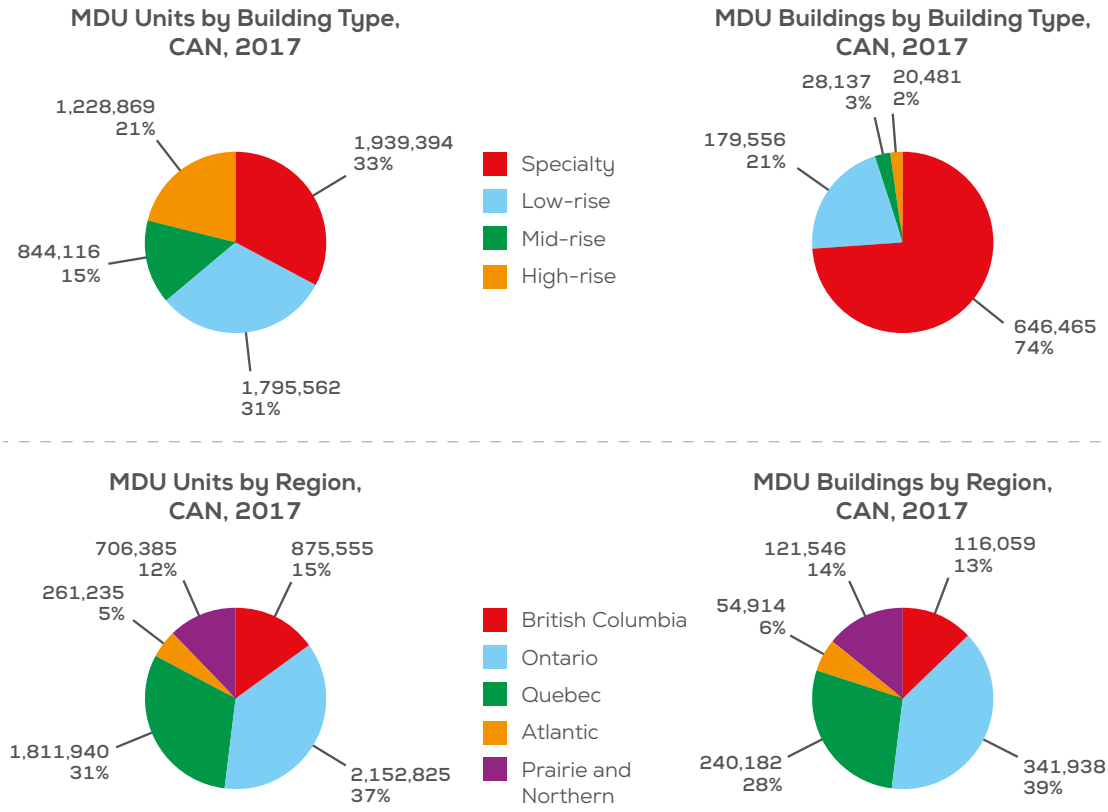
Over 70 percent of MDUs are specialty building types, but these buildings only contain about 32 percent of all MDU units. Low-rise units account for the greatest number of units at 14.1 million, or 34.9 percent of the total units in Canada and the United States. While high-rise buildings only represent 2.2 percent of all MDU buildings across these regions, they contain 19.7 percent of all units.

Figure ES.9 United States MDU Buildings & Units by Type and Region



Source: US Census Bureau, National Multifamily Housing Council, Harbor Research Analysis

Figure ES.10 Canadian MDU Buildings & Units by Type and Region



Source: StatCan, Harbor Research Analysis

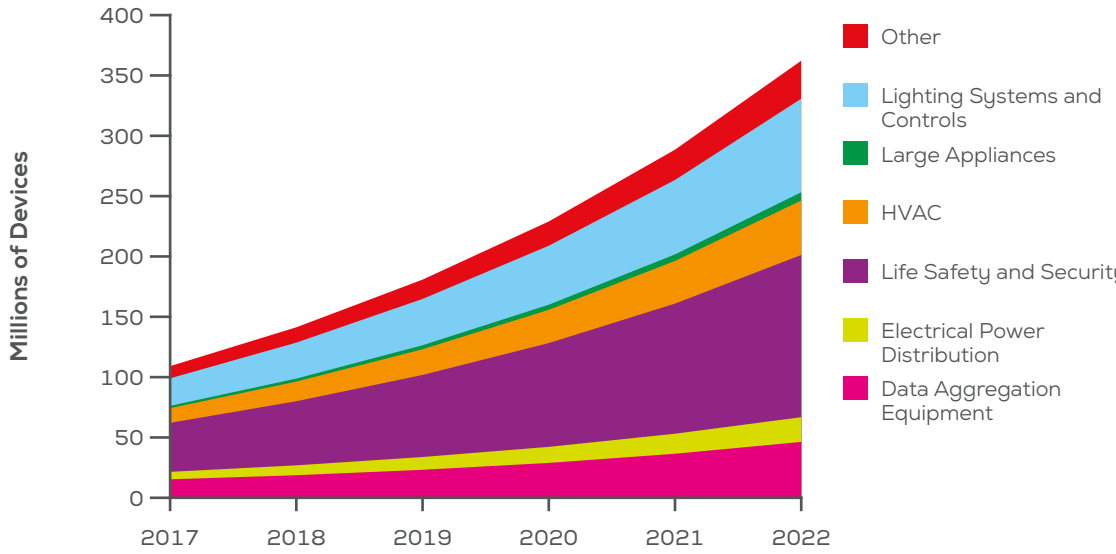
Smart Devices within MDUs

Across the forecasted device segments, there are over 92 million installed connected devices in the United States and over 16 million installed connected devices in Canada for a total of 109 million connected devices between the two countries in 2017. This installed base is forecasted to grow at a rate of 27.1 percent over the forecast period, resulting in 362 million installed devices in 2022.

There are over 36 million shipped connected devices in the United States and over six million shipped connected devices in Canada for a total of 42.5 million connected devices shipped in 2017. The number of shipped devices is forecasted to grow at a rate of 24.1 percent over the forecast period, resulting in 125 million devices shipped in 2022.

The largest device segment by number of devices installed is Life Safety & Security, with 40.6 million devices installed in 2017, growing at a rate of 27 percent over the forecast period resulting in 134 million devices installed in 2022.

Figure ES.11 Installed Devices by Device Segment, 2017-2022



The MDU market presents a significant opportunity for smart systems and IoT-based revenues, with a total opportunity of $2,908 million in 2017 growing at a compound annual growth rate of 31.6 percent to $11,488 million in 2022. Smart Systems revenues for MDUs break down into the following macro categories:

- **Enablement revenues**, the smallest revenue stream, represent an opportunity of $282 million in 2017.
- **Network services revenues** represent 20 percent of the total opportunity in 2017, with a value of $586 million and growing to $1,926 million in 2022 at a CAGR of 26.9 percent.
- **System applications revenues** are growing at a rate of 32.9 percent over the forecast period, increasing from a $420 million opportunity today to a $1,738 million opportunity in 2022.
- **Value added applications** represent the largest revenue opportunity at $1,620 million in 2017 growing at a CAGR of 35.1 percent to $7,278 million in 2022.

The value added application revenue stream is broken down into five applications within MDUs, all explored in-depth in the following sections. The largest of these applications is Building & Equipment Management, an operations-focused application targeted at building owners and operators. The opportunity for this application is $457 million today, growing at a CAGR of 35.9 percent to $2,119 million in 2022. More details on the opportunities around these applications can be found in the report body.

Figure ES.12 Smart Systems Revenues by Revenue Stream, 2017-2022

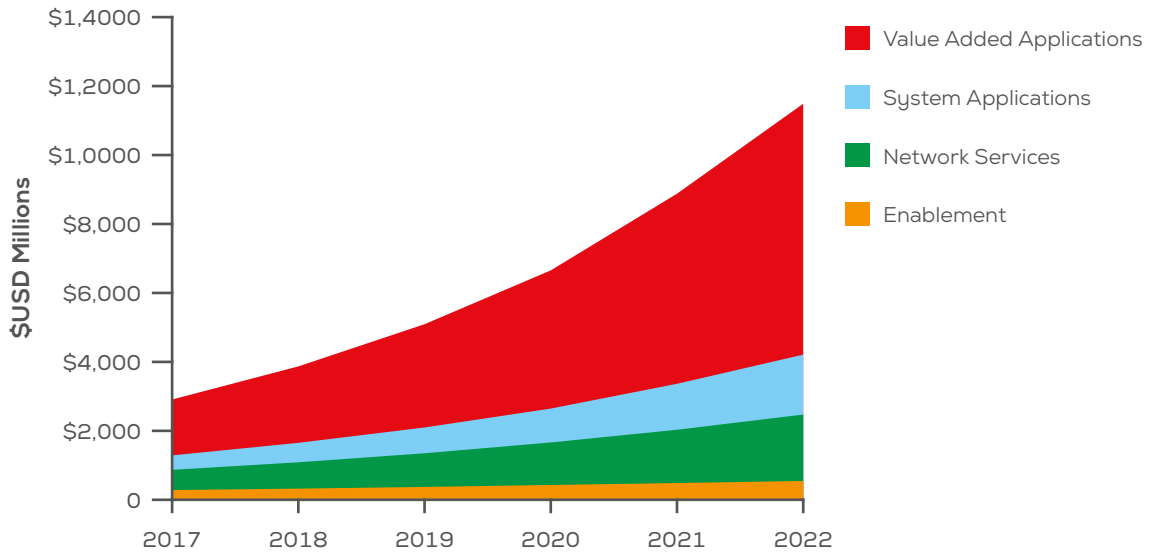
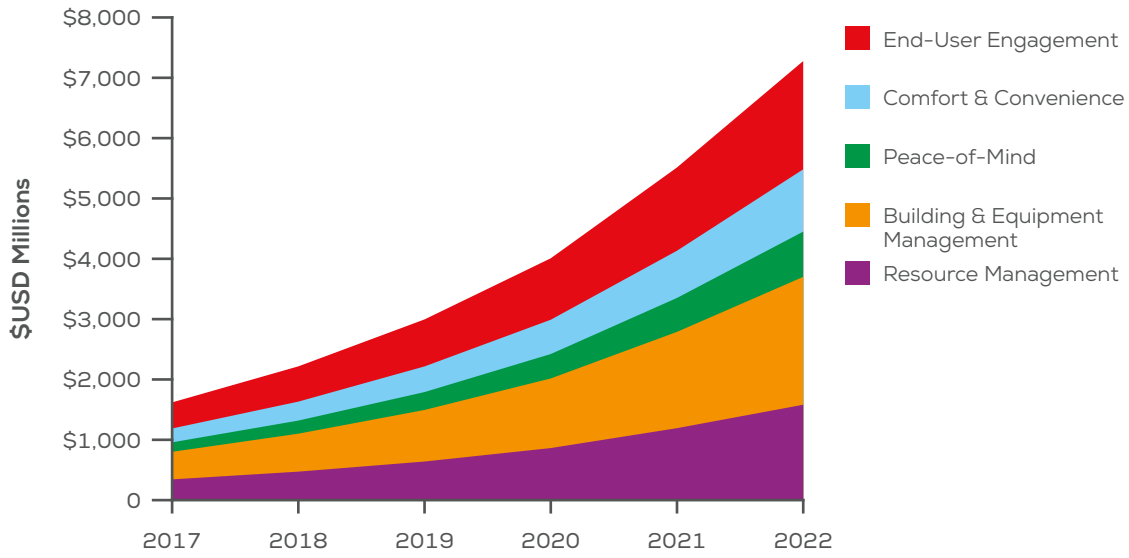


Figure ES.13 Value Added Application Revenue by Application, 2017-2022



Key Trends and Forces Affecting MDU Opportunities

Technical developments are leveraging IT functionality to enable new capabilities in OT applications, as increasingly powerful wireless tools enable new sensing opportunities and advanced data management tools allow value to be created from collected data with greater ease. Meanwhile, building operators and occupants, especially tech-focused millennials, expect interactions with building and unit systems to be intuitive where needed but generally minimized. Ideally, systems operate in the background of buildings, requiring limited user interaction to enhance peace-of-mind and comfort or maximize operational efficiency.

Recognizing the opportunity opened by the inability of incumbent Commercial and Single-Family Residential automation players to adequately serve the MDU market, specialists have begun to find

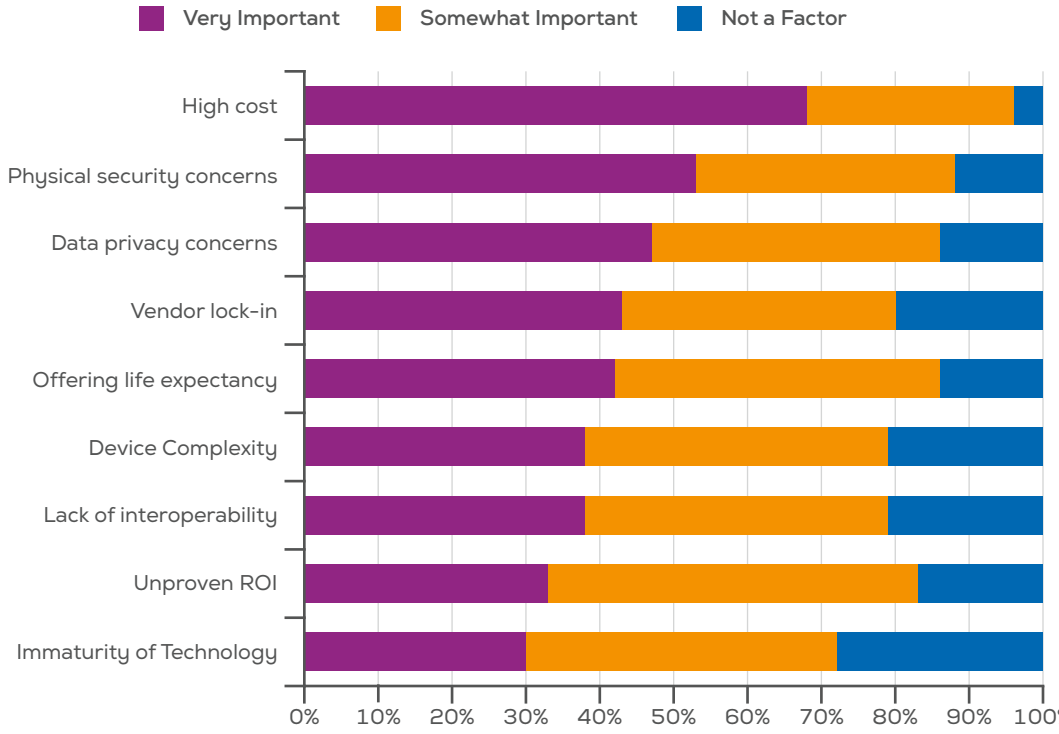
success with targeted offerings that bridge the "split incentive" challenge of serving occupants and building operators in this market. Comfort and convenience focused offerings are especially popular among tech-savvy, environmentally-conscious millennials who make up the largest portion of the renter population and are seeking housing in urban centers.[8]

This migration is creating competitive MDU markets as rates of new construction continue to recover from the stall precipitated by the 2008 economic downturn, encouraging operators to differentiate their buildings with connected offerings. Meanwhile, regulatory action and volatile energy prices have encouraged building operators to invest in management systems to increase energy consumption efficiency, thereby lowering operating costs and extending the life of equipment.

Drivers and Barriers of Offering Adoption

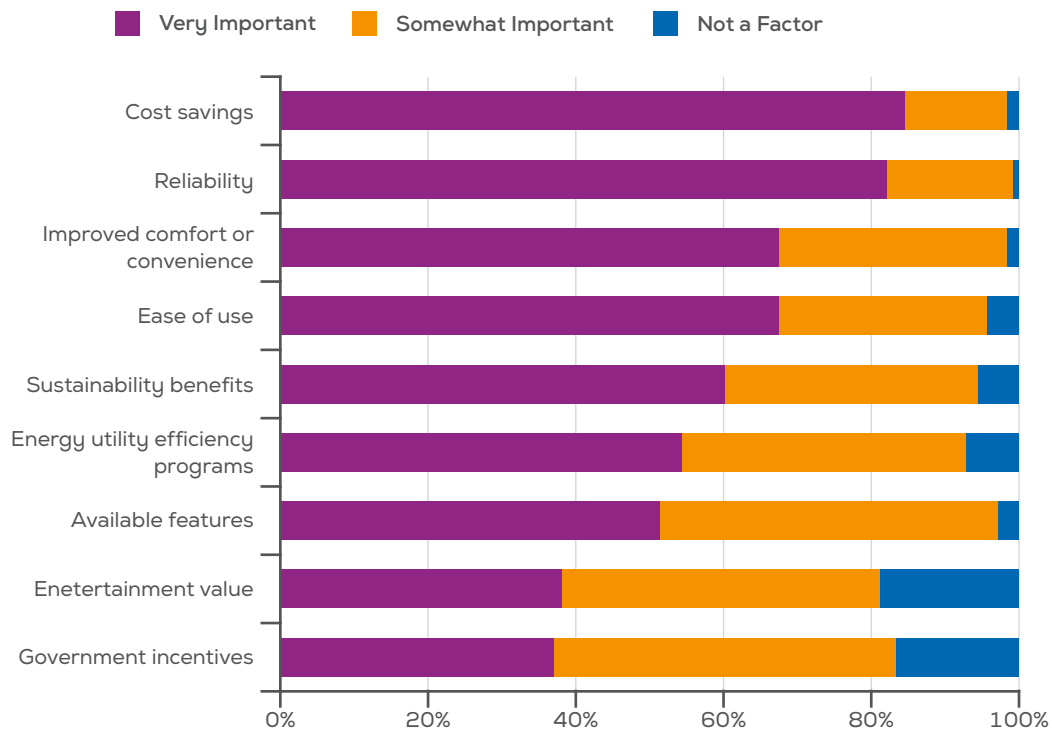
The high initial cost of connected offerings continues to be a primary impediment to device adoption, though high-profile device hacks and network breaches have elevated personal security and data privacy concerns. A promising sign to suppliers is the relatively low number of respondents who note a lack of belief in the benefits of connected offerings as a barrier to adoption.

Figure ES.14 Occupant Barriers to Adoption, n=809



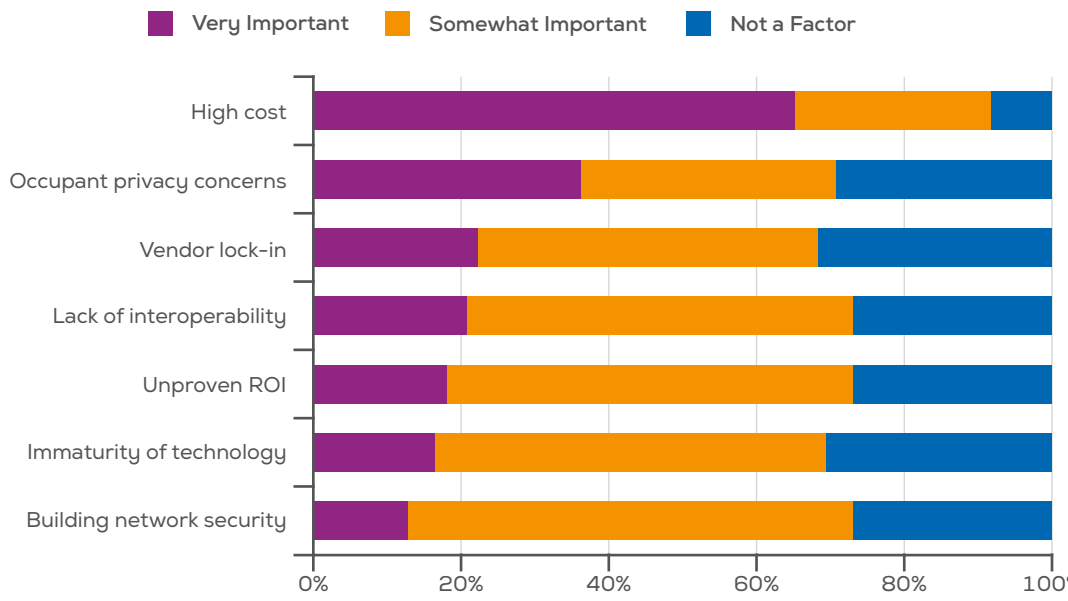
In terms of driving adoption, occupants rank cost savings, reliability, and improved satisfaction from connected offerings as their primary motivators, further emphasizing that those interested in these offerings are informed of their benefits. Aside from directly reducing utility expenses, implementations have highlighted that convenience-enhancing offerings generate indirect cost savings for end-users by reducing the cost of and time spent on maintaining their units.[9] This indicates that providers should focus on reaching a broader audience with messaging, and should increase awareness outside of the tech-fluent that these offerings have proven value.

Figure ES.15 Occupant Adoption Drivers, n=522



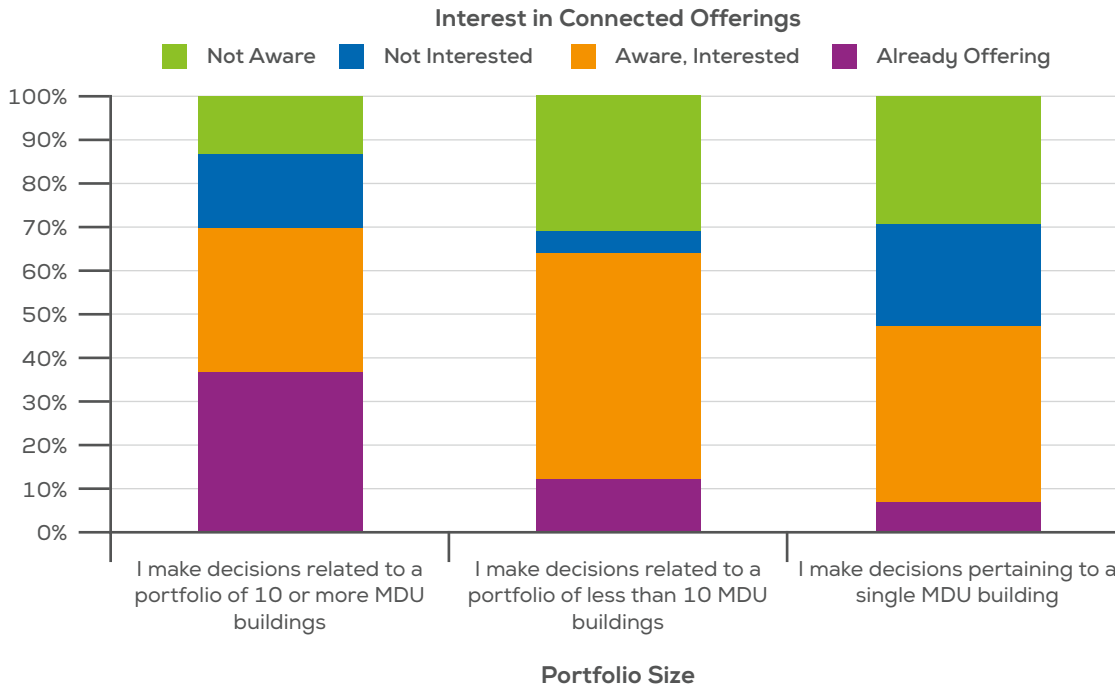
Cost, far and above all other factors, is the biggest barrier to adoption by owners, operators and developers, followed by occupant privacy concerns. While a small portion of respondents rank "confidence in offering benefits" as a major barrier, it is clear that they remain unconvinced that the lifetime benefits outweigh the initial costs of offerings.

Figure ES.16 Owners, Operators and Developers: Barriers to Adoption, n=58



Further, awareness of and interest in connected offerings is found to be significantly higher among operators and developers of large portfolios of MDUs, reflecting the focus of suppliers on the attractive scale offered by these targets. Small property managers and developers, as well as operators of single buildings, are individually less attractive of a target than a larger firm, though the overall market for offerings tailored to operators at smaller scales is large.

Figure ES.17 Owners/Operator Portfolio Size and IoT Interest, n=110



Smart MDU Business Opportunities - Chapter 4

Connected devices and services within MDU buildings and individual units can be combined in numerous combinations to enable simple, compound, or complex applications. Five distinct value added application segments have been identified that create value for building occupants or operators in different ways.

- **Resource Management**: Applications that monitor and analyze resource and energy usage data to inform and enable efficient consumption and reduce costs.
- **Peace-of-Mind**: Applications that enable remote monitoring of home and occupant safety and connecting to third party security services.
- **Building and Equipment Management**: Applications that monitor and manage equipment/building usage and performance and/or provide greater visibility into operations and reduce operating expenses.
- **Comfort and Convenience**: Applications that enable automation and/or wireless control of devices and services to increase comfort and ease of use while reducing device and appliance failure.
- **End-User Engagement**: Applications that use data and analytics to increase the value of services offered by equipment manufacturers, traditional or specialist service providers, or third-parties.

Each of these applications, depending on the complexity of the use cases installed in and across MDU buildings and units, stand to create value for multiple stakeholders. Building operators/managers stand to gain the most from Smart Systems apps in MDUs, with offerings either reducing operating expenses or increasing margins through enhancing occupant acquisition, satisfaction or retention.

Figure ES.18 Overview of Value Proposition of Smart Systems for Suppliers

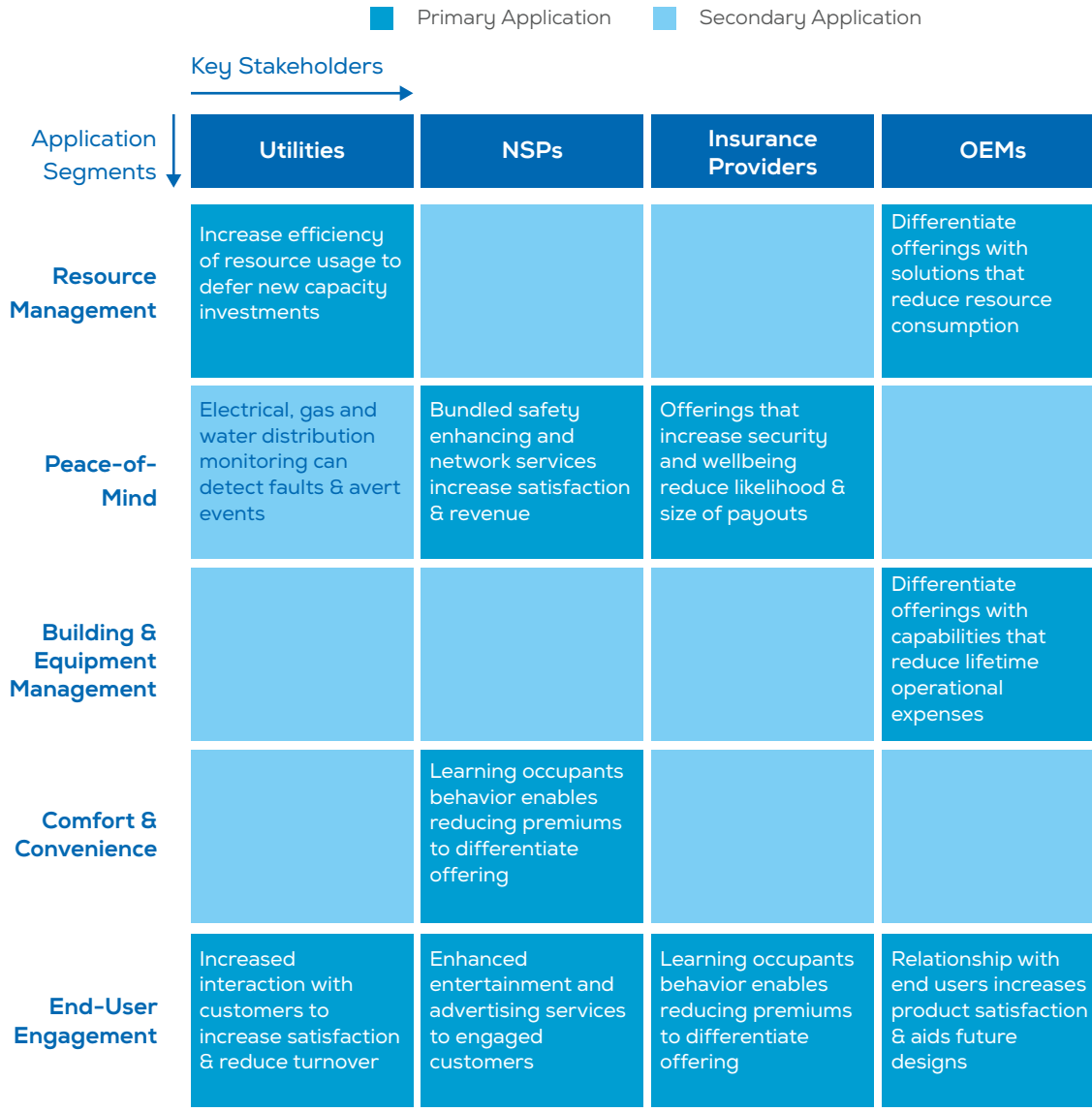


Figure ES.19 Overview of Value Proposition of Smart Systems for End-Users

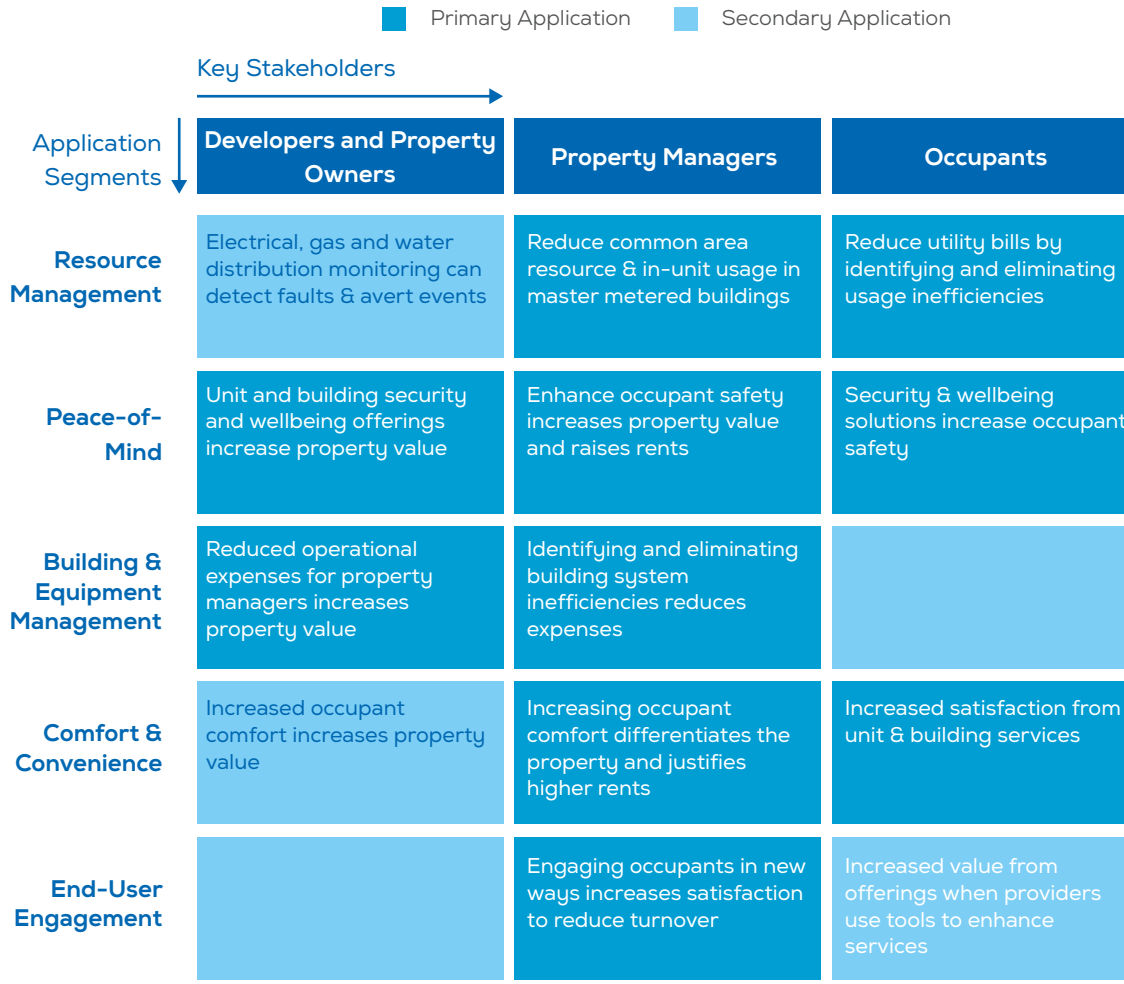
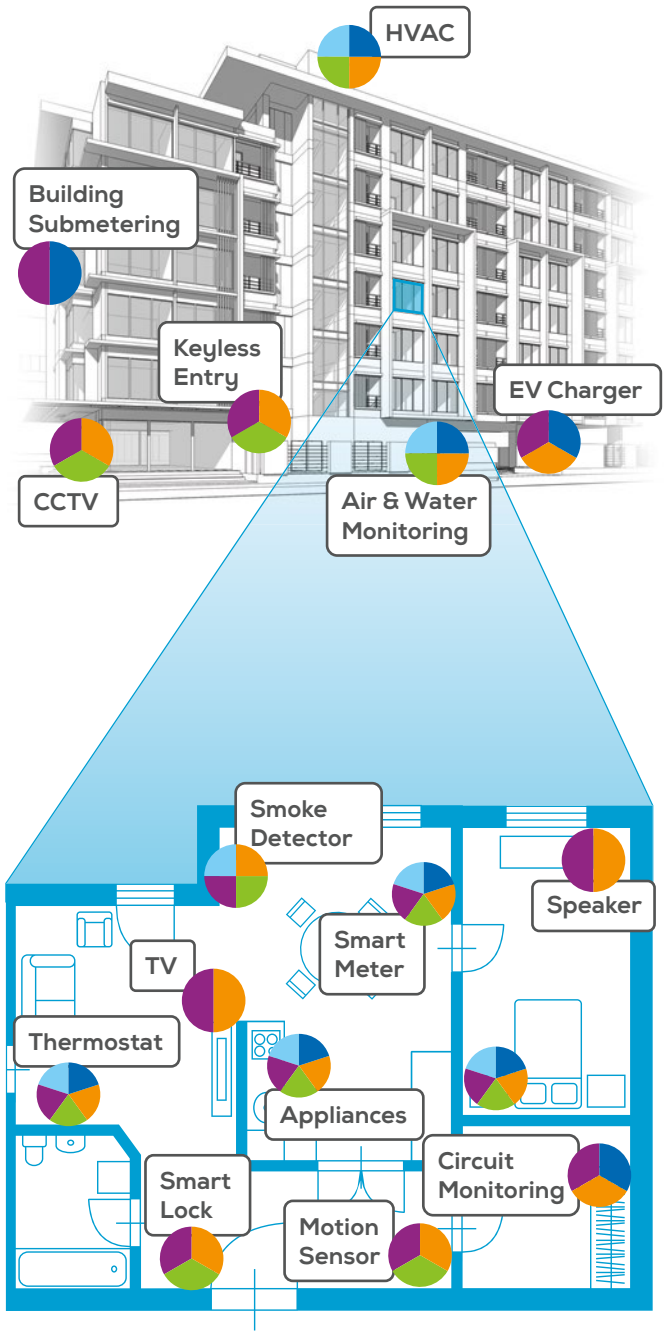


Figure ES.20 Overview of Devices within Application Segments and the Stakeholders Who Stand to Benefit



Resource Management

Applications that monitor and analyze resource and energy usage data to support efficient use and reduce costs

Primary Value Captured By:
• Occupants • Building Operators

Comfort and Convenience

Applications that use wireless control or automation to increase comfort and ease of use and reduce offering failure

Primary Value Captured By:
• Occupants • Building Operators

Peace-of-Mind

Applications that enable remote monitoring of home and occupant safety and connect to third party security services

Primary Value Captured By:
• Occupants • Building Operators

End-User Engagement

Applications that use end user data to increase the value of offerings delivered by OEMs and service providers

Primary Value Captured By:
• OEMs and Service Providers • Building Operators

Building & Equipment Management

Applications that manage equipment and building usage to identify inefficient operations and reduce operating expenses

Primary Value Captured By:
• OEMs and Service Providers • Building Operators

For each of these five application segments, Chapter Four of this report details:

- The scope of potential use cases, including the technical complexity and value created for various stakeholders;
- The scale of the revenue opportunity across MDU building types;
- Trends and forces affecting the desirability, development and deployment of use cases of varying complexity;
- Key factors identified from the market study that indicate interest in application adoption;
- Case studies highlighting implementations of use cases of varying degrees of complexity and benefits for various stakeholders;
- Channels to market by which manufacturers and service providers deliver new offerings to end-users;
- Conclusions and recommended actions for MDU stakeholders include:
    - Electric Utilities
    - Network Service Providers
    - Insurance Providers
    - Specialty IoT Service Providers (e.g., energy management providers, security monitoring providers)
    - IoT Hubs, Platforms, and Software Providers
    - HVAC-R and Water OEMs
    - Lighting OEMs
    - Appliance OEMs
    - Electrical OEMs
    - Security OEMs
    - Building Products OEMs

Conclusions and Implications - Chapter Five

Key Opportunities and Targets

The exact makeup of offerings, the types of stakeholders to target with those offerings, and the solution delivery paths tend to vary by application, but there are guidelines for success that are broadly applicable as suppliers consider offering connected devices and services.

Property Manager Priorities are the Key Variable. The property manager persona has the biggest impact on the type of solutions desired and the delivery of those solutions.[10] Owner/occupant decision-making primarily focuses on device and service investments that increase in-unit comfort, convenience, and peace-of-mind, or reduce unit operating expenses. On the other hand, private owners/managers are seeking connected offerings that either significantly increase the value of units or provide differentiating value to units and create long-term operational expense reductions for themselves. The value to small and large property management firms varies with the MDU structure. In small buildings without onsite staff, remote access and equipment management reduces manager time and labor costs, while these same offerings in larger properties with dedicated staff enable managers to reduce staff expenses and increase response quality. Managers of large properties also seek solutions that utilize scalable cloud tools that extend property management capabilities across a large portfolio of properties.

Creating Multi-Stakeholder Value. Suppliers stand to gain a unique, sustainable competitive advantage from offerings that create new end-user value while enhancing their own service delivery. Differentiated solutions enhance customer loyalty, and data collected from connected offerings enables enhanced value creation over time to reduce turnover. Meanwhile, reducing friction in service delivery enables suppliers to actually reduce the cost of offerings relative to competitors, further strengthening the value proposition of their offerings.

Access management provides significant convenience value for occupants while enabling managers

to limit access to a defined set of tenants and reducing time and labor expenses during tenant turnover. The device capabilities and overall scope of solutions will vary with targeted occupant personas, with ready-to-control holistic apartment/condo offerings ideal for higher income occupants. Owner/operators of buildings serving lower-income occupants may create the most value by simply providing the network backbone and platform/IoT hub tools, enabling occupants to invest in the devices and services that they can afford or prefer.

Opportunity Targets and Timing. Managers of all-inclusive or high turnover properties are most likely to adopt offerings that provide resource consumption and building access management. Targeting large property managers provides suppliers an opportunity to capture a significant volume of deployed devices if they can install offerings across all future new build or retrofit projects in the portfolio. Small property management firms and individual owner/managers may find new connected appliances and building systems prohibitively expensive for their limited capital budgets, while large property managers undergoing retrofits and developers of new builds may be capable of making upfront investments that will reduce long-term expenses.

DIY and add-on offerings that provide energy management, equipment and appliance monitoring and control, and security have a significant opportunity to enhance occupant value or reduce operating expenses without requiring major renovations. Retrofitting unit-by-unit during occupant turnover presents the largest opportunity for devices requiring owner/operator installation in MDUs, granted that firms are able to develop cost structures suited for the small margins and lack of scale which unit-by-unit retrofits offer.

Technology Success Factors

The ability to create new value in the background of users' lives, enhancing comfort, convenience, peace-of-mind or reducing costs without additional user interactions with a device or service is key to successful adoption of offerings. Offerings that leverage open source conventions have the potential to create the most value by seamlessly interacting with adjacent devices and value-adding services.

Software Enabled Interoperability. Operators are looking for offerings that integrate disparate HVAC-R, water and air distribution, lighting, electrical distribution, and security systems onto a single IP-based platform that enables remote monitoring and control with minimal complexity.[12] The ability for disparate systems to communicate with each other and share data with analytics engines and automation services is critical to enable these tools to create value for MDU stakeholders across the value chain. A focus on open source data models and communications protocols enables this communication to occur innately, though middleware platforms and hubs are being utilized to provide interoperability in the absence of adhered-to standards.

Benefits in the Background. Operators and occupants alike seek tools that move beyond data visibility and control to actually reducing costs and/or increasing comfort, convenience, and peace-of-mind with automated actions that occur in the background. Rising consumer adoption of machine learning services, especially in the form of digital assistants offered via smart phones and speakers, give service providers a powerful interface for connecting with users and tailoring services to individual needs.

Flexibility and Extensibility. End-users are eager for solutions that readily adapt and expand as needs change, technology evolves, and regulatory and market factors shift the economic rationale for adoption of connected offerings. Cloud-based platforms for managing IoT offerings within a single MDU can readily be scaled to provide monitoring and control of systems across a portfolio of buildings. As costs of devices and services declines and the demands of a shifting occupant base encourage operators to invest in new offerings, the ability to easily incorporate additional solutions will differentiate MDU offerings.

Distributed Architectures Unlock Smart Systems. Intelligent processing and transactional computing cannot occur on clients with intermittent server connections, proprietary "locked" platforms, or large installed footprints. Networking technologies and the standards that support them must evolve to the point where data can flow freely among sensors, computers, and actuators. Software to aggregate and analyze data, with intuitive user/system interaction design techniques, must improve to the point where huge volumes of data can be absorbed by human decision makers or synthesized to guide automated systems more appropriately. Devices that host intelligent software components must communicate to other devices directly (peer-to-peer) or to logical collections of devices (peer-to-group) in any programming language, and do so autonomously, with or without network connectivity.

Key Supplier Considerations

Technology, equipment and service suppliers have opportunities to leverage connected devices and services to differentiate their offerings and increase margins. Success depends on their ability to develop business models that enable efficient delivery and support of those offerings.

Collaborate Between Organizations. Industry participants are beginning to realize the importance of having continuous interactions within an ecosystem of partners and allies. As information, automation and equipment systems become more complex, customers are looking to suppliers to provide broader services and address business outcomes. Companies who choose to address the Smart Systems market on their own will undoubtedly fall short of their true potential. Partnerships that encompass all aspects of production and service provisioning are necessary to create and capture value from increasingly complex Smart Systems. OEMs and service providers need to partner with technology and device manufacturers to develop the requisite sensing, connectivity, analytics, control, and autonomy capabilities for new and enhanced services. Providers must keep an eye on the adoption of in-unit connectivity platforms, whether a specialized hub, gateway, smart phone or speaker, as popular offerings present a valuable channel to providing new services to end-users.

Establishing a Service-Oriented Business Model. Simple, product-oriented business models ignore significant opportunities for revenue throughout a product's life cycle. Equipment manufacturers must recognize the opportunity to leverage sensing and connectivity in their offerings to provide new monitoring and management services. Traditional service providers can utilize connected devices to capture new revenues with enhanced or new adjacent services, increase customer satisfaction and acquisition, and even increase margins by reducing the friction of service delivery and value creation. As connected devices proliferate, suppliers will be able to establish an ongoing relationship with customers based on post-sale services that provide greater value to end-users. Senior executives must recognize that realizing this opportunity requires shifting from a product-centric to a solution-centric business model.

Process Differentiation. Successful suppliers are shifting from a focus on product differentiation to focus on process differentiation, including customer service, supply chain, delivery, and support. Initial and ongoing support of connected offerings is one of the most significant criteria for success, creating a major opportunity for installers and systems integrators as equipment and tech suppliers are often poorly organized to provide these services. Suppliers must therefore develop business models that incorporate installer and integrator margins to ensure that these parties are adequately incentivized to assist in solution delivery.

Address the Reality of Customers' Environments. As customers continue to invest in new network and communications technologies, a significant premium will be placed on leveraging legacy equipment due to the large investments required to replace them. Since legacy equipment will continue to be part of building systems for years to come, solutions that integrate and share legacy system data with new systems will be highly valued.

Security Cannot Be Overlooked. The importance of securing systems to prevent theft of data and IP and ensuring the safety of operations and building occupants requires players to prioritize security and support throughout the product's life. Adopters, often possessing little background or interest in IT systems, must be provided with the appropriate tools and support to effectively and securely deploy and use connected offerings.

Organizing for the Future of Smart Systems in MDUs

There are several significant opportunities for emerging and incumbent equipment and service providers to become Smart Services providers in MDUs. Rising technological fluency and consumer demand for smart devices and services with proven value will accelerate adoption, enticing more players to take part in this market. As the underlying technologies advance, processing tools become increasingly powerful, and innovative business models are developed, new opportunities will arise - companies must begin preparing if they wish to remain competitive.

Brokering Emerges with Proven Data Privacy: Transparency and trust will enable suppliers to utilize end-user data to provide new services and benefit from both new revenue opportunities as well as enhanced service value and delivery. If suppliers can prove that end-users' personal devices and data are safe from external attack, users have demonstrated a willingness to share data with suppliers in exchange for more personalized, higher value services. Suppliers must embed data capture and two-way communications into offerings, make clear the benefits that users will capture by sharing data, and clearly define data usage terms.

Platform Players Leverage Ecosystem Control: IoT hubs and platform offerings are driving interoperability between devices and services from a range of vendors, overcoming the lack of standardized protocols for data formatting and communicating within and across buildings. The providers of these platforms sit at a critical control point in these ecosystems, particularly players with both a dedicated customer base and strong relationships with suppliers who can provide a comprehensive suite of offerings. From their control point of ecosystem offerings, platform providers will expand their reach from device and data management and application enablement into adjacent services. Asset management, insurance services, security monitoring, resource management, energy delivery within increasingly local grids, and even network services all fall within the realm of services that disruptive platform providers might expand into from their ecosystem control point.

Hidden Complexity with Intelligent Automation: As more devices become connected and enable more services to be delivered, the complexity required to manage the system threatens to erode the value that users receive. Ensuring that net value creation is positive (that connected value exceeds complexity cost) means that the vast majority of device and system interactions must occur in the background of users' lives. Put another way, suppliers should be less focused on whether to provide computing device interactions via touch or voice interfaces and more focused on figuring out how to avoid interactions altogether. Open source semantic data models are enhancing the ability of machine learning software tools to contextualize and automate services based on programmed and learned preferences. In this sense, artificial intelligence has the potential to be not just another software tool, but the next platform from which computing takes place, orchestrating automated, personalized actions in the background of end users' lives that maximize efficiency while increasing comfort, convenience, and peace-of-mind.

MDUs are a Proving Ground for User-Focused Smart Buildings

The MDU market, representing over 40 million units in six million buildings across the United States and Canada, has remained underserved by the suppliers of commercial and single-family residential buildings and thus remains largely unconnected, creating a significant opportunity for suppliers. MDUs sit at the intersection of residential homes and commercial buildings, forcing suppliers to cater

to a unique set of needs. While building structures and centralized HVAC-R and air/water distribution systems are reminiscent of commercial buildings, the close consideration of individual unit occupant needs is similar to the demands of the single-family home market.

The fragmentation of the supplier base is exceeded by that of the adoption base, with owner/operator type, building physical structure, and occupant persona affecting the desire for various use cases, the makeup of those solutions, and the optimal delivery channel. Ultimately, the variability of building types, number of stakeholders involved, and low margins are the primary reasons that commercial building automation players have not developed MDU solutions to date. Meanwhile, home automation providers have failed to develop solutions which create value for both MDU occupants and building operators/managers while adding minimal complexity to holistic building management.

The era of buildings that do not create tailored value for building users who expect connectivity-enabled convenience in all aspects of their lives is rapidly coming to a close. Ultimately, offerings that create value for building operators while also delivering personalized value to occupants/tenants will evolve out of the MDU market and dominate the buildings space. The MDU market will be a proving ground for innovative offerings; solutions that find success in MDUs will expand across the market and create broad-reaching, multi-stakeholder value for users in all building types.

Notes

1. Interview with Product Manager at Optergy, 2 February 2017; Director of Product Management at Dude Solutions, 2 February 2017
2. Interview with Executive at BuLogics, 11 January 2017
3. Interview with Executive at StratIS, 19 January 2017
4. Interview with VP at IOTAS, 12 January 2017
5. Interview with Executive at WhiteSpace Building Technology Advisors, 05 January 2017
6. US Census Bureau, Statistics Canada, National Multifamily Housing Council, HRI Analysis
7. Interview with Vice President at NMHC, 13 January 2017
8. Interview with VP at the National Multifamily Housing Council, 30 January 2017
9. Interview with Executive at Dwelo, 27 January 2017
10. Interview with Vice President at Alarm.com, 05 December 2016
11. Interview with Editor of AutomatedBuildings.com, 05 January 2017
12. Interview with Executive

1. SMART SYSTEMS OVERVIEW

1.1 REPORT INTRODUCTION

This report was prepared by Harbor Research for the Continental Automated Buildings Association (CABA) Connected Home Council (CHC) to examine in-depth the impact of Smart Systems in the multi-dwelling unit (MDU) buildings market segment. In doing so, this report provides actionable insights and data, as well develops business cases that identify barriers to adoption and new revenue opportunities for incumbent stakeholders in the MDU value chain and potential new entrants.

The opportunities presented by Smart Systems within MDUs are examined for stakeholders including building occupants, owner/operators and property managers, builders and developers, integrators and installers, technology manufacturers, equipment manufacturers, and service providers, including: insurance companies, net service providers and utility companies. For greater detail on the background of this report, including further information regarding CABA, Harbor Research, and the research methodology, please see Section ES.1 of the Executive Summary.

1.2 INTRODUCTION TO SMART SYSTEMS

The emergence of Smart Systems is unleashing an age of "always-on" connectivity in which every connected product turns its manufacturer into a new kind of "Smart Services" business. We have entered an era where people, business and social organizations are beginning to understand the profound impacts that awareness, collaboration, and intelligence will bring. In the not too distant future, hundreds of millions, then billions, of individuals and businesses will interact with billions, then trillions, of smart, connected devices, stretching the boundaries of today's business and social systems and creating the potential to change the way we work, learn, entertain and innovate.

The intersection of sensing capabilities, intelligent device connectivity, cloud computing, and big data analytics creates new value across the business and public systems spectrum. Cloud computing services and large-scale data management infrastructure services will increasingly dominate information and communications technology (ICT) systems and services development. Coupled with the maturation of IoT technologies, these trends are beginning to transform enterprise and public sector systems and have the potential to create unimagined new value at two disparate ends of the business spectrum.

Cloud computing has been rapidly embraced by enterprise, putting managed information technology (IT) services in an increasingly dominant role in ICT systems and networked services development. At the other end of the spectrum, we are witnessing the transition of IoT product companies into value-added service companies. Manufacturers are learning that by connecting their products via networks they are essentially placing themselves into continuous contact with their customers, thereby enabling them to better understand their customers' needs and act appropriately.

The convergence of these two trends creates an opportunity for new, differentiated business models which cleverly combine the potential of both. The two need to be interwoven and mutually supportive, and success will be had only by the player that effectively utilizes their combined potential.

A new generation of information architecture (including hardware, software, network technologies and application services) will provide real-time awareness based on inputs from machines, people, video streams, maps, newsfeeds, sensors and more. This architecture allows for the integration of people, processes, and knowledge to create a collective awareness that better informs decision makers. This emerging paradigm is driving businesses to address the need for a fundamental shift in their strategies and structure, due to the opportunities arising from the shift from a "product-centric" to a "Smart Services-centric" model, which leverages connected products to provide value-adding services over the life of the product.

1.3 SMART SYSTEMS TRENDS & FORCES

We believe Smart Systems that connect people, devices, business processes, and content to enable collective awareness will drive a multi-year wave of growth based on the convergence of the virtual and physical worlds. The Internet of Interactions, between and among "Things" and "People," requires much more than simple incremental improvements in today's technologies to be fully realized. The challenge is much more than a simple patch, Band-Aid, or new flavor of what we already do.

What's required is a true shift in thinking about how devices, people and physical systems will be integrated and how they will interact. We need an approach that is not about leveraging aging IT technology into a new application context; it's about looking forward to a single, unified architecture for the nearly infinite interactions to which any person or thing can contribute.

1.3.1 Overarching Forces & Impacts

Several fundamental changes in the way that these systems are defined and how they are being deployed are laying the groundwork for this architecture to become a reality:

Networking: How will the physical aspects of this networking actually take place? How will virtually any device, right down to a lowly lit light bulb, become a peer that connects at will to the global data network?

"Internet" is short for "internetworking." The Internet was designed in the 1960s to allow the incompatible data networks and computing systems of the time to share information—to "talk to each other," as people like to say. The Internet is literally a "network of networks." That's what the "inter" means. The public Internet as we know it today is a worldwide embodiment of those original data communications protocols—which are, by design, extremely simple. For this discussion, their key attribute is that they make very few assumptions about the data they are sending and the devices connecting to the network to send and receive data. It is this extensible, technology-neutral basis of the Internet that has allowed it to scale so dramatically (and gracefully) since its inception, with minimal central administration.

Smart Systems hold the potential for what Harbor Research calls "the networking of every manufactured thing," but it also presupposes the existence of "a zero-infrastructure, ad-hoc network" that makes seamless physical connection possible. Obviously, billions of devices of wildly varying types cannot each receive individual attention and configuration, or conform to elaborate *a priori* specifications. If it literally takes a network engineer to screw in a smart light bulb, pervasive computing is never going to work. An elegant answer is offered by IP, which is predicated upon the idea that we already have an excellent way to get every conceivable device on the Internet—the original design principles and protocols of the Internet itself.

Computing Meets the Real World: Experience tells us that traditional IT and network services players do not understand how to translate the value of computing and networks into the real (physical) world. They are clueless when it comes to integrating information and communications technologies with real time intelligent sensors, machines and infrastructure. The next big thing is really about the

idea of embedded intelligence, communication, and control in physical systems—biological, mechanical, and electronic—becoming much more intimately integrated with more general-purpose computing and networked systems.

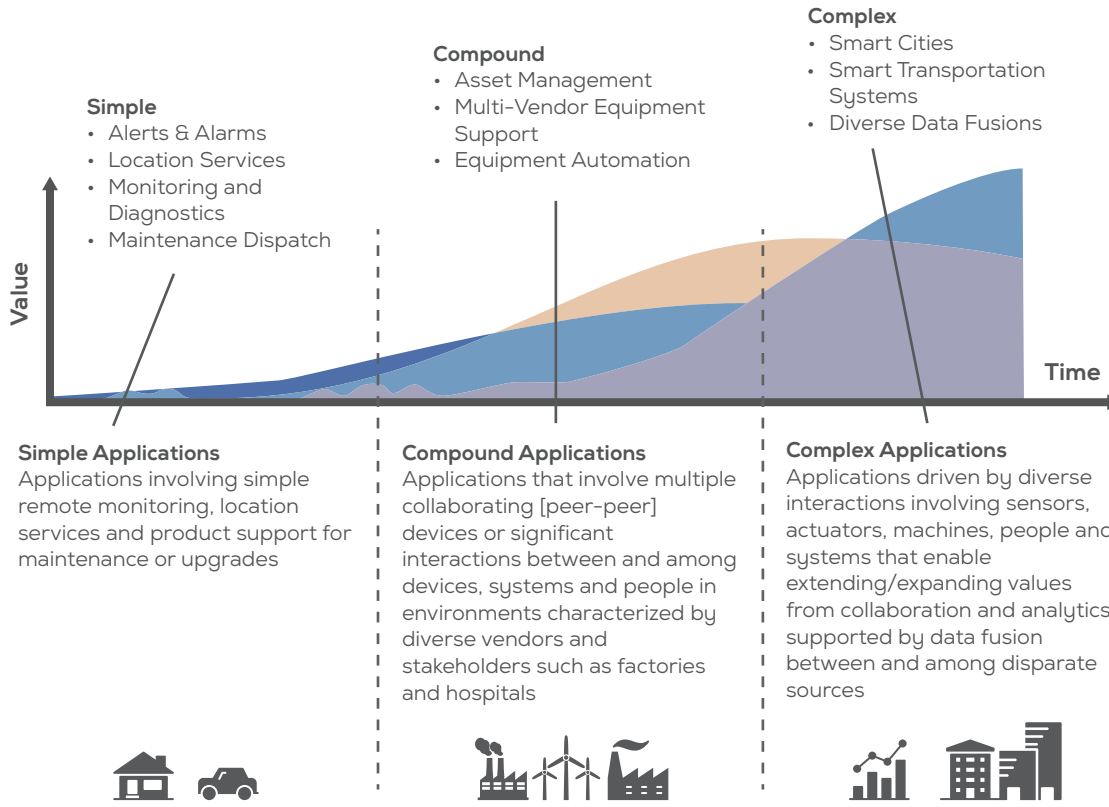
Next Generation Connectivity, Cloud, & Services Delivery Platforms: Next generation technologies for unified communications, embedded systems, network enablement tools, virtualization technologies, and software services delivery infrastructure will be the foundational elements. Beyond these core technologies, new platform capabilities will revolve around real-time situational awareness and automated analysis. As a result, technology moves beyond just proposing task solutions — such as executing a work order or a sales order — to sensing what is happening in the world around it, analyzing that new information for risks and possibilities, presenting alternatives, and taking actions.

Awareness-Driven Application Services: As enablement technologies take a stronger foothold in the Smart Systems market, new sensor technologies allow customers to gain deeper insights into the way their business functions, and in turn, develop new potential services to maneuver into. Increased sensing and instrumentation combined with new software to increase "awareness" in physical systems will drive a revolution in business processes, including asset management, supply chains, energy management, and other applications. Increasingly, vertically focused solutions integrate awareness of all the people, processes, systems and assets a company has or serves to allow for real-time, cross-system enterprise management.

Unlocking the Value of Smart Systems: The convergence of large-scale data management and networked computing with real time machine intelligence is driving the integration of the physical and virtual worlds. The intersection of these trends - the Internet of Things and People - can create unimagined new values if enabled by appropriate data and analytic tools. Sensors, machines and a wide range of devices will generate massive amounts of structured and unstructured data, requiring a whole new class of data modeling, management and analytics tools to uncover and capture value. In the hands of talented users, analysts and data scientists, these data will generate productivity improvements, uncover operational risks, signal anomalies, eliminate back-office cycles, and even drive enhanced security protocols.

Increasing analytic capabilities, combined with connectivity, data storage, and processing advances are enabling use cases to become more complex, creating more value for a wider variety of stakeholders. Smart Systems have traditionally focused on "simple" applications involving a single device used in monitoring and alerting cases. Interoperability and increasing capabilities are enabling "compound" applications, in which a simple application is coordinated with others, sharing data and orchestrating device actions. "Complex" applications, which drive interactions across many devices, systems and people, are no longer predominantly held back by technology, but rather by business models. Without the structures in place to develop and capture value from multi-vendor solutions, these applications will remain elusive.

Figure 1.1 The Value of Smart Systems in Increasingly Complex Applications



1.3.2 Trends & Forces

Whenever Harbor Research considers the trends and forces having an impact on any market, four types of trends are taken into account: Technology, Customer (technology adopter), Competitive (technology supplier), and Socioeconomic. These four trend types help to paint a picture of the market that includes all relevant dimensions.

Technology Trends & Forces

Existing technology has proven cumbersome and costly to apply, with many conflicting protocols and incomplete, component-based solutions. The return from investment in simple applications, while extremely valuable, is limited to the manufacturer's service delivery efficiency. As technologies mature and open standards and collaboration become the norm, applications based on deeper, peer-to-peer interactions between devices, systems and people will drive more compound and dynamic value streams. These compound and complex value-adding applications will be responsible for a large share of the revenues generated by Smart Systems.

We expect the decline of connectivity costs, coupled with the rise of new features from network operators and IT infrastructure suppliers to continue driving the connectivity trend. These additional technology trends will also affect investment flow in Smart Systems over the next five years:

Bringing Cloud Computing to the Edge: More connected devices means more infrastructure is needed to collect the data from such devices, organize it, and structure it in a way that can allow for real-time analytics. Some providers believe that doing this through the cloud will waste space and time, and that some of the process can and should be done at the edge itself using infrastructure like a network router. This would free up bandwidth while allowing continued performance of Smart Systems in the event of a

network or (as with Amazon's recent S3 malfunction) server failure. This localized, distributed computing can also provide companies enhanced security for sensitive information by avoiding that data being transmitted to distant data centers.

Analytics Applications Driving Diverse Opportunities: Combining and analyzing datasets across markets has the opportunity to unlock massive value. We've reached the tipping point where the IoT is becoming commonplace, and where capturing and learning from device and machine data is fast, cheap, and easy. Analytics capabilities are finally robust enough to be applied for direct value across many diverse applications. Achieving a higher level of integration between analytics systems and the many remote monitoring and data integration platforms now entering the market can help bring these insights within reach.

Open Source Software Platforms: Open source software platforms are becoming more widespread and will continue to drive software applications in the face of the myriad of different devices and disparate protocols through which these devices connect to the Internet. As open source platforms become the standard, users will have the ability to personalize their experience, aggregating more devices on a network and combining the data received from these devices into more integrated and encompassing solutions.

Security Receives Due Attention: There is growing concern regarding the security of smart devices and the networks to which they are connected. As the number of devices connected to the Internet increases, so too does the threat of malicious activity. If hackers can access a manufacturer's automated processes, they could wreak havoc on the production line resulting in downtime and loss of revenue for the manufacturer. This same idea applies to all venues and all applications. Security is a far more deeply rooted challenge than people understand—and no one wants to shoulder the responsibility. The supply-side technology vendor solution models may not even qualify to be relevant in the future. The current models like big IT services may not suffice. There may be transition and evolution from new players we have not anticipated. Technology providers must address this issue or risk the entire smart systems opportunity.

Unified Software Development Framework: As the number of nodes being connected to the network increases, so too does the complexity of the network. The fact that so many devices can now interact with people and other devices anywhere, in real time, points to the increasing complexity of technological products. For example, software for the average mobile phone contains more than 10 million lines of code; over the last five years, software in automobiles has grown from an average of 35 million lines of code to more than 100 million. This astronomical growth of features and functions pushes the bounds of what those products' software designers ever had in mind. As customers expect evolving software tools to be functional, ubiquitous, and easy-to-use, a common means of development is required that can leverage tools, tasks and code across families of interrelated devices.

Competitive Trends & Forces

Business challenges for suppliers of Smart Systems are abundant. Moving from "Simple" to "Compound" applications involves multiple collaborating systems with significant interactions between and among devices, systems and people. No longer is the focus solely on the product supplier's ability to deliver support for their product efficiently. Rather, value is brought to the end-user and customer through integration of multiple parallel ecosystem participants, as well as from business process automation and optimization.

The vendor landscape is increasingly crowded with many new personas. Product vendors, services suppliers, and a host of specialist technology and application players will need to address and strategize around the following forces:

Collaborative Communities: Many of today's connected devices enable only simple applications of the IoT (e.g., tracking assets, monitoring statuses, product support). This is due to the traditional view that a company must derive value internally without help from outside businesses. However, compound and complex systems, where most of the Smart Systems value resides, will only come to fruition once fluid relationships are made. These require open alliances between suppliers rather than hub and spoke networks of bilateral alliances. Collaborative communities between all aspects of the production and distribution process are necessary for companies to capture the most value from the market.

Data Analytics Enabled by A New Generation of Players: There have been signs of this beginning to emerge over the last two years. Today it has become evident that the large business intelligence incumbents are not in the driving seat in this market, despite their recent dominance. A growing number of relatively young companies are introducing products that have been purposely designed for IoT data integrations and analytics. For providers of core device integration and management platforms for the IoT, developing partnerships to extend the platform's reach beyond simple monitoring to machine data analytics capabilities is a prime example of an opportunity to differentiate offerings and gain market share.

The convergence of IT and OT: Information technology and operational technology (OT) have long been stuck in their ways, having the preconceived notion that the responsibilities and capabilities of each are completely separate from the other. Yet, these segments of a company must be able to work together to properly collect and use the data generated by devices and processes of Smart Systems. As the IoT becomes a bigger part of everyday life, those companies that are able to integrate the IT and OT departments will be poised for success in the Smart Systems market.

Recognizing the Smart Services opportunities: Just as data analytics can influence business processes, data on user behavior can further be utilized to improve end-user experience. The idea of companies providing enhanced services related to their products is central to the proliferation of IoT devices. Providing services like preemptive maintenance and personalized support opens revenue opportunities many times greater than only selling products. What's more, such services extend a company's interaction with their customers, leading to more opportunities as the relationships progress. Companies that recognize these opportunities and incorporate them into their offerings will have the best positions moving forward in the Smart Systems market.

Customer Trends & Forces

The traditional notion of Smart Systems applications has largely grown up in a B2B context – equipment manufacturers developing remote services and support automation tied closely to their equipment service contracts. These models are focused almost exclusively on customer support and automation – not on new Smart Services value beyond support. As these two classes of business models inch closer to each other in the marketplace it is increasingly evident that the consumer Smart Systems business models provide many lessons for the "cloistered" equipment manufacturers in B2B arenas.

Product manufacturers have focused strictly on their own value chain and aftermarket services for too long, missing the services opportunity that lives within the customer's product life cycle. Manufacturers of equipment and machines are now beginning to use their historic strengths in key verticals to move into Smart Systems. Players like GE, Bosch, Honeywell and Siemens are now building and offering IoT products and platforms. While most people don't think of GE or Bosch as IT vendors that compete in the same space as IBM, Oracle, SAP or Microsoft, they clearly have intent to cross and integrate the "OT" – "IT" canyon in order to meet growing demand for adaptability, agility, and capability.

The following customer forces are affecting the way product manufacturers and technology adopters direct support for their customers:

Data Driven Security and Privacy: Security and privacy have become increasing concerns for the development of the IoT. As of today, there are very few regulations regarding who can collect data, what data can be collected, and what can be done with the collected data, as well as any foreseeable method of securing devices or regulation of the overflow of data. The lack of regulation leaves many questions in the eyes of customers who own the devices being monitored. Top IoT providers are integrating the rigorous best practices developed in the IT sector into their offerings, and gaining a competitive advantage among astute customers in the process.

Customizable Customer Support: As technology adopters are able to gather more data and information from their connected devices, customers will expect better service that is tailored directly to their individual needs. This data is allowing adopters to pinpoint a customer's issues and apply the appropriate applications or service deliveries to fix the issues and to fulfill the customer's needs while increasing revenue.

More Internet Users: The increasing number of connected users with mobile devices is driving services that are geared more towards end-users. Not only do end-users expect suppliers to anticipate their specific needs, they will want suppliers to project an experience for them on their mobile devices through a host of tailored application platforms.

Demand for Preemptive Maintenance: Advances in technology, shifting demographics, increasing machine complexity, and pressures to cut costs are driving significant changes in maintenance practices, with most customers recognizing the benefits of just-in-time service.

Customers are Already Moving Forward: End customers are typically already integrating data aggregation, management and analytics tools and have organized data stores that can be combined with data from wireless sensor and device applications. As the market continues to mature, specification of wireless connectivity and mobile services solutions will shift towards end customers and greater end customer spec influence will grow.

Increasing Demand in Add-On Services: Customers are looking to equipment manufacturers not just for high-quality equipment, but also for help in optimizing their ability to supply consistent and high-quality products and services to their customers. This evolution will allow manufacturers to tie their revenue and pricing models directly to the benefits they provide. Applications that drive interactions across enterprise and public sector systems will potentially allow extending and expanding values from third-party collaboration and large scale data integration and analytics that, while complex, will drive maximal value creation from Smart Systems.

Socioeconomic Trends & Forces

Several external market factors across the global economy are presently driving regulatory and policy initiatives, demographic changes and cultural shifts that are affecting the overall economic landscape and adjusting the context in which Smart Systems growth is occurring. These forces include:

Increasing Energy Demand: Electricity consumption in most developed economies is growing at roughly two percent per year[1] and has been doing so for many years while supply capacity has been steadily falling. Unpredictable energy prices and steadily growing global demand have varied effects. Energy consumption accounts for a large and variable cost component, contributing to ongoing interest in reducing dependence and usage. This is a significant driver in energy management systems to reduce environmental impact and save on energy and maintenance.

Re-urbanization: The movement of people back into cities has changed the way people interact with buildings. Mixed-use buildings are becoming increasingly common. This means that buildings are now required to be accessible at all hours of the day, yet completely secure. They must operate completely efficiently, yet must remain flexible as the traditional 8am – 6pm work hours are no longer the only hours determining necessary functionality.

Longer Lifespans: People are living longer, augmenting the strain on infrastructure such as the healthcare, welfare, and insurance systems. A 65-year-old has a 70 percent chance of needing long-term care, which could cost as much as $300,000 over a lifetime. Healthcare costs continue to be a driver for innovation in the IoT. As people age, there is a higher demand for products that monitor health, both by the people themselves and insurance companies. The use of sensors in monitoring medical device such as pedometers, blood glucose wearables and magnetic resonance imaging equipment are becoming increasingly necessary to keep healthcare costs down.

Aging Workforce: Longer lifespans lead to people working longer before retirement. By 2020, 25 percent of the US workforce will be 55 or older, up from 13 percent in 2000.[2] When these workers decide to retire, they leave behind a skills gap that will require companies to devote a greater amount of resources to the training of new workers. This provides an opportunity for the replacement of some of the more menial jobs with automated processes. Increased automation supports an already burgeoning tech job market. This shift is especially relevant for manufacturing industries, as younger workers are largely uninterested in simple factory jobs held by past generations.

Government Investment in the IoT: Governments are beginning to invest in the IoT to create comparative advantages and stimulate innovation within their countries and cities. Germany's 2012 Industry 4.0 initiative aims to help German companies capitalize on the IoT. China has pledged to spend $600 billion on IoT projects through 2020 and has been declared the world leader in the space. The United States has 750 major IT projects in the works, including the White House SmartAmerica Program that encourages private and public innovation in Smart Systems. Cities such as San Jose, California; Incheon, South Korea; and Barcelona, Spain are investing and participating in Smart City programs.

Congestion of Transportation Infrastructure: As populations continue to grow and re-urbanization brings more people into cities, there will be more cars on the road and more strain on transportation infrastructure. This causes economic losses for people in the form of time, with the average person in Los Angeles, California spending 90 hours a year stuck in traffic, and a decline in the health of transportation infrastructure. Smart Systems will come to replace existing infrastructure as it fails, and consumers may opt for smarter vehicles and products that can communicate with such infrastructure. These improvements will have the dual purpose of extending the life of the transportation system in general while providing a safer environment for people using the system.

National Security: National security continues to be a main concern for governments and people alike. Leaks of government documents have fostered civil unrest in regards to external and internal spying on the personal lives of citizens. In addition to espionage, terrorist activity continues to be a problem for many countries around the world. Together these threats provide a niche for infrastructure monitoring and technological security solutions made possible by Smart Systems.

Near-Shoring and Re-Shoring: China's cheap labor supply is dwindling and wages are rising. For the manufacturing giant, this means lower levels of growth, as less foreign companies will decide to offshore their manufacturing to China. For the rest of the world, the trend is now moving towards near-shoring and re-shoring. To lower the cost of transporting materials and products, companies are beginning to locate manufacturing facilities closer to home and near bigger markets. Many US companies are now

re-locating factories to Mexico, where wages are lower across all markets of factory work than in China. Re-shoring is taking place as well, as capital-heavy companies are now substituting capital for labor. As technology improves and capital becomes cheaper compared to human labor, automated processes will make manufacturing more competitive in developed countries, resulting in the re-shoring of industry.

1.4 MARKET DEVELOPMENT CHALLENGES AND OPPORTUNITIES

We are reaching a critical juncture in market development where engineering organizations will soon be crying out for a completely new approach, one where the network operating system and its components can be utilized again and again across an ever-broadening spectrum of devices, applications and business processes. With this juncture comes significant opportunity.

When it comes to preparing for the global information economy of the 21st century, most people assume that "the IT and telco technologists are taking care of it." They take it on faith that the best possible designs for the future of connected things, people, systems and information will emerge from large corporations and centralized authorities. We strongly believe those are big, unfounded assumptions. In fact, most of today's entrenched players are showing little appetite for radical departures from current practice. Yet current practice will not serve the needs of a genuinely connected world.

In order to realize the full potential of the IoT, we will have to find a stable solution that effectively balances human interaction and technical autonomy. We have a long way to go before we reach this equilibrium. Data from sensors, along with information from social networks and the Web, will freely and creatively combine. While this integration and interaction is still decoupled, the online integration of the physical world and the virtual world is progressing. Sensors and monitoring programs are not acting alone, but in concert with their human partners and an increasing number of machine learning algorithms. Data analysis, visualization, and other techniques for seeing patterns in data are going to be increasingly valuable moving forward.

Realizing this new mode of interaction requires shifting the focus from simple device monitoring to a model where device data is aggregated into increasingly complex applications to achieve true systems intelligence. It's a shift from knowing "what happened" to knowing "what is happening" all the time, and automatically controlling systems with that knowledge. While some companies will always choose to stay with the status quo, leading product OEMs will vigorously embrace the power that lies within self-initiated communities. Particularly as customers begin to expect the immediate gratification or responsiveness to their problems that device and social networking enables, companies will want access to the device data and content necessary to delivering the full customer experience. This opportunity, when brought to fruition, will have an enormous impact across virtually every market of the global economy.

Though their business models are intermingling today, all of the major categories of traditional solution suppliers have historically operated within well-established business models that reflected the distinctive competencies that each group believed to be at its core. The advent of Smart Systems is blurring these legacy business models and forcing all the major suppliers to re-think their strategies. In addition to creating robust solutions that meet tangible customer needs, providers will be responsible for tackling a host of demanding challenges, including:

Lack of Interoperability: For all their supposed sophistication, many of today's IoT systems are a direct descendant of the traditional cellular telephony model where each device acts in a "hub and spoke" mode. The inability of today's popular enterprise systems to interoperate and perform well with distributed heterogeneous device environments is a significant obstacle to the development of compound applications.

Device Disparity and Complexity: The growing disparity of devices on networks is diluting the ability of technicians to effectively manage them. Each new device requires too much customization and

maintenance just to perform basic tasks. Software and methods must evolve to speed development, facilitate re-use and automate support or risk constraining the growth of this market.

Antiquated Web Architecture: The growing scale of interactions between devices with more and more features for producing and consuming device data and the antiquated client/server architecture of the Web is a disaster in the making. Devices will need to host intelligent software components that communicate to other devices directly (peer-to-peer) or the logical collections of devices (peer-to-group) in any programming language, over any network, and do so autonomously.

Little Collaboration: To overcome the lack of interoperability and the complexity of devices, technology providers will have to make an effort to collaborate with adopters as well as other providers. Current business models are structured in a way that doesn't allow this to happen, and therefore must be modified with collaboration in mind to bring the IoT up to its full potential.

The convergence of innovations in software architectures, back-room data center operations, wireless and broadband communications, and smaller, powerful, and numerous client devices connected to personal, local and wide- area networks will drive a multi-year wave of growth. However, to leverage the full potential of this opportunity, companies will need new system platforms and partners that bring to this opportunity deep knowledge of how smart systems work in the real world. This is not something we can hope for or expect to originate from traditional IT and network services providers.

Notes

1. https://www.eia.gov/outlooks/ieo/electricity.cfm
2. https://blogs.cdc.gov/niosh-science-blog/2012/07/19/agingworkforce/

2. SMART BUILDING SYSTEMS

Smart Building Systems provide a distributed control and information system that enables the control and maintenance of a building environment, leveraging a network of intelligent devices to monitor and control the mechanical and related systems in a building. In this context, our use of the term "Smart Systems" is analogous to what is commonly referred to as "building management systems" (BMS's). The two terms are often used interchangeably, but within this report there is a distinction, and it is one that reflects the key changes affecting the market: our use of the term Smart Building Systems encompasses a broader set of control and information devices and systems.

Simply put, an intelligent building is a structure in which sensors, switches and systems contained within the building's infrastructure are networked and can communicate with each other and with a human operator through a monitoring or control interface. While this may seem relatively straight-forward, like most things, it is far more complex when put into practice.

The building market includes leasing agencies, property management companies, owners, operators and developers. This market is focused on building tenants and residents and is therefore service-oriented. Building managers and tenants greatly benefit from networking and have traditionally applied automated systems to HVAC, lighting, power devices, security and fire and life safety systems.

Forward-looking building managers are seeking cost-effective means for better coordination of traditional systems while linking to other systems, such as external lighting or parking systems, that have historically been operated in a stand-alone mode. In parallel, the latest wireless technologies simplify installation and reduce the costs to connect a wide range of additional devices, including remote sensors. As the costs of networks and associated monitoring and control systems continue to drop, the potential market in smaller buildings, including residential properties, increases dramatically.

The desire for simplicity and uptime is largely driven by smaller staffs with less technical ability. In the case of building asset management and support coordination, the objective is to fix problems remotely, or if that is impossible, to dispatch a person with the right expertise, tools, and parts. Traditionally, developers and building managers have networked devices to remotely control and regulate the health and energy consumption of building systems. While this remains a key concern, new demands from power suppliers have prompted interest in more advanced systems that do a better job of balancing environmental comfort while minimizing energy usage.

Building managers will look to use Internet-enabled devices and systems based on open standards, provided they are reasonably priced. Building and facilities managers continue to invest in device networking capabilities to enhance tenant environments and better assess their needs.

The requirements for open standards to foster integration, the promise of lower operating costs and higher customer service levels, and the necessity of integrating disparate legacy systems are attracting adopters to Internet-enabled applications in the Smart Buildings arena. A current snapshot of the buildings sector reveals that progress towards these goals will likely be uneven and "bumpy" because of the diverse range of suppliers and players.

2.1 BUILDINGS MARKET TRENDS & FORCES

Dominant trends in this venue include increased awareness and interest in building systems that provide greater visibility and systems awareness. Meanwhile, ongoing interest in energy management among end-users is driven by socioeconomic factors as well as increased convergence and consolidation in the supplier marketplace as networked products proliferate. These factors are driving end-users towards adoption of solutions prioritizing integration and security issues.

Technology Trends & Forces

Advances in technology are responsible for the shift from basic building automation and management systems to smart, IoT-driven systems. So far, adoption has been limited by many of the same issues that have plagued historical systems and Smart Systems as a whole: security and integration. Security fears have grown as the vulnerability of building systems, often left unattended, has been glaringly exposed. Integration is still difficult. After over a decade of struggling to develop an industry-wide standard, a few winners—BACnet and LonWorks, for instance—have emerged, but confusion has not entirely disappeared. Ultimately, buildings, utility systems and machines will have to collaborate in order to maximize savings and energy use for all, with the potential for significant environmental and quality-of-life improvements.

Falling sensor and device costs. The cost of devices will continue to plummet with advances in silicon, packaging and integration technology making them network fluent and affordable to virtually everyone. Component miniaturization and the integration of a broad range of sensing capabilities into intelligent devices will continue to provide a variety of features that support the integration of digital information and sensory inputs from the physical world, thus broadening the range of possible applications available.

New service capabilities. The storage capacity and processing power of computers will continue to grow exponentially and enable a whole new generation of infrastructure to perform an enormous variety of data management tasks. Both carriers and IT infrastructure providers are working to develop software and data management platforms to support new application services.

Improving interactions. Technology advances have improved and simplified system and user interfaces and interactions, which in turn is driving acceptance of and adoption of increasingly complex offerings.

Distributed information architectures. Systems designed for distributed capture, computing and control are enabling new application and system functions such as exception reporting and edge analytics. Realizing the value of complex Smart Systems applications in buildings will require systems that utilize but are not reliant on remote, centralized servers.

Customer Trends & Forces

Although customers are increasingly interested in what smart buildings have to offer, buying behavior is strongly influenced by whether or not buildings are mission-critical. This has led to uneven adoption across verticals. As building systems become cheaper and easier to integrate, end-users in both mission-critical and non-mission-critical verticals are pursuing new and expanded applications, rather than focusing solely on HVAC and energy management.

Demand for Adaptability. Building operators are prioritizing agility and flexibility, preferring offerings that allow them to expand the number of devices integrated and the scope of services offered.

Occupant-Centric Models. Increasing emphasis on maximizing occupant comfort while optimizing building efficiency is indicative of operators' perception of building users' expectations of space personalization and customization via connected offerings.

Avoiding App Fatigue. Building managers seek new tools that create value without adding complexity to operations. Integrating systems onto a single interface negates the need for a building operator to utilize multiple applications, from multiple mobile or fixed interfaces, to capture value from connected devices and systems.

Cyber-Security. Physical and cyber-security threats to building networks highlight the need for a convergence of IT and facilities security operations, to ensure that new entry avenues opened by connected devices do not threaten cyber or physical security.

Competitive Trends & Forces

The competitive environment in this venue has been experiencing some uncomfortable change as long-dominant incumbents face competition from new technology startups. More innovative players are developing creative solutions, blending existing products with new technology to build entirely new services and business models for the market, like Bytelight's use of Bluetooth LE in LED lighting fixtures and Enlighted's Global Energy Optimization financing option. Service and solution providers in this market must develop offerings that meet the high quality and ROI demands that customers increasingly require.

Opening Systems: Incumbent building and energy system control companies and HVAC players have all been making moves towards open systems to complement their legacy, mostly proprietary, product lines.

Convergence of BMS & IoT: Increasing IoT adoption in buildings is driving demand for a common IP platform from which to exchange information and feed common analytics engines, making non-IP compatible communications standards decreasingly valuable.

Suppliers Addressing Homes or Commercial Buildings: Suppliers have largely ignored the multi-family space, focusing instead on either commercial buildings and single-family houses. MDUs remain a "niche" market that traditional suppliers have underserved.

Rise of Smart Home Hubs: Consumer tech providers continue to expand smart home offerings through partnerships and acquisitions, leveraging brand recognition and customer trust to spur adoption of new devices and services in the home.

Socioeconomic Trends & Forces

Increased government activity and the variable cost of energy both have significant impact on the smart buildings market. Energy trends and regulatory standards can support or constrain demand across the entire market. For instance, the European Union, where many are deeply concerned about energy security and climate change, has set the bar very high for member countries. By 2020, member states must have building codes in place, requiring that all newly constructed buildings consume nearly zero energy.

Climate Change Policies: Initiatives to reduce emissions from the buildings sector are driving adoption of building management systems (BMSs), which increase operator visibility into consumption patterns and automatically increase the efficiency of critical building systems.

Continued Urbanization: Increased urban migration and rising metropolitan densities is increasing the number of high-rise buildings, for both residential and commercial purposes, in which adoption of automation and management offerings is highest.

Generational Turnover: Increased penetration rates in residential and commercial buildings of tech-fluent Millennials and Generation Z occupants is driving adoption of connected products and services that personalize user environments.

2.2 SMART BUILDING SYSTEMS TECHNOLOGY ENABLERS

The required technology stack for capturing and utilizing data to generate new value from Smart Systems in buildings is composed of four layers, representing four primary revenue opportunities for technology suppliers.

Figure 2.1 Smart Systems Revenue Opportunities

Value-Added Application Services	Value-Added Application Services revenues are derived from the installed base and modules, together with an average revenue per device unit for each application service and venue
System Applications	Systems Applications revenues are derived from the installed base of connected devices and modules, together with an average monthly service charge for each venue
Network Services	Network Services revenue is derived from the installed base of embedded devices and modules actually connected rather than those shipped and the average revenue per device
Enablement	Enablement revenue is derived from a combination of connected devices/module shipments, their average selling prices and costs associated with hardware, embedded software and related engineering

2.2.1 Enablement & Security

Enablement encompasses the hardware and software that enables secure device connectivity. Board and silicon connectivity componentry, from suppliers such as ARM or Intel, provide the foundation for communicating with local or wide area networks. Falling silicon prices and the decreasing pace of processor improvements is leading to new approaches to integrate system architectures at the device level. Meanwhile, software has rapidly grown in importance and value, as innovative architectures allow increasingly powerful software to be embedded in chips.

These software developments have increased the capability of security services performed at the device level, protecting the privacy of data captured and transmitted while restricting unauthorized network access. Data encryption, end-point authentication, pre-boot verification and public key cryptography are all important aspects of embedded security at the device layer.

Data aggregation equipment currently plays a critical role in connecting disparate devices and services operating across buildings with large footprints. Routers and gateways are providing a short-term fix to the interoperability challenge, allowing building operators to interact with systems using numerous communication protocols from a single interface. These devices also offer a platform for more advanced software to perform edge computing, reducing network demands by performing processing at the point of data capture.

Routers and gateways are also a key enabler of securing data transmission and building networks at large. Relative to other venues, buildings are generally at low-risk for cybersecurity threats, due to the relative simplicity of network environments and non-critical systems likely to operate on the network. However, the 2014 Target hack, in which attackers breached the retailer's network by way of the building's HVAC system and stole customer credit card information, made clear the risk posed by adding weakly secured network entry points. Gateways serve as a firewall for such attacks, separating the network into more-readily securable regions.

While network innovations may soon render these capabilities and even the aggregation points themselves redundant, in the near-term gateways and routers offer a straightforward means of providing peace-of-mind with respect to end-users' data privacy.

2.2.2 Networks

This research divides networks into four main types, within which there are many competing standards: Wireline Networks like Ethernet, Wireless Personal Area Networks (WPAN) like Bluetooth, Wireless Local Area Networks (WLAN) like Wi-Fi and Wireless Wide Area Networks (WWAN) like cellular and satellite. While there is an overarching trend towards wireless networks, many markets and applications are still dominated by wireline networks.

Networks in many existing buildings are not capable of effectively handling the number of smart, connected devices coming online. This is particularly apparent in regions like the Northeast United States where buildings are older than other parts of the country. Further, the extent to which networks will need to be expanded and replaced is relatively uncertain. As such, it is important to consider the strength and capacity of buildings' network backbones.

Most network backbones in buildings today are copper and coaxial-based. These networks are fine when only handling classic personal computing devices, but start to run into bandwidth limitations when other smart, connected devices come online. Copper network cable-based technologies continue to improve, however, and protocols like G.Fast, a digital subscriber line (DSL) protocol, and others like AT&T's Internet 1000 (formerly GigaPower) are leveraging existing copper infrastructure to improve network speeds. With this said, these improvements are little more than a "patch" for retrofitting buildings with faster networks at a relatively cheap price compared to fiber-optics technologies.

Over the past 20 years, fiber optics-based network backbones have started to erode the installed base of copper and coaxial. Fiber networks provide a significant bandwidth advantage over traditional networks, but are significantly more expensive and are prone to breaking—fiber-optic cables are made of glass with a coating of rubber or plastic on the outside for protection. In addition, fiber technologies are continuing to improve, and it can be hard to justify the upfront investment when better technology will come along in a couple of years.

Some companies have worked to address these issues in recent years. One such company is Dura-Line, a manufacturer of hardened ducts for network cable. Dura-Line has created a duct specially for fiber cables that protect the cable, while making it easy to add or replace network bandwidth as needed. FuturePath MicroDuct solutions are particularly attractive for new-builds, however, they can be used in retrofit applications as well. More and more, network service providers like AT&T, Verizon and Comcast, as well as new entrants like Google, are leveraging these duct technologies to install their fiber networks in MDUs, often parallel to each other, to support all of the new devices coming online.

Building controls are still mainly based on proprietary legacy wireline networks, although some are built on IP-based infrastructure like BACnet IP. These networks can remotely control lighting, heating, cooling, and door-locking mechanisms as well as interface to safety and security systems for fire, occupancy and security. Although many traditional HVAC and security vendors have been experimenting with wireless technologies, particularly in WLAN and WPAN technologies, there have been few real deployments at scale.

We have also seen a trend to interface legacy and proprietary wireline systems with external cloud and other SaaS providers' systems by using WWAN modems to avoid having to connect through the

building's own infrastructure which is often heavily protected and fire-walled by IT departments. Because of these segregation issues it is rare to see a building where WLAN infrastructure is used to provide full building services.

Another factor holding back deployments of wireless technologies is the difficult radio frequency environment posed by some building constructions methods. This is particularly true in the commercial sector where steel frame buildings with a significant amount of steel in partition walls and ducting make for a complex signal environment. We have seen trials of lossy antenna technology where long, deliberately 'leaky' antennas are threaded through building service trays to provide wide coverage in difficult and often reflective environments.

In the home market, these issues are a lot less complex and WLAN technology is more widely seen supporting building controls and audio visual installations. Even Wi-Fi thermostats are becoming commonplace, and given its inherent advantages of interfaces to consumer electronics and mobile device platforms, we anticipate that many more applications like this will be served by WLAN.

In many MDUs, there exists both the IEEE 802.11-based Wi-Fi networks in the home, usually at the rate of one network per unit, as well as the building control network for the more centralized building systems. While Wi-Fi will continue to dominate the in-unit network, as building monitoring and control systems shift towards wireless networks, there will likely be more IEEE 802.15.4-based networks, particularly ZigBee, or the widely adopted but proprietary Z-Wave, used in the near term to offer wireless connectivity while reducing potential interference between these systems and in-unit Wi-Fi. ZigBee, however, doesn't provide the full range of connectivity and communication capabilities required, and will likely need to leverage some sort of 802.11 standard to provide a complete and interoperable solution. Z-Wave is interoperable with Wi-Fi, and may be an effective short-term solution to wireless connectivity for buildings system while Wi-Fi continues to develop, but develop it will. Through the IEEE working group and the companies that leverage it in the market, Wi-Fi will continue to improve both in cost and robustness. Harbor Research contends this focused attention will result in Wi-Fi coming out on top of the WLAN standards battle, resulting in ubiquitous connectivity throughout MDUs and other types of buildings.

There will likely still be some applications for WPAN and WWAN technologies for specific applications, such as data offloading or remote maintenance and service of high value equipment. Regardless of what communications protocols are leveraged, bandwidth and reliability must increase to support new connected equipment and devices and the software and services provided on top of them.

2.2.3 Systems Applications

Systems Applications consist of software platforms and services for provisioning, certification, and integration of devices, as well as device and data management functions such as: location and tracking, monitoring and state, diagnostics and prognostics, device management and connectivity, and automation and analytics. When considering the development of increasingly complex Smart Systems in the Buildings Venue, data management and analytic tools are worth special consideration.

The convergence of large-scale data management and networked computing with real-time machine intelligence is driving the integration of the physical and virtual worlds. The intersection of these trends – the Internet of Things and People – will create unimagined new values. Data management, analytic tools and new skills will be the core enablers of these new values.

Sensors, machines and a wide range of devices generate massive amounts of structured and unstructured data, requiring a new class of data modeling, management and analytics tools to uncover and capture value. In the hands of talented users, analysts, domain experts and data scientists, these data can generate productivity improvements, uncover operational risks, signal anomalies, eliminate inefficient service cycles, and even drive enhanced security protocols.

The ability to detect patterns in this data to enhance the value created from devices and services is the holy grail of Smart Systems. Machine data analytics, often thought of as part of the evolving "big data" story, allows not only data patterns but a higher order of intelligence to emerge from large collections

of ordinary machine and device data. The implications of mining and analyzing machine data are immense; this is where the real core value creation opportunity lies within the Internet of Things.

Today's information architectures are not well suited to enabling analytics engines to process with velocity data generated at volume from a variety of connected devices. Traditional relational databases, including those utilized by most IoT platform providers, don't free data to enable effective merging of data with other information to promote discovery and intelligence. *What would truly, liberated information be like?* It might help to think of the atoms and molecules of the physical world. They have distinct identities, of course, but they are also capable of bonding with other atoms and molecules to create entirely different kinds of matter with unique and valuable properties.

Taking cues from other data intensive applications such as Facebook, Twitter, Google and others, the open source Project Haystack community addresses this challenge by defining a methodology to describe the meaning of data from smart devices with tags and standardized semantic data models. This enables software applications to automatically consume, analyze and present data from devices and equipment systems.

The Project Haystack community has streamlined the interchange of data and the techniques for managing the vast amount of data generated by smart devices. Companies like SkyFoundry are leveraging the Haystack framework to avoid the confinements and limitations of the today's differing data types and relational database-oriented tools. It allows data to maintain their fundamental identity while bonding freely with other data. Data and information accessibility and cumulative systems intelligence open the possibilities for third-party analytics tools to identify previously undiscovered trends occurring not just within but between Smart Systems.

2.2.4 Value Added Applications

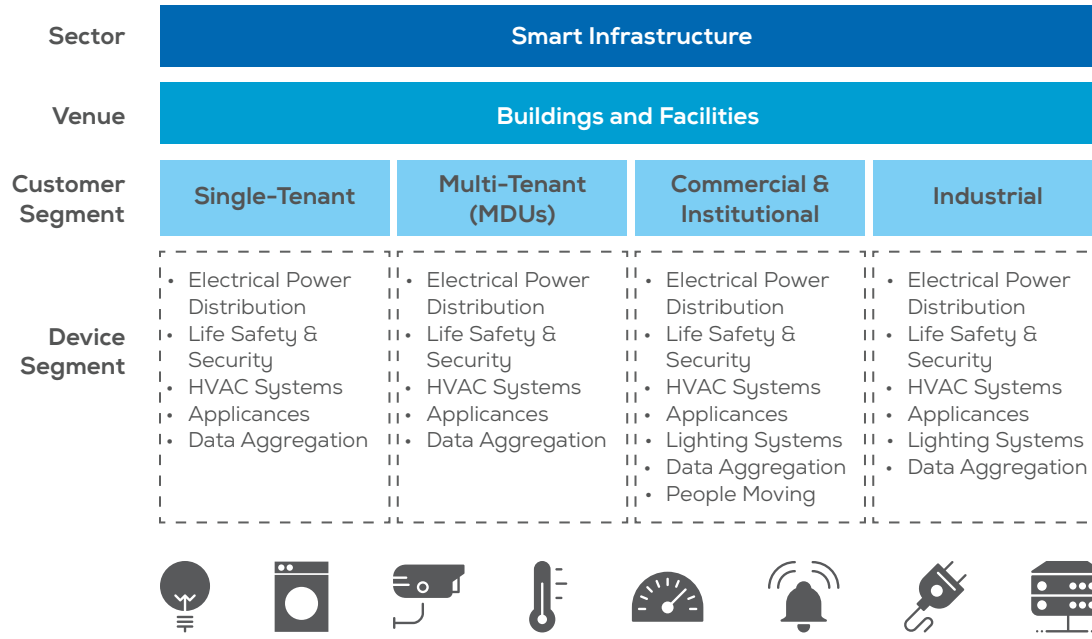
As the number of connected devices, people and processes increase over time, the values created through the interactions of connections will compound, resulting in a system where the whole is greater than the sum of its parts. As these Smart Systems become increasingly complex, Value Added Applications will be the services that translate that value into dollars.

Value Added Applications (VAAs) utilize a set of System Applications to integrate people, business processes and assets into a managed service. VAAs are the primary driver of Smart Systems revenue over the long-term. Given this, it is no surprise that suppliers of all types are seeking to develop new offerings and adjust business models to become providers of IoT-enabled VAAs. The VAAs relevant to the multi-dwelling unit Customer Segment of the Buildings Venue are covered in detail in the Smart MDU Business Opportunities section of this report.

2.3 BUILDINGS MARKET SEGMENTS

This research segments the Internet of Things into five sectors that encompass eight venues. Within the eight venues, there are 29 customer segments with over 400 distinct connected product segments that this research analyzes and forecasts. The Buildings Venue resides within the Smart Infrastructure sector and consists of systems that are either part of the building's internal systems (e.g., HVAC, lighting, electrical power distribution) or devices that are installed on or within buildings that are not meant to be moved regularly (e.g., appliances, security and life safety equipment).

Figure 2.2 Smart Buildings Market Map



The four customer segments within the Buildings sector are organized as follows:

- **Commercial and Institutional**, including: big box retail, specialty retail, malls, office buildings and related commercial real estate;
- **Industrial**, including factories, labs, distribution centers, etc.;
- **Single-tenant residential homes**; and
- **Multi-tenant, multi-dwelling unit (MDU) buildings**, including: multiplexes, townhomes, low-rise, mid-rise, and high-rise condo or apartments.

This report focuses on the opportunities for Smart Systems in MDU buildings, a market that has traditionally been served not by a dedicated set of suppliers but rather by those focused primarily either on commercial buildings or single family homes. The physical structures and centralized building systems of MDU buildings are similar to characteristics of commercial buildings, and the needs of MDU building operators and property managers (which are interchangeable stakeholders for our intents and purposes) are similar when it comes to building and equipment management. However, the presence of occupants means that individual units and common areas must operate more like single-family homes, enhancing the comfort, convenience, and peace-of-mind of occupants. Suppliers coming from both angles, commercial and single-family, have failed to adequately meet the unique needs of this market. Before focusing in on the MDU market, it is necessary to discuss Smart Systems offerings in these adjacent buildings market segments.

2.3.1 Commercial & Institutional Buildings

The market for Smart Building Systems in commercial buildings is well-established and dominated by a handful of global players that have developed and extended their core offerings to add functionality, services and increased architectural openness that integrates equipment into larger information systems offerings. While this move from closed to more open industry-standard-based systems has been underway for more than a decade, the nature of the market and the strong incentives for vendors (and often their customers as well) to stick with more closed systems has meant that a shift to interchangeability and mixed vendor deployments has been a slow one.

The building market includes leasing agencies, property management companies, owners, operators and developers. This market is focused on providing basic comfort and convenience to building tenants while minimizing operator costs. Building managers, who are responsible for energy and water bills as well as property risk management greatly benefit from connected offerings and have traditionally applied automated systems to HVAC-R, lighting, power devices, security and fire and life safety systems.

Forward-looking building managers are seeking cost-effective means for better coordination of traditional systems while linking to other systems, such as external lighting or parking systems, that have historically been operated in a stand-alone mode. In parallel, the latest wireless technologies simplify installation and reduce the costs to connect a wide range of additional devices, including remote sensors. While building management systems have traditionally been limited to large commercial buildings, the falling costs of networks and associated monitoring and control systems continue to drop, creating a potential market in smaller buildings.

The desire for simplicity and uptime is largely driven by smaller staffs with less technical ability. In the case of building asset management and support coordination, the objective is to fix problems remotely, or if that is impossible, to dispatch a person with the right expertise, tools, and parts. Traditionally, developers and building managers have networked devices to remotely control and regulate the health and energy consumption of building systems. While this remains a key concern, new demands from power suppliers have prompted interest in more advanced systems that do a better job of balancing environmental comfort while minimizing energy usage.

Building managers will look to use Internet-enabled devices and systems based on open standards, provided they are reasonably priced. The requirements for open standards to foster integration, the promise of lower operating costs and higher customer service levels, and the necessity of integrating disparate legacy systems are attracting adopters to Internet-enabled applications in the Smart Buildings arena. A current snapshot of the buildings sector reveals that progress towards these goals will likely be uneven and “bumpy” because of the diverse range of suppliers and players.

Across the Smart Buildings market, our previous research has highlighted diverse challenges in realizing such growth, including:

- Difficulty adopting new business models and justifying the business case;
- Complex services and solution-delivery ecosystems that require businesses to relate in new and different ways;
- Anticipation of new product, service and systems innovation modes that are not widely adopted today;
- A fragmented IoT and Smart Systems vendor landscape that is not yet well aligned with the larger IT infrastructure and carrier players; and
- Requirements for vertically-focused solutions from a supply-side world that has historically been far more horizontally driven.

2.3.2 Single-Family Residential

A Smart Home is a single-family residence home outfitted with smart, connected devices that grant users increased control over their environments and support additional services like automation, energy management, security management, and highly personalized customer support.

A key enabler of the Smart Home market is the decreasing costs of home controls systems. Not only

are they becoming cheaper, but also increasingly versatile, multi-functional, and easier-to-use. These systems help tie together multiple devices to manage entertainment, security, entire home energy systems, lighting, heating and cooling, solar panels, and even energy storage devices. They are remotely controllable from everywhere: from home on a local PC, a hand-held remote, or from outside by mobile device. Most importantly, they have the potential to improve our quality-of-life, make more efficient use of resources, and grant customers more control and convenience.

To consider the broadest vision for the Smart Home is to consider it less from a standpoint of connecting more 'things,' and more from a standpoint of connecting our lives in the ways that matter - securing those we love, reducing our energy consumption, and enabling our most personal of environments. Value creation in the home has been limited by a focus by vendors on the design of products that enable point applications for slight enhancements of end-user comfort and convenience. Widespread offering adoption will only occur when end-user experience in coordinated ecosystems of devices and services is prioritized. Conformity to communications and data formatting standards enable offerings to collaborate to create value for end-users, vendors and third-party service providers with minimal direct user interactions.

While adoption of Smart Home is limited today, the market is ripe and forecasted for significant growth. Manufacturers, telecom providers, retailers, and other service providers will both react to and proactively drive this adoption, both to sustain their business models and support users' expectations and society's need for greater efficiencies. From broadband Internet penetrating more homes to smartphones penetrating more pockets, forces driving this growth are diverse.

3. SMART SYSTEMS IN MULTI-DWELLING UNITS

Multi-dwelling units (MDUs) sit at the intersection of single-family homes and commercial buildings, sharing characteristics of each. Responsible for decision-making around central building offerings, as well as installed devices within units, owners and operators (including third-party managers, owner/managers, and owner/occupants) have two unique needs which must be met to justify adoption of connected offerings. First, they must retain an appropriate level of service control, which does not impinge on occupant privacy, but provides the ability for the manager to manage services during turnover and ensure that terms of the lease are maintained. Second, they must realize an attractive ROI from connected offerings, which can be captured in several ways.

> "We saw a big, unmet need with regards to occupant-focused building automation solutions in apartment buildings. Everyone is concerned with either commercial or residential, and don't look at the intersection of these two markets. Even companies that serve both commercial and homes tend to shy away from MDUs."
>
> - Product Manager, Optergy

Operating margins can be increased by reducing operating expenses with the adoption of devices and services that increase the efficiency of building systems and management processes. Operating expenses are also decreased by reducing vacancy and occupant turnover, both of which can be accomplished with adoption of offerings that increase occupant satisfaction. Such offerings also grow the top line by differentiating the property and enhancing customer acquisition in competitive markets.

> "The split incentive means we have to put together packages with tools that work for everyone. You can market it to occupants, but if the owner is the one buying it you better make sure the value to them is clear. I think we're getting away from the marketing focus and entering a period where value is really getting created, and that this is where we'll see things really start moving."
>
> - Executive, PowerSage

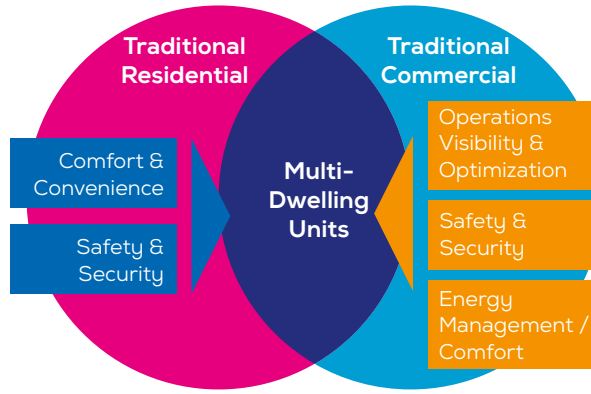
The inability of both commercial and home automation players to organize offerings for this market has left the door open for agile startups to create solutions tailored to the unique needs of MDU building stakeholders.

> "Few players are really looking at multi-family as a distinct product offering - most building automation systems players are looking to put a square peg in round hole. They have control systems that they're trying to put everywhere, they have common protocols thrown on thermostats, contact sensors, and think that they start to chip away at it. In reality, they are far from actually hitting the needs of the operators and the occupants. It's a space they aren't set up for, and it's expensive to change."
>
> - Executive, Cytexone

Figure 3.1 MDU Requirements Represent a Blend of Residential & Commercial Needs

Residential
Technology in residential settings has always focused on two applications: comfort & convenience and safety & security. As such, traditional suppliers have tended to target a specific application. While the line between the two groups of suppliers is blurring, these consumer-oriented companies are rarely geared towards commercial applications.

Due to the fragmented user-base and fickle nature of consumers, new entrants are coming from all angles and some are experiencing mild success as the race for consumer acceptance (and data) continues.



Multi-Dwelling Units
MDUs are characterized by two groups of stakeholders: occupants and owner/operators. The structures themselves are closer to commercial buildings in terms of size and more centralized systems, however, the needs of individual unit occupants must be considered.

Commercial
Technology in commercial buildings has traditionally focused on operations visibility and optimization and safety and security. These buildings are characterized by more centralized systems, and due to the size of these buildings, they incur high operations costs (e.g., energy, maintenance, etc.).

Larger IT companies and equipment manufacturers have controlled much of this market in the past. These traditional suppliers have acquired new software and application platforms to provide better services to their customers, and are entrenched in their market-leading positions.

The inability of both commercial and home automation players to organize offerings for this market has left the door open for agile startups to create solutions tailored to the unique needs of MDU building stakeholders. The margins per building may be small relative to the Commercial Venue, but the addressable market is anything but, with greater than six million MDU buildings across the US and Canada housing over 40 million individual units.[1] Further, as the percentage of renters continues to increase, driven by the perceived risks of ownership following the 2008 recession and the flexibility and freedom desired by millennials, who make up the largest portion of both renters and the general population,[2] connected offerings for rental units will be increasingly desirable.

3.1 MARKET ORGANIZING PRINCIPLES FOR IOT OPPORTUNITIES IN MDUS

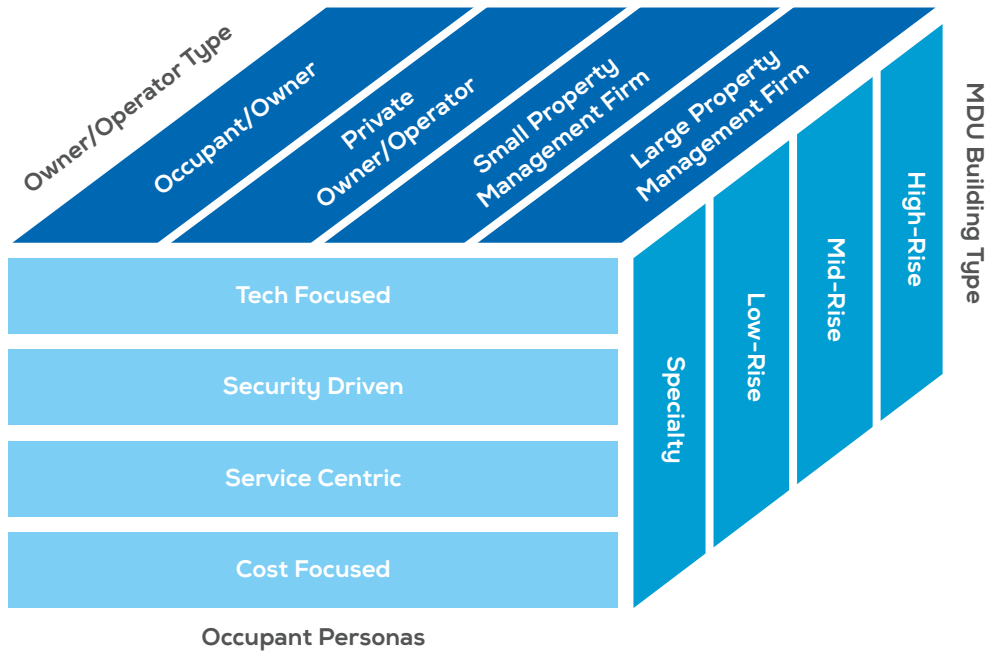
The opportunities for IoT technology-enabled use cases in MDUs are shaped primarily by three factors: building structure, property manager persona, and occupant persona. Factors across these three dimensions combine in any and every manner, leading to a very complex and fragmented set of adoption characteristics. The combination of these factors for a given MDU determines which use cases are most desired, the technical capabilities of those use cases, the stakeholder who captures value from adoption, the stakeholder who makes decisions regarding adoption, and the suppliers who are best positioned to deliver solutions.

> "Apartments are an interesting market. We see it as an opportunity to expand outside the 'home' and potentially connect the more centralized building systems. We aren't targeting this market now, but our partnerships will be key to addressing this market because of the variability between buildings and sizes, types of units."
>
> - Corporate Manager, Cielo

This complexity necessitates that suppliers have flexible offerings and delivery mechanisms in order to meet the needs of different MDU structures, manager types and occupant personas. Traditional suppliers of building automation systems to commercial buildings have focused on scale, are challenged by both the complexity posed by the three dimensions of MDU opportunities and the demand that solutions be tailored for the specific needs of that structure/manager/occupant combination. Further, our discussions with managers have indicated that the willingness-to-pay for automation solutions in MDUs is considerably smaller than that in commercial buildings, challenging the cost structure of traditional building automation suppliers.

> "Big [building automation system] companies have gigantic infrastructures that require really big price tags…that doesn't work in MDUs…because big price tags aren't a part of this. Even the best situated property managers aren't going to throw out half a million for a building."
>
> – Executive, StratIS

Figure 3.2 Framing the IoT Opportunity in MDUs



Meanwhile, smart home suppliers who have attempted to scale their offerings out of single family residential and into MDUs have been challenged by the requirement to meet the needs not only of building occupants but also of property managers.

> "Traditional players have really struggled with this space. Telcos have struggled, we saw Verizon and AT&T both flop because they failed to create value for property managers. ISPs are pushing building-wide Wi-Fi, Google looking to bring fiber to buildings and help managers control them. The traditional BAS guys just don't have the cost structure required to sell unit by unit offerings. Even if the system is set up for an entire building, those guys will quote $10k to monitor within an apartment. Even the smart apartmentguys are focusing only on residents, missing opportunities to reduce building OPEX. Huge opportunities to create value across the chain are being overlooked or missed."
>
> - Executive, WhiteSpace Building Technology Advisors

Our research confirms that consumer adoption of connected devices that they bring with them, including: light bulbs, speakers, TVs, cameras and motion detectors, is on the rise among tech focused occupants; enhancing in-unit comfort, convenience, and peace-of-mind.

> "The tech players might get into the home, but their data expertise doesn't prepare them for dealing with complexity of physical systems. That's where the OT, control guys will continue to have the upper hand. But they're still trying to make everything from the factory, banking on users not being IT-savvy, and its making costs go way up, which doesn't work for the MDU market."
>
> - Editor, BuildingContext

However, without coordination with devices and systems that unit owner/operators install, including thermostats, major appliances, HVAC-R equipment, air and water distribution systems, and the building network backbone itself, the ability to create value within the unit is limited.

> "The Internet of Things is driving unpredictability in amount and location of bandwidth needed to support connected devices. MDUs in particular provide a unique case, as the increase in streaming and other Internet services are likely going to be used during similar hours in the evening, not to mention other potential device and equipment connections. Access to high-speed Internet is #2 on list of top amenities by today's renters and 33 percent of all Internet traffic today is Netflix. Fiber networks are really the only way to support all of these bandwidth needs."
>
> - Vice President, Duraline

3.1.1 MDU Building Types

For the purposes of this research, MDUs structures are segmented into four categories based on the number of units and stories as well as the physical characteristics of the building.

- "Specialty" structures include multiplexes, townhomes and row-houses, which tend to house two to four units in structures of three floors or less that lack interior building entries, shared building spaces, and centralized building HVAC and air/water distribution systems.
- Low-rise buildings are also less than three stories but have centralized systems, interior entries and common spaces, and contain up to 24 units.
- Mid and high-rise buildings are similar in physical makeup to low-rise buildings, with mid-rise buildings classified as those with 25 to 49 units and up to 10 stories and high-rise buildings those with more than 50 units and more than 10 stories.

Figure 3.3 MDU Building Types & Market Characteristics

	High-Rise	Mid-Rise	Low-Rise	Specialty	Totals
Floors	10+	3-10	1-3	1-3	–
Units	50+	25-49	5-24	2-4	–
Entry Type	Internal		External/ Internal	External	–
Building Systems	Central	Central	Central	By Unit	–
# of Buildings	129,315	186,253	1,428,129	4,330,457	6,074,155
% of MDU Buildings	2%	3%	24%	71%	100%
% 2015 Completed Buildings	9%	26%	41%	25%	100%
# of Units	7,758,910	5,587,597	14,281,295	12,991,371	40,619,173
% of All Units	19%	14%	35%	32%	100%
% 2015 Completed Units	46%	32%	18%	4%	100%

Sources – US Census Bureau, Statistics Canada, NMHC, HRI Analysis

While specialty buildings make up the largest portion of all MDU buildings and low-rise buildings house the most units in the US and Canada, recent developments have favored high-rises, reflecting the urban migration of the large millennial population. The new build opportunity is therefore currently dominated by mid and high-rise buildings, while the significant base of low-rise and specialty buildings offer a significant opportunity for retrofit installations.

> "Property managers in different classes of buildings have different needs, and we have to work to make solutions and financing that works for their situation."
> – Development Associate, Alarm.com

3.1.2 Occupant Personas

Multi-dwelling unit occupant needs are widely variable, based on factors such as age, income, family status, tech fluency, and the type of community in which they live. Our findings highlight that, while occupants of MDUs come from all walks of life, they can be grouped broadly into four categories based on their strongest motivators.

- **Tech-Focused**: Occupants driven by comfort and convenience improvements to their home and common building areas, who have medium incomes and no children.
- **Security-Driven**: Couples with children living with them who are focused on physical and cybersecurity and for whom technology is a means to an end that they would prefer to not complicate their lives.
- **Hassle-Free/Service-Centric**: Middle-aged occupants who desire minimal interactions with technology offerings that they expect to operate without fail in the background of their lives to enhance comfort and convenience.

- **Cost-Driven:** Lowest income demographic of occupants who desire any means of reducing living expenses and are willing to have frequent interactions with devices to enable cost savings.

Figure 3.4 MDU Occupant Personas

	Tech-Focused	Security-Driven	Hassle-Free/ Service-Centric	Cost-Driven
	Strongest needs are ensuring comfort and lifestyle through attractive appliances no matter the cost	**Avoiding service interruptions in physical and cyber security is a top concern**	**"Want high degree of service and minimal hassle in choosing, operating and configuring systems "**	**Highly motivated to reduce costs of bills and appliances –want high degree of control to ensure goals are met**
Age	18-44	30-44	45-64	"18-30, 65+"
Income	"~$75,000+"	"~$50,000"	"~$75,000+"	"~$35,000"
Family Status	"Single/couple, no children"	"Couple, with children in house"	"Single/couple, with children"	"Single/couple, no children in house"
Technology Usage Goal	Comfort and Convenience	Safety and Security	Convenience and Cost	Cost
Device Profile	High tech home	Home security system	Minimalist	Cost-saving appliances
Price Sensitivity	Low	Medium	Low	High
Technology Interest	High	Medium	Medium	Low
Security Concerns	Medium	High	Low	Low
Environmental Concerns	Medium	Low	Low	Medium

> "We advertise as a green community, which have been an important selling point for the millennial crowd we're fighting hard to attract currently. One of the major green feature is solar panels on our garages and other parking areas, which feed building energy demands."
> - Manager, Greystar

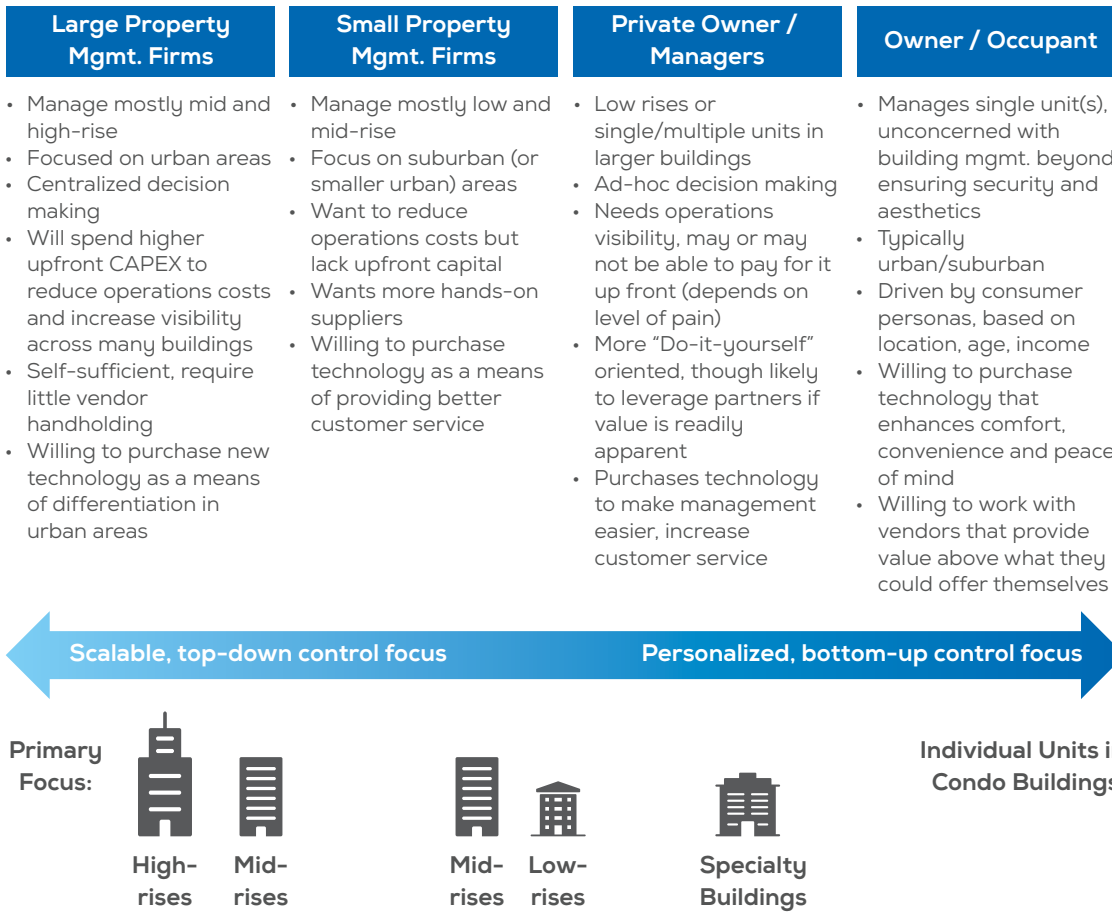
These generalized personas make it easier to consider the infinitely varying needs of occupants relative to the place they live, however, it is important to note that no two occupants are alike. All expect and require a different number of touchpoints and levels of support.

> "One of the biggest challenges is that user needs aren't defined by their age or income or community type, but actually very dependent on individual experiences and characteristics. Safety is huge to someone who's experienced an electrical fire, while being able to turn off outlets is big for parents of young children. Ultimately, we try to develop the broadest set of capabilities that appeal to end-users from all walks of life."
> - Executive, SafePlug

3.1.3 Owner/Operator Types

A primary challenge in the development of successful horizontal offerings for MDU buildings is the shifting responsibility for decision-making and priorities of the party responsible. Based on Harbor's research, the initial consideration is whether these units are occupied by the owners or renters; in condominium-style buildings, occupants own their units and decision-making focuses on investments in devices and services that increase in-unit comfort, convenience, and peace-of-mind or reduce unit operating expenses. A separate property manager, condo board, or homeowner's association is responsible for building-system decision-making, including purchasing and maintenance of common area, building air and water distribution, and HVAC-R equipment.

Figure 3.5 Owner/Operator Segmentation and Needs



In rental buildings, unit management is performed by a building owner/operator who falls into one of three categories. Private owners and managers tend to operate at a local scale, overseeing individual units in multiple buildings or one or more specialty buildings. With limited capital to invest in technology, their decision-making around investments is typically *ad hoc* and driven by building maintenance needs, much of which is done by the managers themselves. While these managers desire the ability to remotely manage their units and increase operational visibility, they lack the requisite funds to make significant upfront investments in new technology and are a prime candidate for models exchanging upfront for contracted service costs.

> "Unit automation play is great…you have the potential for revenue lift; ability to differentiate property. I don't think that's where the actual ROI for owners and managers is. They're the ones paying for the actual hardware. It has to get installed by someone. You need to target solutions that will add value to the unit while also creating direct value to the operators. With increasingly interoperable systems, this is becoming much easier. When we focused only on energy solutions, adoption was slowed by the relatively small benefits seen by operators. Since we added access management in the summer of 2015, we've installed the joint offering in 150,000 apartments. It's a win-win for managers."
>
> - Executive, BuLogics

Small and large property management firms are third-party providers of property management services, working with building developers and owners to efficiently and economically maintain and manage MDU properties. Our research shows that small firms tend to manage predominately low and mid-rise buildings, especially in suburban or smaller urban regions, and prioritize technology offerings that enhance the services that they can provide to building occupants. These firms are often more hands-on with suppliers and seek tools that reduce operational expenses with minimal initial capital investment, given relatively tight budgets.

> "In MDUs,access management is an issue of convenience. Managers want to be able to let people into vacant units for showings, occupants want to be able to grant access to visiting friends and family in addition to making it easier for themselves to access the building, their unit, and particular building services, like laundry or the pool."
>
> – Manager, LockState

Large property management firms have regional or national portfolios of properties that they manage for a variety of property owners, including many mid and high-rise buildings. Large capital budgets enable these firms to invest significant capital in technologies that will reduce lifetime operating expenses and, especially in competitive housing markets, differentiate units with enhanced amenities for comfort, convenience, and peace-of-mind.

> "In terms of opportunities, scale is the biggest thing. Large MDU holders, think the top 50 managers in the country, we start there looking for retrofits. The efficiency demanded by these guys to manage big portfolios makes our sales pitch much easier. Even better are managers of master metered buildings. With a straightforward incentive to reduce inefficiencies, it's really our best chance to prove ourselves in this market."
>
> - Executive, PowerSage

3.1.4 Other Factors Affecting MDU Opportunities

Several additional factors are worth noting in the segmentation of opportunities within the MDU market. First, whether building targets are under construction ("new builds") versus undergoing retrofits. Our research reflects that there exists at least a three to four-year period post-construction that property owners and operators are unwilling to spend further on a building.[3] Firms with solutions requiring hard-wiring into electrical systems in new buildings likely need to get involved over a year before completion to be part of discussions prior to any orders being placed by electricians. New builds represent roughly two percent of the overall MDU market,[4] and many players are instead focusing on solutions for retrofit opportunities.

As a rule of thumb, in an average year, property managers will seek to upgrade 10 percent of the buildings in their portfolio,[5] retrofitting or renovating whole buildings or individual units. While building-wide installations are valuable opportunities for property owner/operators to enhance building value with reduced installation costs, the disruption of occupants required can be prohibitive, leading

many to focus on retrofitting or renovating units during occupant turnover. Suppliers lacking the organizational and cost structure to enable them to take advantage of unit-scale installations risk missing a large portion of the opportunities in MDUs.

> "The biggest barrier, for Johnson Controls and Siemens, is that their models have worked great since pneumatics. They don't necessarily feel the same demand to move towards open standards because things have been working so well for them. These guys will begin to quickly realize that they don't have the same hold on the market that they once did, and will begin to see their margins decrease at an accelerating rate. Most of their profit is coming from services today, and you've got innovative tech players who are more effectively accessing and servicing these markets that the product companies will have to change or will go under. Buildings are on the edge of catching up to every other market out there with open models."
>
> - Senior Associate, RMI

Second, the billing model and associated responsibilities between occupants, owners, operators and suppliers affects the incentive structure of decision-makers within these buildings. As noted in the discussion of manager types, owner/occupants will be responsible for not only operating and utility expenses but decision-making regarding adoption of devices and services to reduce those expenses, as would any single family residential homeowner.

Our survey findings indicate that 10 percent of occupants have their electric bills included in their monthly rents, in so-called "inclusive billing" arrangements. These billing structures are most likely to be found in larger MDU buildings in urban environments, with 60 percent of survey respondents with inclusive electric bills living in urban communities and 53 percent in mid or high-rise buildings. All-inclusive billing arrangements are a major opportunity to resource management technology suppliers, as property managers capture a significant ROI from tools that enhance the efficiency of occupant resource consumption. This billing structure is also common in community living arrangements, including student housing and elderly care facilities, where manager ability to reduce operating expenses is valued highly.

> "It's a complex market, but we're seeing adoption across it. Condos are completely different than rentals, and co-ops are different from everything. We've got low-income and senior complexes where operators pay bills and want to be able to increase efficiency to reduce expenses. You have developers who want to offer tools to renters to allow them to reduce their bills. And then there's big master metered buildings that need us to come in and monitor circuits to allocate bills accordingly. Extensible offerings enable us to scale to fit the needs of each."
>
> - Executive, Powerhouse Dynamics

A third factor of consequence in the evaluation of IoT opportunities in these buildings is the turnover rate. Turnover and vacancy periods exert a significant financial burden on property managers, considering the labor costs of showing the unit, preparing the unit for new occupants (including rekeying), and transferal of utility expenses to the manager during the vacant period. In properties with high turnover rates, managers are therefore incentivized to invest in tools providing access and resource management capabilities, if only to reduce expenses during vacancies and turnover periods. The ability to provide temporary access to units from a cloud-based interface, rather than physically visiting numerous properties, and optimizing unit temperatures to minimize usage while preventing pipes from bursting, can significantly reduce costs.

> "Energy is more complex because you have conflicting interests participating. Depending on the circumstances, maybe your resident doesn't care about building operator energy costs, or only receives benefits themselves. In low vacancy buildings, return really comes from revenue lift from property differentiation rather than from operating expense savings, which mostly accrue during vacancies. For property operators of all-inclusive buildings, we've set up systems to allow them to set up limitations…we saved so much money, increased portfolio valuation by 40 million. Same thing in student housing, another huge opportunity for savings, depending on the type of property and business model."
>
> – Executive, BuLogics

Finally, regional differences including climate, socioeconomic drivers, and regulatory factors need to be considered in the development of MDU solutions. Regions of the northern US and much of Canada lack centralized AC systems due to the limited or non-existent demand for cooling throughout the year, while southern regions of the US lack the need for central or in-unit space heating. Canada has significant regional differences in space heating preferences, with natural gas forced-air furnaces preferred in western provinces and Ontario while electric heating dominates MDUs in Quebec[6] and British Columbia.[7] Though heat pumps offer a more efficient form of electrical space heating, requiring 50 percent energy for the same heat output,[8] baseboard heaters are popular options due to the low upfront cost of these systems.

> "Canadian customers tend to be more 'green'-oriented than those in the US. For the most part, both commercial and residential customers are willing to share energy data, if anything to understand how they compare to their neighbors or similar businesses, but also to see where they could save on this energy usage. Partnerships with utilities become key to creating these values for customers."
>
> - Director, Delta Controls

In regions with high electricity costs, decision-making on space heaters reflects the "split incentive" of building owner/operators and residents; when they are not responsible for utility bills, operator decision-making may not consider long-term operating expenses and in fact be suboptimal for unit occupants. However, baseboard heaters have proven to be a cost-effective option for both operators and residents where average electricity prices are low, as they are in Quebec.[9]

While adoption of IoT offerings has historically been higher in major coastal markets, based on the drive to differentiate high-end units for tech-savvy occupants, adoption is shifting towards smaller, faster growing urban centers. As lower land prices and cost of living encourage corporate headquarters to move to smaller urban centers away from the coast, they are bringing young workers with rising salaries and high expectations for technology in all aspects of their lives. Property managers are increasingly leveraging technology in these growing, in-land urban areas to differentiate their MDUs and satisfy the needs of this incoming, tech-focused working class.

> "As far as regions, we thought it'd be coastal but it's really not. A big chunk is Midwest… Texas, up to Chicago, Indy, Omaha, Kansas City, St. Louis. A lot of coastal cities, where land prices are extremely high, rental prices are extremely high, and monetarily it doesn't make sense for managers to retrofit in those markets till they need to. NY, SF, tech isn't a differentiator - managers aren't fighting over potential renters, who are just hoping there are no rats in their place… A lot of companies are moving regional HQs into secondary and tertiary markets where land prices are lower and trying to recruit the right people by giving the standard of living they expect. That's why we're seeing this Midwest boon."
>
> – Executive, IOTAS

From a regulatory perspective, the most important impact on MDU adoption of IoT offerings is from environmental regulations to increase energy efficiency. Updates passed in 2016 to the National Energy Code of Canada for Buildings mandate that new buildings increase energy efficiency by 27 percent relative to the 1997 standard, while incentives exist at the provincial and city level for energy efficiency assessments and retrofits of legacy buildings.[10]

In the US, requirements and incentives vary broadly across states and even by municipality as cities take aggressive steps towards increasing efficiency to reduce carbon emissions. The West Coast and New England lead the nation in terms of developing regulations that promote efficient building industries which meet environmental goals, reduce exposure to volatile energy costs, and spur economic development.[11] Efficiency mandates are driving both passive design innovations and active management solutions, both of which require distributed sensing and analytics tools. Suppliers need to be attuned to the regulatory factors in regions where they seek to deliver solutions, or be agile enough to deliver solutions to buildings in regions where regulations become drivers of connected offering adoption.

3.2 COMPETITIVE STRUCTURE

Multi-dwelling units are served by a broad range of technology, equipment, and services providers, many of whom have a role to play in providing IoT offerings into these buildings. At a high level, the supply side of the building systems market breaks down in two groups: 1) Large traditional suppliers, which include Johnson Controls, Honeywell, Siemens, Eaton Electrical, Schneider, Emerson, and UTC, and 2) a broad array of smaller independent systems and technology providers. In attempting to organize more broadly integrated offerings, many supply-side constituents have attempted to expand scope through acquisition. Particularly within the last few years, there has been significant consolidation within the supply base, as illustrated by such notable acquisitions as Schneider's purchases of TAC, Andover Controls, and Invensys; Johnson Controls's acquisitions of York and GridLogix; and, Honeywell's acquisitions of Novar and Tridium.

Yet this slew of acquisitions has not yet achieved its goal of delivering open, integrated platform solutions to customers. Conversely, it has left the acquiring companies in a relatively disorganized state, with a number of new assets that they must work to incorporate into their own businesses. Furthermore, simply acquiring new product lines does not line up with the greater vision of a fully integrated energy and facilities environment.

> "MDUs have been neglected in part because there are so many players crucial to successful offerings in the space…Property managers and staff are critical boots on the ground. Supportability has been the biggest challenge for sure - managers aren't technologists so we've developed training programs to give support to vendors, maintenance, managers and residents. Relationships with distributors has proven really important, as has close ties with OEMs - particularly HVAC manufacturers. We'll work with architects as well, but it has to be pretty upstream in order for us to spec into the design stage."
>
> - Executive, StratIS

From the consumer and home side of the market, traditional service providers have been trying to expand into higher-value applications and services as they struggle to achieve differentiation amongst an increasingly crowded market. Arguably, these service-based business models are in a better position to capture the MDU opportunity than the traditional OEMs that still consider incremental product improvements as "innovation." Service providers benefit from being able to extend or enhance existing services and add new "over-the-top" (OTT) services while offering customers different packages or bundles of these services configured to the users' needs. These services-based business models also allow

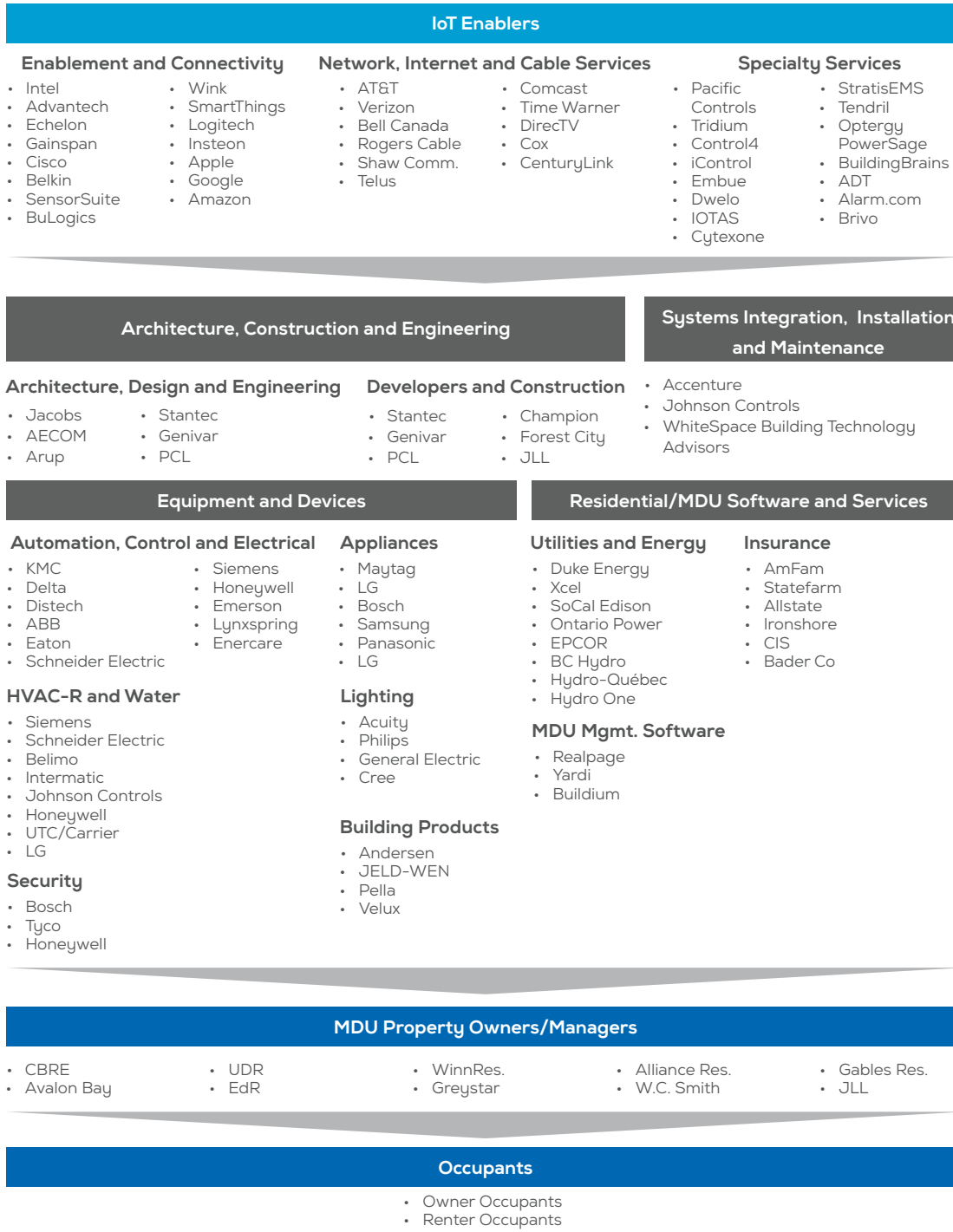
these suppliers to defer the upfront cost of additional devices and equipment to the service contract itself, making it easier for customers to afford these offerings.

> "We are directly targeting MDUs and we want to win this market. We see fiber as a key aspect of this strategy, but 5G and utilizing existing copper and coax infrastructure will be critical as well. In places where our wired networks don't reach yet, we are leveraging DirecTV offerings as a way to get to MDU occupants."
>
> - Executive, AT&T

IoT Enablers have emerged to disrupt traditional building system providers by offering more technologically advanced, open solutions. These players are all over the market, working with OEMs, service providers, and even directly with end-users. Their sensors and hardware may be embedded into an OEM's products during the manufacturing process, or a systems integrator may be responsible for building a network that includes hardware from multiple enablement vendors. Recently, seeing an untapped, growing market, specialty IoT platform and service providers have cropped up, targeting the MDU market specifically. Players such as IOTAS, Embue, Optergy, StratIS and Dwelo have taken the challenges of this market head-on, and stand to benefit greatly from the inaction of traditional buildings suppliers.

The primary stakeholders involved in developing, deploying, and supporting connected devices and services in MDUs are outlined below.

Figure 3.6 MDU Competitive Structure



Recommendations for which opportunities stakeholders are best positioned to target and how they should organize to develop, deploy and support offerings are provided for key MDU market participants. These stakeholders have been organized into the following categories:

- **Utilities**: Electric, gas or water generators and distributors
- **NSPs**: Cable, network, internet and cellular providers
- **Insurance Providers**: Building, condo and rental insurance providers
- **Specialty Services**: Service providers who take advantage of connected devices to provide enhanced or new services
- **IoT Hubs, Platforms and Software**: Hardware or software based platforms that enable monitoring and management of connected devices and services
- **HVAC-R and Water OEMs**: Temperature sensors and thermostats; building HVAC-R equipment; water heating, treatment and distribution systems; leak detection sensors
- **Lighting OEMs**: Bulb and fixture manufacturers
- **Appliance OEMs**: Washers/dryers, dishwashers, ovens, refrigerators, microwaves, coffee makers, etc.
- **Electrical OEMs**: Electrical distribution and load management equipment manufacturers
- **Security OEMs**: Lock, camera and intrusion detection sensor manufacturers
- **Building Products OEMs**: Door, window, elevator and other building product manufacturers

While traditional software and service providers are increasingly becoming indistinguishable from IoT application and service providers, they must continue to adjust their businesses as smart buildings become more prevalent. Providing basic software that delivers a single service disconnected from the building or business itself is no longer enough. IoT Enablers are offering value added applications that blur the lines between traditional property management software and an IoT-enabled one.

> "We use the Dwelo smart home app, it allows residents to unlock doors, turn off their lights, and adjust their thermostat all through their phones. It's really easy for residents to manage: all they have to do is download the app and make a profile. We also use it in the leasing office to see what's going on in unoccupied units; it'll alert us if an apartment is getting too cold or anything like that. The biggest benefits are energy savings and monitoring/safety features."
>
> - Manager, Alliance Residential

As the market becomes less hardware-driven and more service-oriented, players from other parts of the market will attempt to move into this category, driving increased competition in services delivery.

3.3 MDU TRENDS & FORCES

As millennials move to urban centers, with little interest in home ownership and high expectations of technology-enabled convenience in their lives, demand for connected offerings in apartment buildings continues to climb. Specialist firms are taking advantage of the failure of both commercial and home-focused automation players to develop offerings appropriate for MDU needs, deterred by the complexity of the adopter base.

Technology Trends & Forces

IT functionality is enabling new capabilities from OT applications, as increasingly powerful wireless tools enable new sensing opportunities and advanced data management tools allow value to be created from collected data with greater ease.

- The integration of IT systems into OT applications is occurring across the economic landscape

and enabling many new functions and capabilities based on the attractive cost reductions associated with cloud and IT infrastructure. IT-based managed service delivery platforms and business models are proliferating throughout the venue.

- Integration of access management systems across the building is providing end-users with unified, provisional mobile access to building common spaces and individual units.
- Wireless technology is gaining momentum by addressing its two key drawbacks – reliability and cost, and when combined with new classes and categories of sensing technology is driving many new growth opportunities.
- AI-powered digital assistant offerings are creating value to building occupants, via both smartphones or standalone devices, by providing an intuitive interface to a growing range of entertainment and home automation services. This technology is driving adoption of in-unit automation services, but have yet to enable holistic building services that would drive value to building operators.
- Metadata tagging conventions for buildings, including Project Haystack and recently BrickSchema, are working to solve the challenge of freeing building systems data for analytics tools to generate new efficiencies and enable machine learning to be applied to optimization problems.
- Standardized data models, such as the Green Button Initiative, are enabling democratized data access and enabling parties across the value chain, including suppliers, adopters, and third-party service providers to perform analytics on collective data stores to identify new value-adding opportunities.
- Powerful applications, accessible to an occupant or operator via smartphone, now reside largely in the cloud, where ongoing updates resolve issues and rollout new features without disruption.

Customer Trends & Forces

Building operators and occupants, especially tech-focused millennials, expect interactions with building and unit systems to be intuitive where needed but generally minimized. Ideally, systems operate in the background of buildings, requiring limited user interaction to enhance peace-of-mind and comfort or maximize operational efficiency.

- Widespread customer familiarity with mobile devices has increased expectations for “always on” capabilities.
- Occupants and operators alike expect interactions to be quick, simple, and seamless, and mobile applications are enabling monitoring, controlling, and automating resource management devices and services to be just this.
- The “millennial” generation makes up the majority of the renter population and are most likely to believe that technology makes their lives simpler and more enjoyable.[12]
- Baby Boomers have high expectations of service providers, and prefer that technology be a passive rather than active part of their lives, running in the background to provide value without direct interaction.
- End-users prefer applications that create value predominantly in the background of their lives, rather than demanding direct interactions.

Competitive Trends & Forces

The inability of commercial and home automation providers to develop effective solutions for the unique needs of the MDU market has opened the door for specialists and consumer electronics players to serve this Buildings Customer segment.

- Traditional building management and automation providers are challenged by cost structures designed for high CAPEX, large scale commercial scale deployments. Solution development and sales channels resulting from this cost structure limit these suppliers' ability to pursue

smaller opportunities in residential buildings.

- Dedicated suppliers to the single-family residential market have focused on enhancing homeowner comfort and convenience. These providers have been challenged in entering the MDU market by the demand that offerings cater not only to occupants, but building operators as well.
- Suppliers have struggled to develop successful horizontal offerings for the MDU market due to the diverse needs of building operators, which vary with their portfolio size, the type of buildings in the portfolio, and the types of occupants that reside in those buildings.
- Platforms enabling both building automation and control systems and occupant comfort and convenience solutions are well positioned for rapid growth across building sub-segments.
- Developing, deploying and supporting connected offerings is demanding that providers collaborate both across layers of the technology stack, from enablement to applications, and within them to offer cohesive, complex offerings to end-users.
- The inability of both commercial-focused building automation and single-family home-focused automation players to address the MDU market has created an opportunity for agile startups to create solutions tailored to the unique needs of these buildings.
- Building operator experienced with cloud-based applications and services, which have embraced usability to meet the needs of end-users rather than IT professionals, has allowed suppliers to provide far more capable software tools via the cloud.

Socioeconomic Trends & Forces

Comfort and convenience focused offerings are especially popular amidst continued urban migration by tech-savvy, environmentally-conscious millennials. Increased demand from this migration is creating competitive MDU markets as new construction rates recover from the stall precipitated by the 2008 economic downturn, encouraging operators to differentiate their buildings with connected offerings.

> "We've been on a run for several years where multi-family housing has been on fire. During the recession, construction ceased but demand for MDUs increased as millennials started coming of age and entering the workforce, particularly in urban areas where the job market took them. Due to the recession and cultural changes, millennials are marrying and having kids later, and are instead opting to rent for longer instead of buying a house to raise a family. This will begin to change, but the condo market will continue to benefit from urbanization."
>
> - Vice President, NMHC

Meanwhile, regulatory action and volatile energy prices have encouraged building operators to invest in management systems to increase usage efficiency.

- New building construction stalled during the 2008 economic downturn, while at the same time millennials coming of age were actively looking for apartments in urban settings.[13]
- Millennials now make up the largest portion of renters, and as they advance in careers, they prefer to put their higher wages towards a higher level of comfort and convenience in urban living environments.
- Baby Boomers are following their kids (millennials) into urban environments, with lower expectations for technology as an active influence on their lives.
- Younger generations are marrying and having children later, migrating from urban to suburban neighborhoods later, and buying homes later, increasing the demand for apartments in urban environments as the influx of mid-twenties professionals exceeds the exodus of mid-thirties professionals.
- Unpredictable energy prices are driving building operators to invest in building automation systems that increase the efficiency of usage to drive down operating expenses.

- Governments are responding to global warming, pollution, fluctuating prices, and other challenges posed by power generation by increasing their involvement in energy markets, including developing efficiency standards for the buildings market that is responsible for 30 to 40 percent of global final energy usage.[14]

Together, these trends have created a significant desire for solutions by MDU owner/operators as well as building occupants. Numerous challenges continue to hinder widespread adoption, with a large market opportunity incentivizing technology vendors, OEMs and service providers to develop innovative tools which overcome these hurdles.

3.4 DRIVERS & BARRIERS TO ADOPTION HIGHLIGHTED IN MARKET SURVEY

Occupants

Two fundamental challenges are impeding occupant adoption. Of the 1,140 MDU occupants surveyed across the United States and Canada, nearly a quarter responded that they are unaware of connected devices and services that could exist within their buildings. There is little demographical difference between occupants that are aware and those who are not, though there is a clear correlation between self-identifying as an "early adopter" of new technology and interest in purchasing new connected devices and services. Belief in the potential benefits of connected services has failed to develop outside of tech-fluent circles, and represents a significant hurdle to greater adoption.

Further, findings highlight that even when occupants are aware of and interested in connected offerings, the ownership model in many MDUs limits their ability to adopt devices and services. Slightly more than a quarter of all occupant respondents indicated that they own their unit and can modify as they like, while 17 percent rent their units and have the ability to modify them. The remaining 56 percent of occupants either require approval from building managers to install new devices or are unable to make any modifications whatsoever, limiting their ability to adopt and benefit from connected offerings.

Figure 3.7 Occupant Awareness of Connected Devices, n=1,140

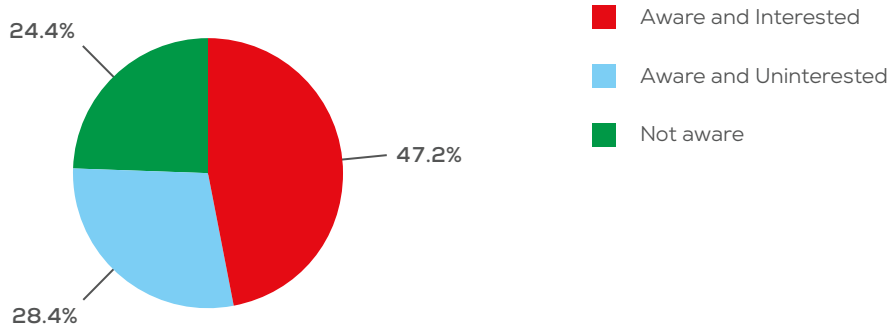


Figure 3.8 Occupant Agreement with "I Consider Myself an Early Technology Adopter" by Interest in Connected Offerings, n=1,140

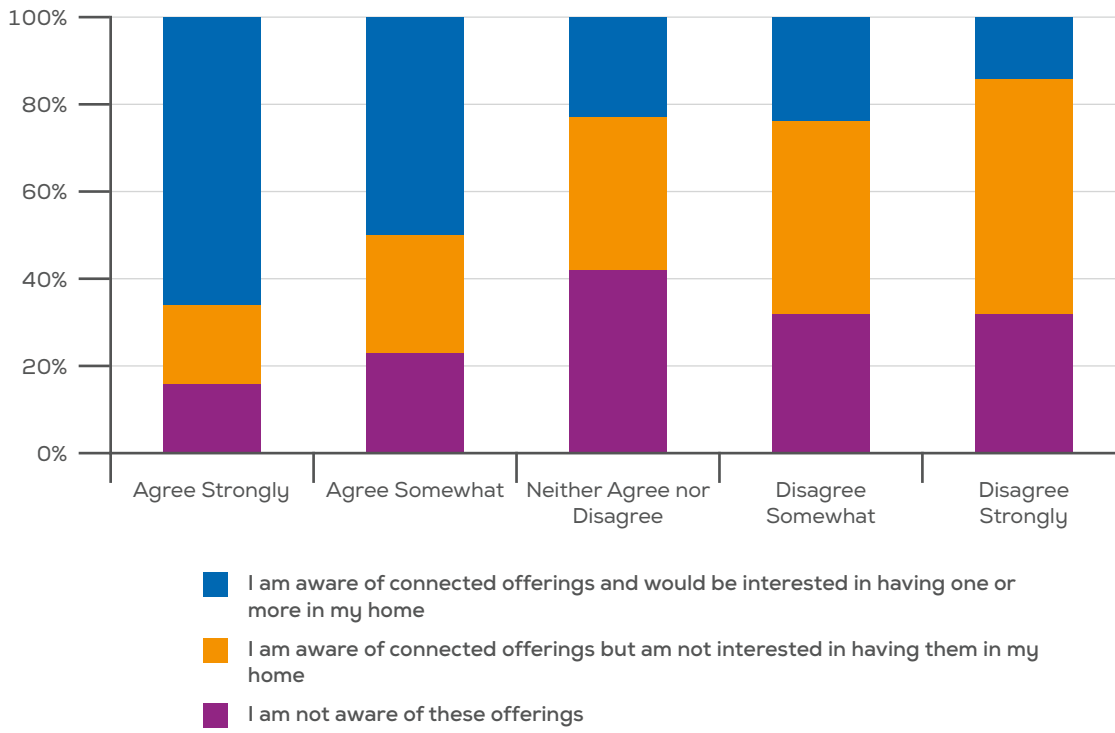
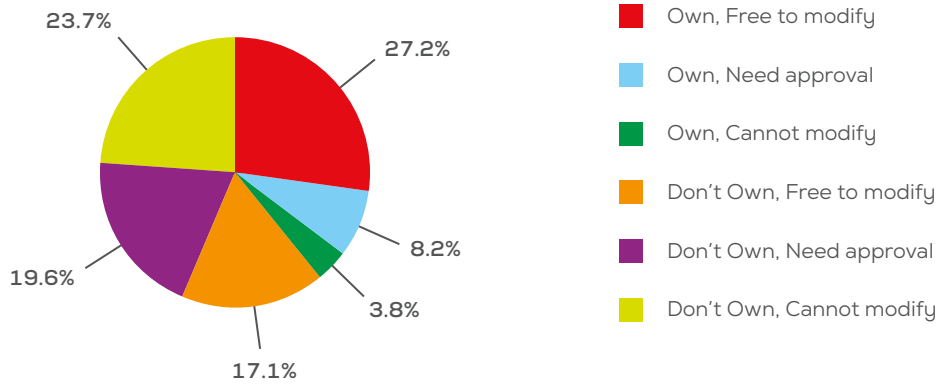
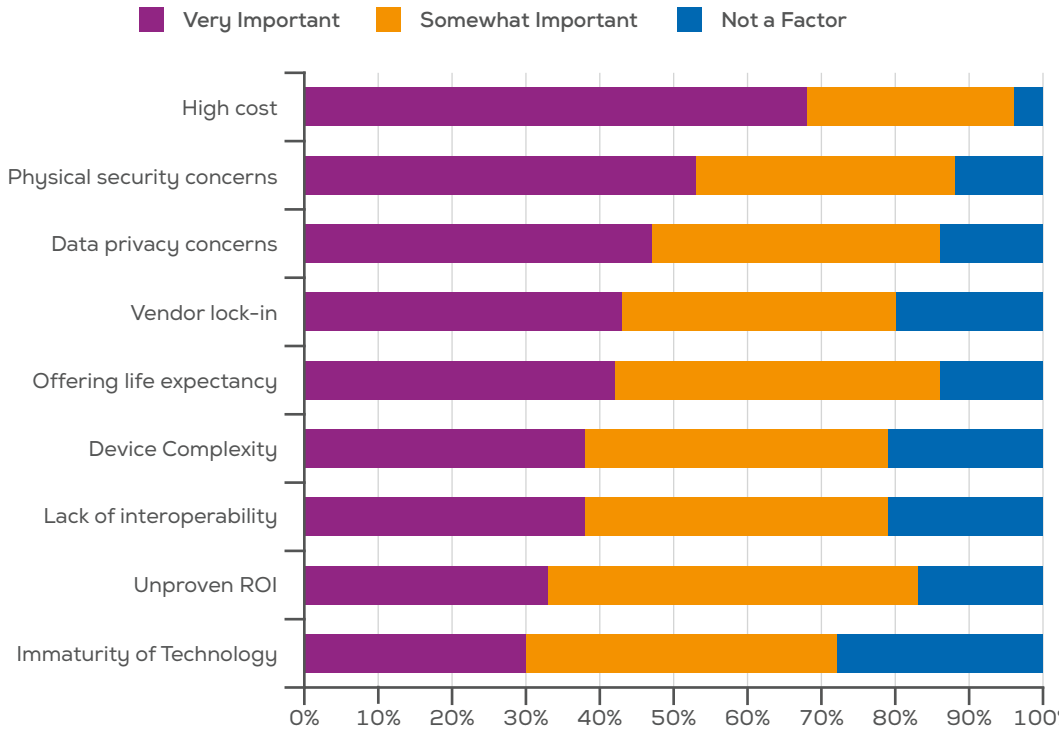


Figure 3.9 Occupant Decision-making Capability, n=1,140



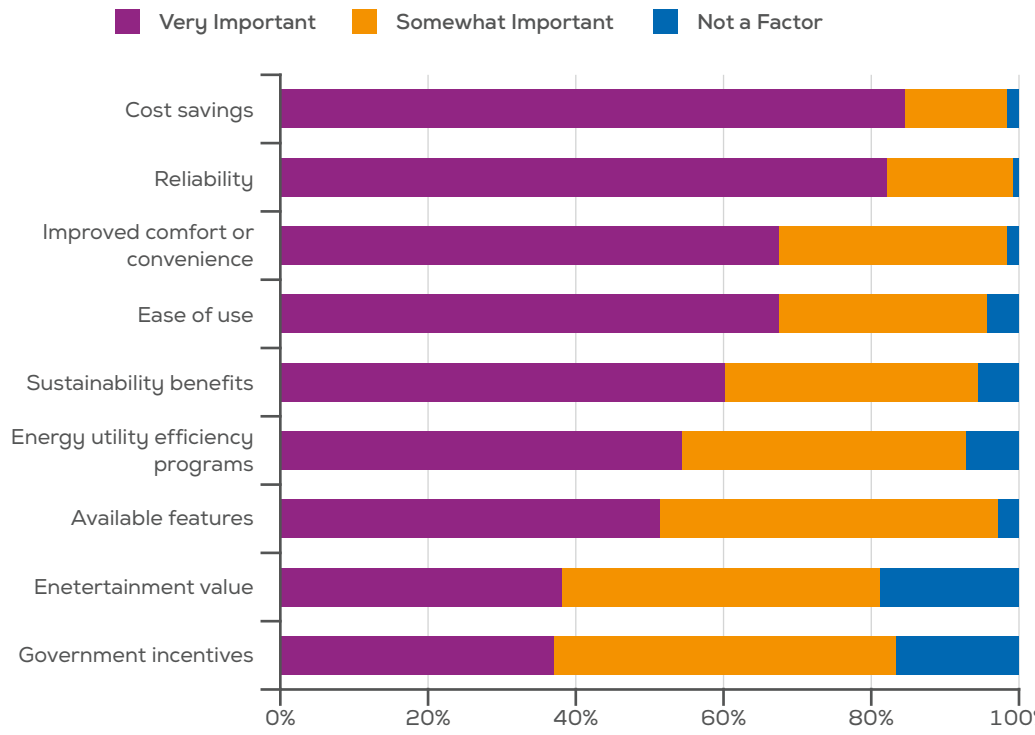
The high initial cost of connected offerings continues to be a primary impediment to device adoption, though high-profile device hacks and network breaches have elevated personal security and data privacy concerns. Promising to suppliers is the relatively low number of respondents who note a lack of belief in the benefits of connected offerings as a barrier to adoption.

Figure 3.10 Occupant Barriers to Adoption, n=809



In terms of drivers of adoption, occupants rank cost savings from, reliability, and improved satisfaction from connected offerings as their primary motivators, further emphasizing that those interested in these offerings are informed of their benefits. Aside from directly reducing utility expenses, implementations have highlighted that convenience-enhancing offerings generate indirect cost savings for end-users by reducing the cost of and time spent on maintaining their units.[15] This indicates that provider focus should be on reaching a broader audience with messaging, to increase awareness outside of the tech-fluent that these offerings have proven value.

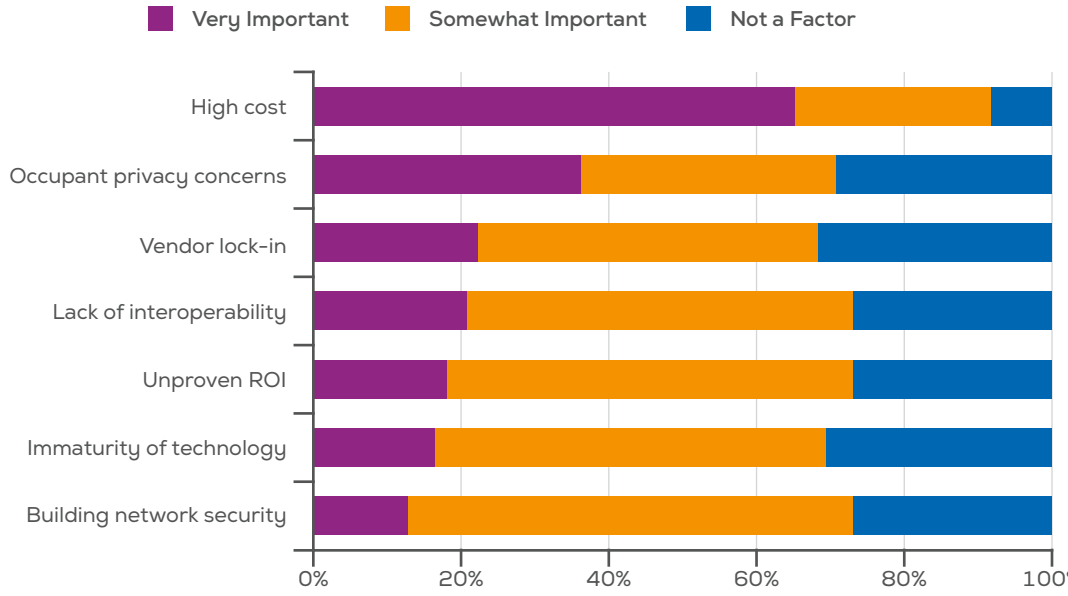
Figure 3.11 Occupant Adoption Drivers, n=522



Owners/Operators, Developers, Architects & Engineers

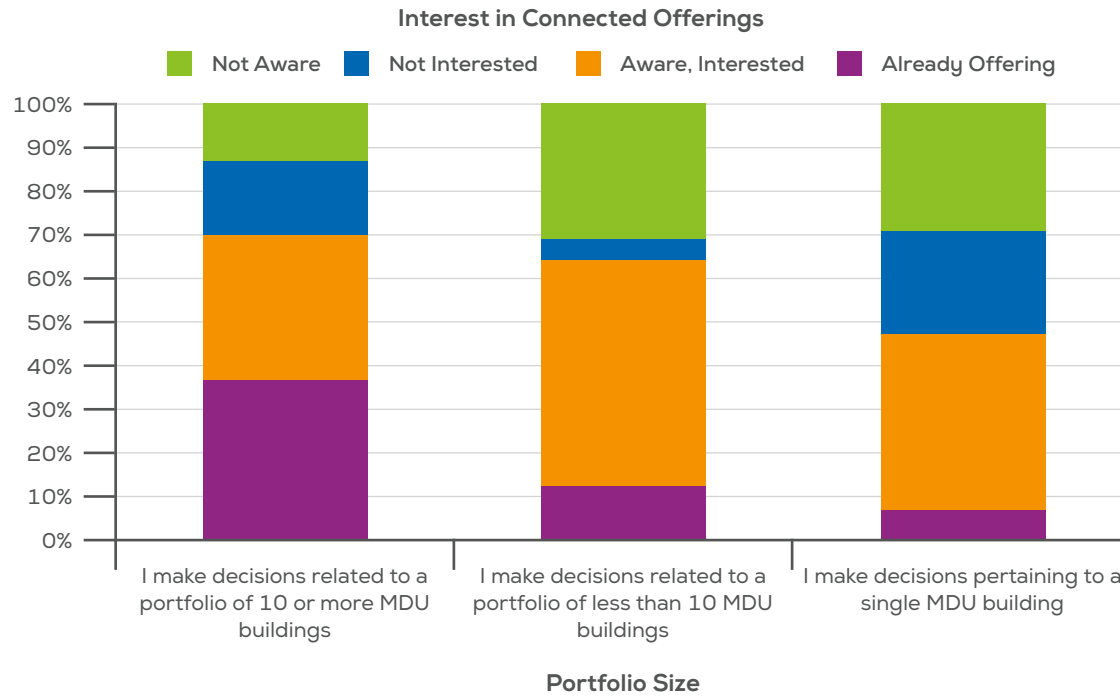
Cost, far and above all other factors, is the biggest barrier to adoption by owners, operators and developers, followed by occupant privacy concerns. While a small portion of respondents rank "confidence in offering benefits" as a major barrier, it is clear that they remain unconvinced that the lifetime benefits outweigh the initial costs of offerings.

Figure 3.12 Owners, Operators & Developers: Barriers to Adoption, n=58



Further, awareness of and interest in connected offerings is found to be significantly higher among operators and developers of large portfolios of MDUs, reflecting the focus of suppliers on the attractive scale offered by these targets. Small property managers and developers, as well as operators of single buildings, are individually less attractive of a target than a larger firm, though the market for offerings tailored to operators at these scales is large.

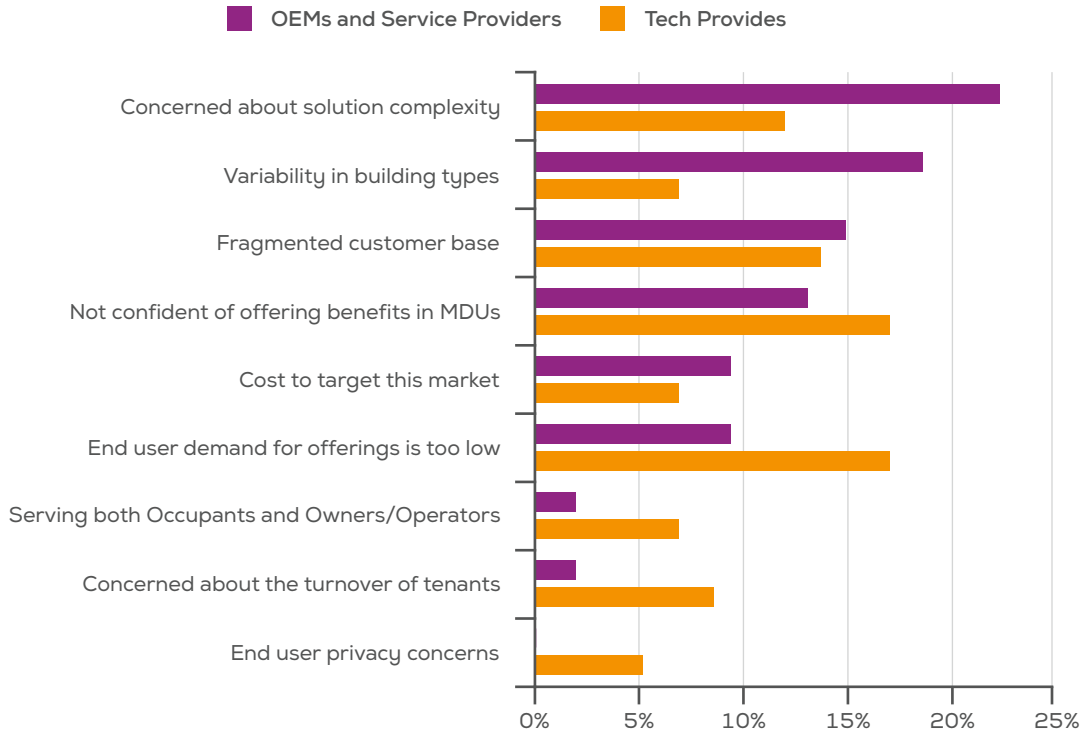
Figure 3.13 Owners/Operator Portfolio Size by IoT Interest, n=110



Equipment Manufacturers, Service & Technology Providers

Of the equipment manufacturers and service providers who have chosen not to develop connected offerings, the complexity of solutions required in the MDU market is a primary barrier. As we have noted, the fragmented adoption base reflects the range of building types, owner/operator types, and occupant personas that make up the MDU market. Meanwhile, technology providers are primarily deterred from developing MDU-specific connected offerings by a lack of confidence in the value of their offerings in this environment, mirrored in lack of end-user demand for these suppliers' products in MDUs.

Figure 3.14 Barriers to Supplier Development of MDU Offerings, n=54



3.5 SCALE OF SMART MDU OPPORTUNITY

Within Harbor's Smart Systems Forecast Model, the Buildings Venue represents a large and growing opportunity. The multi-dwelling unit customer segment includes 40 distinct device types within seven device segments and is forecasted across five distinct regions, including North America. Using public government data, and the survey and interviews completed for this research, Harbor updated and validated its device and revenue forecasts across the multi-dwelling unit segment.

In the context of newer Smart Systems and IoT technology in buildings, connectivity hardware has historically driven the market. Now, hardware prices are falling across the board and the basic enablement opportunity is decreasing as a percentage of the total Smart Systems opportunity. Today, the most substantial revenue opportunities can be found in applications and managed services. As technology stabilizes, it becomes more valuable to focus on service opportunities to drive future growth.

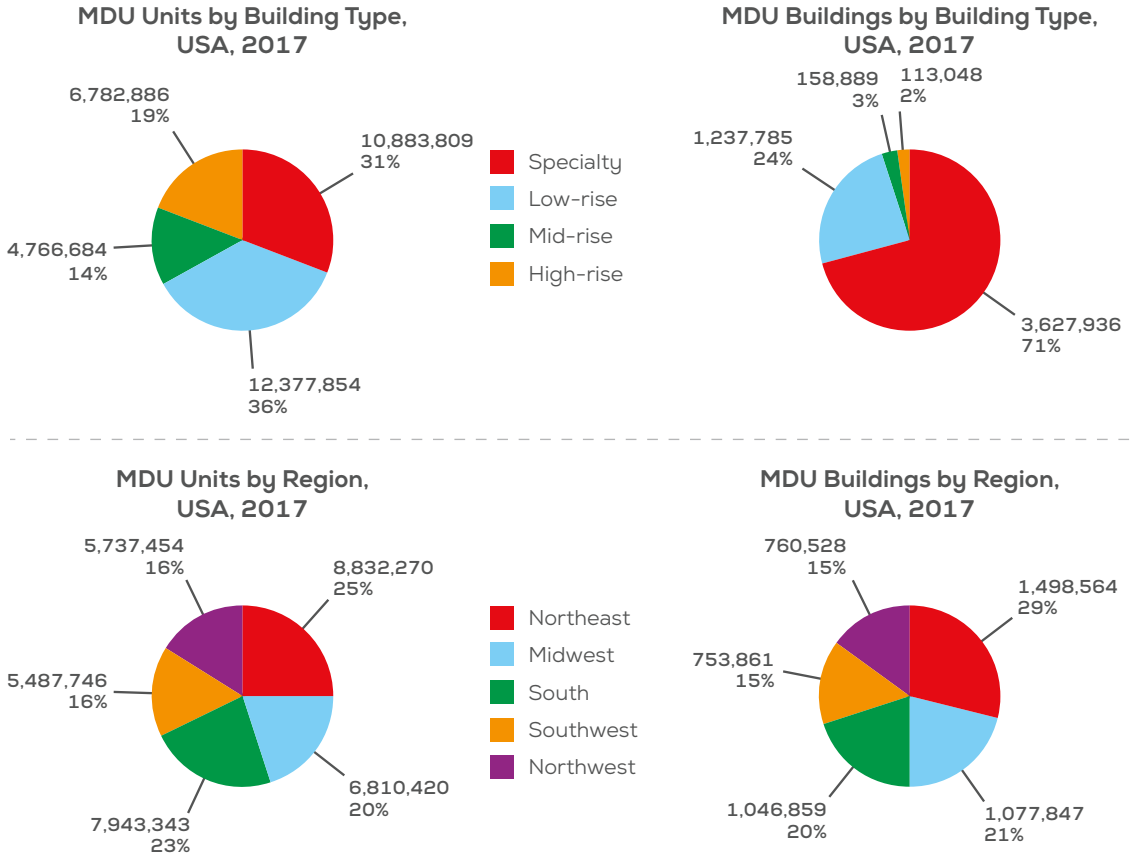
3.5.1 Multi-Dwelling Unit & Building Statistics

There are over six million MDU buildings across the United States and Canada containing over 40 million units. Over 85 percent of both units and buildings are in the US, with the Northeast, South and Midwest regions all individually containing more units and buildings than all of Canada. In Canada, Ontario

and Quebec account for over 68 percent of all units (3.9 million) and 66 percent of all MDU buildings (0.58 million)

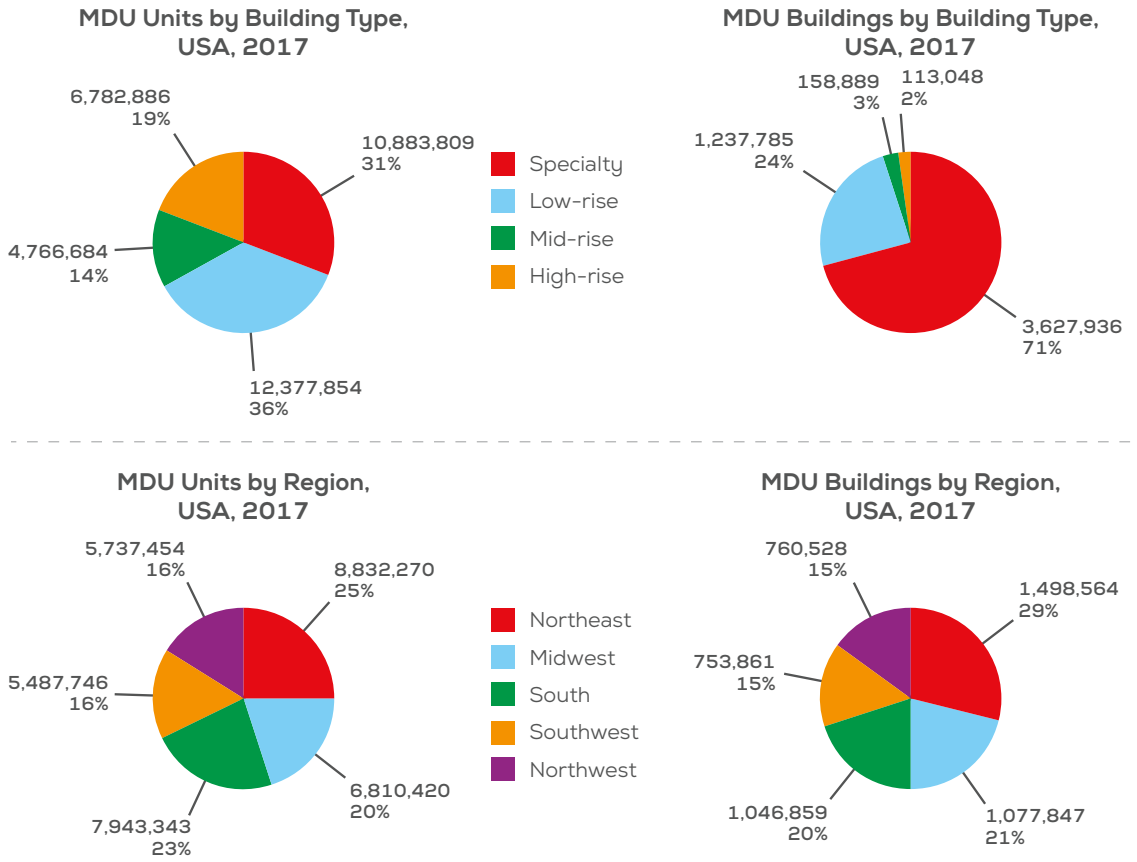
Over 65 percent of MDUs are specialty building types, but these buildings only contain about 32 percent of all MDU units. Low-rise buildings account for the greatest number of units: 14.1 million, or 34.9 percent. Low rises make up 23.5 percent of all MDU buildings, and high-rise buildings are only 2.2 percent of all buildings, but contain 19.7 percent of all units.

Figure 3.15 United States MDU Buildings & Units by Type & Region



Source: US Census Bureau, National Multifamily Housing Council, Harbor Research Analysis

Figure 3.16 Canadian MDU Buildings & Units by Type & Region



Source: StatCan, Harbor Research Analysis

3.5.2 Smart Devices within MDUs

Across the forecasted device segments, there are over 92 million installed connected devices in the United States and over 16 million installed connected devices in Canada for a total of 109 million connected devices in 2017. This installed base is forecasted to grow at a rate of 27.1 percent over the forecast period, resulting in 362 million installed devices in 2022.

There are over 36 million shipped connected devices in the United States and over six million shipped connected devices in Canada for a total of 42.5 million connected devices shipped in 2017. The number of shipped devices is forecasted to grow at a rate of 24.1 percent over the forecast period, resulting in 125 million devices shipped in 2022.

The largest device segment by number of devices installed is Life Safety and Security, with 40.6 million devices installed in 2017, growing at a rate of 27 percent over the forecast period resulting in 134 million devices installed in 2022.

Figure 3.17 Shipped and Installed devices by year, 2017-2022

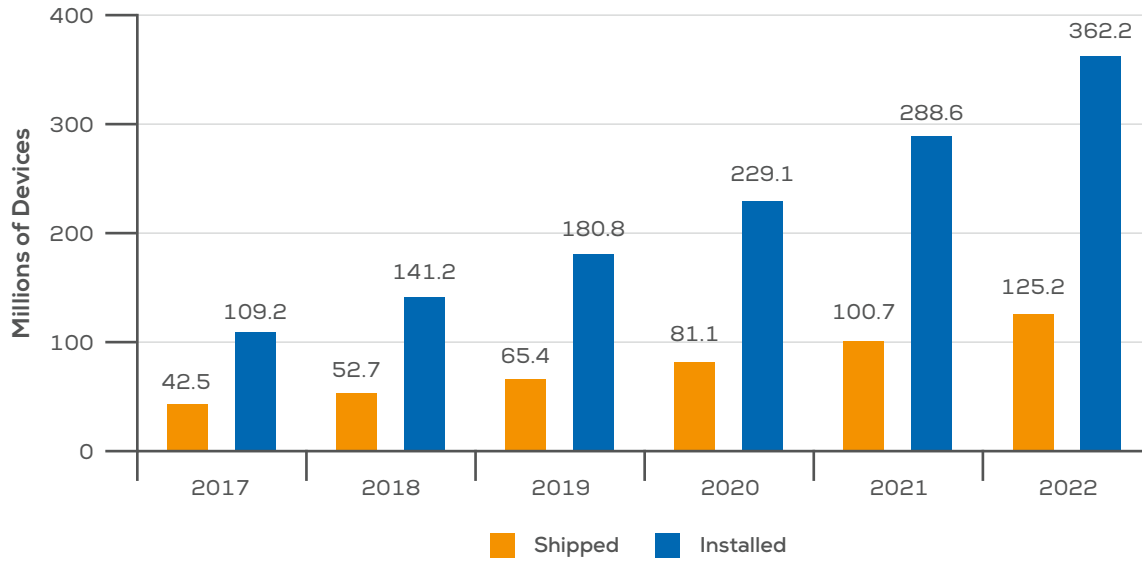
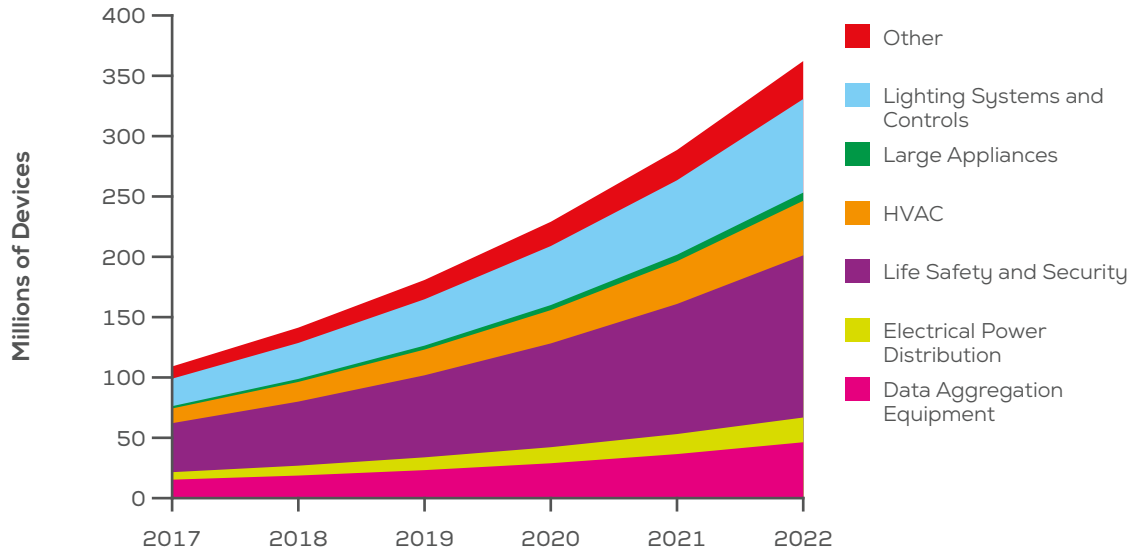


Figure 3.18 Installed Devices by Device Segment, 2017-2022



3.5.3 Smart Systems Revenue Opportunities

The MDU market presents a significant opportunity for smart systems and IoT-based revenues, with a total opportunity of $2,908 million in 2017 growing at a compound annual growth rate of 31.6 percent to $11,488 million in 2022. Smart systems revenues for MDUs breakdown into the following macro categories:

- **Enablement revenues**, the smallest revenue stream represent an opportunity of $282 million in 2017.
- **Network services revenues** represent 20 percent of the total opportunity in 2017, with a value of $586 million in growing to $1,926 million in 2022 at a CAGR of 26.9 percent.
- **System Applications revenues** are growing at a rate of 32.9 percent over the forecast period,

increasing from a $420 million opportunity today to a $1,738 million opportunity in 2022.

- **Value added applications** represent the largest revenue opportunity at $1,620 million in 2017 growing at a CAGR of 35.1 percent to $7,278 million in 2022.

The value added application revenue stream is broken down into five applications within multi-dwelling units, all explored in-depth in the following section. The largest of these applications is Building & Equipment Management, an operations-focused application targeted at building owners and operators. The opportunity for this application is $457 million today, growing at a CAGR of 35.9 percent to $2,119 million in 2022. More details on the opportunity around these applications can be found in the pages to follow.

Figure 3.19 Smart Systems Revenues by Revenue Stream, 2017-2022

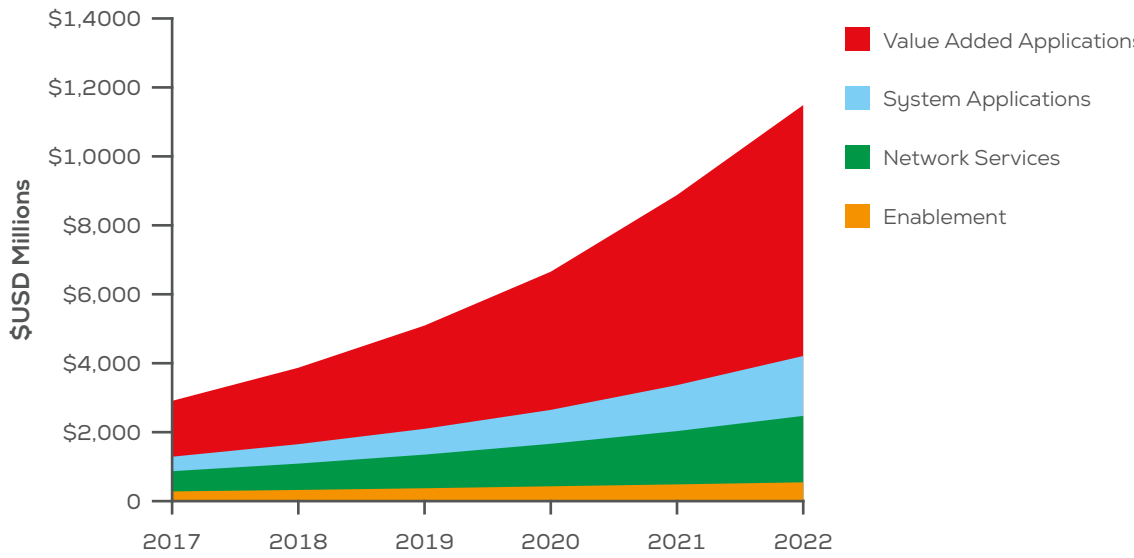
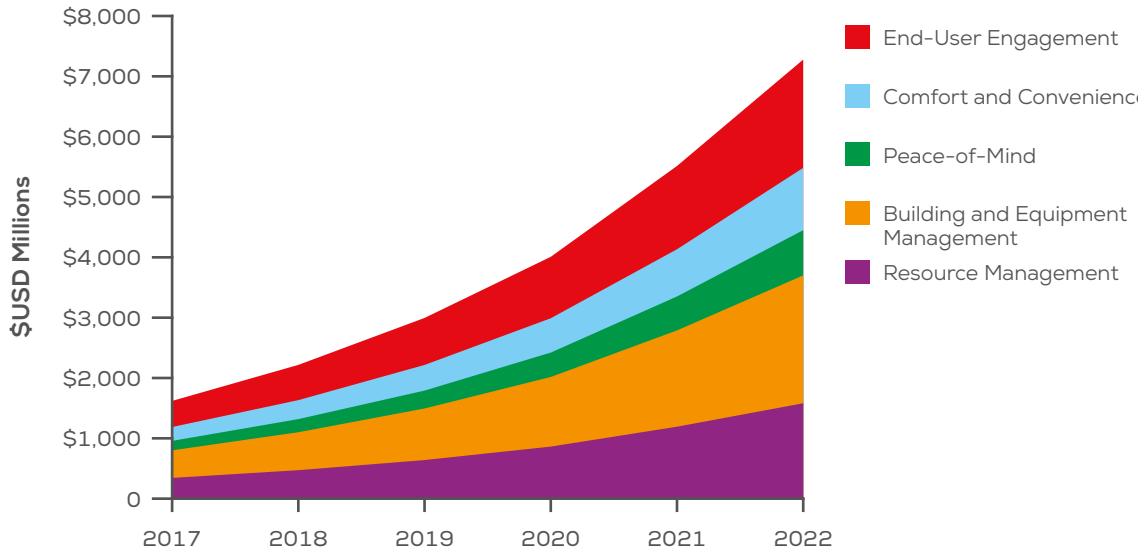


Figure 3.20 Value Added Application Revenue by Application, 2017-2022



Notes

1. US Census Bureau, Statistics Canada, National Multifamily Housing Council, HRI Analysis
2. Interview with Vice President at NMHC, 13 January 2017
3. Interview with Executive at Dwelo, 9 January 2017
4. US Census Bureau statistics
5. Interview with Vice President at Embue, 12 January 2017
6. http://www.statcan.gc.ca/pub/11-526-s/2010001/t002-eng.htm
7. Interview with Project Manager at BC Hydro, 30 March 2017
8. https://energy.gov/energysaver/electric-resistance-heating
9. http://www.hydroquebec.com/publications/en/docs/comparaison-electricity-prices/comp_2016_en.pdf
10. http://news.gc.ca/web/article-en.do?nid=1039549
11. http://aceee.org/state-policy/scorecard
12. Interview with Editor at AutomatedBuildings.com, 05 January 2017
13. Interview with Vice President at NMHC, 31 January 2017
14. http://www.iea.org/Textbase/npsum/building2013SUM.pdf
15. Interview with Executive at Dwelo, 27 January 2017

4. SMART MDU BUSINESS OPPORTUNITIES

Connected devices and services within MDU buildings and individual units can be combined in numerous combinations to enable simple, compound, or complex applications. Five distinct value added application segments have been identified which create value for building occupants or operators in different ways.

- **Resource Management**: Use cases that monitor and analyze resource and energy usage data to support efficient consumption and utility expenses.
- **Peace-of-mind**: Use cases that enable remote monitoring and alerting of home and occupant safety and/or connect to third-party security services.
- **Building and Equipment Management**: Use cases involving monitoring and managing equipment/building usage and performance to provide greater visibility into operations and reduce operating expenses.
- **Comfort and Convenience**: Use cases that leverage automation and/or wireless control of devices and services to increase comfort and ease of use while reducing device and appliance failure.
- **End-User Engagement**: Use cases that utilize data analytics to increase the value of services offered by equipment manufacturers, traditional or specialist service providers, or third-parties.

Each of these applications, depending on the complexity of the use cases installed in and across MDU buildings and units, stand to create value for multiple stakeholders. Building operators/managers stand to gain the most from Smart Systems apps in MDUs, with offerings either reducing operating expenses or enhancing occupant acquisition, satisfaction or retention to increase margins.

Figure 4.1 Overview of Value Proposition of Smart Systems for Suppliers

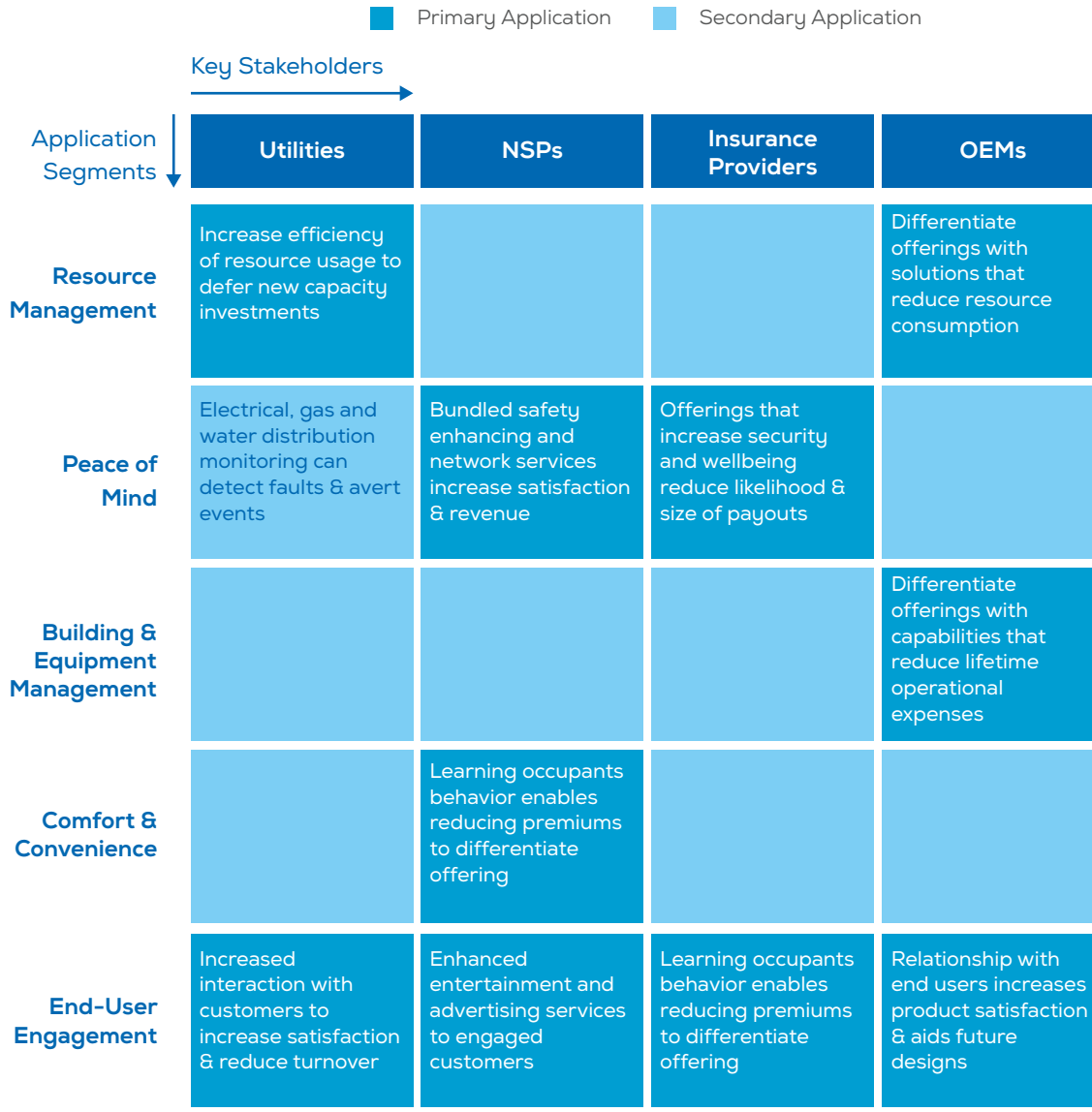


Figure 4.2 Overview of Value Proposition of Smart Systems for End-Users

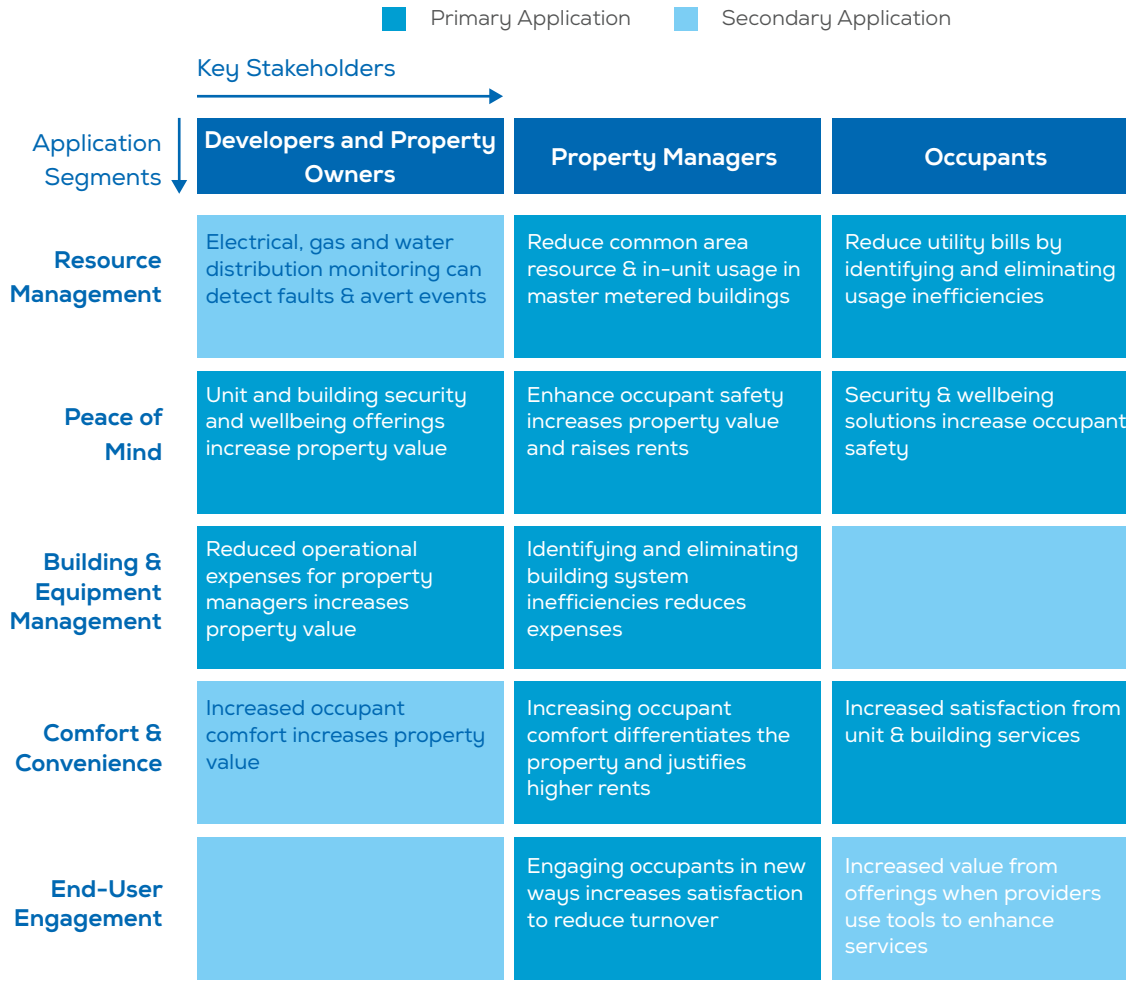
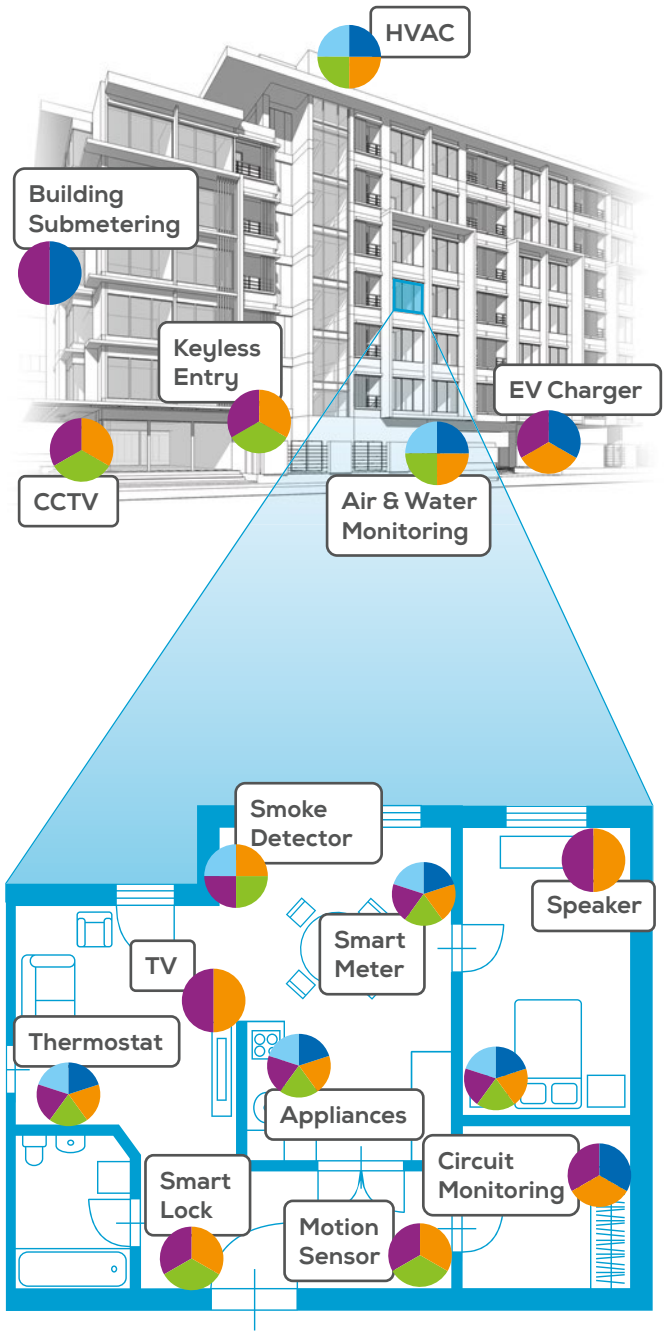


Figure 4.3 Overview of Devices within Application Segments & the Stakeholders Who Stand to Benefit



Resource Management

Applications that monitor and analyze resource and energy usage data to support efficient use and reduce costs

Primary Value Captured By:
• Occupants • Building Operators

Comfort and Convenience

Applications that use wireless control or automation to increase comfort and ease of use and reduce offering failure

Primary Value Captured By:
• Occupants • Building Operators

Peace-of-Mind

Applications that enable remote monitoring of home and occupant safety and connect to third party security services

Primary Value Captured By:
• Occupants • Building Operators

End-User Engagement

Applications that use end user data to increase the value of offerings delivered by OEMs and service providers

Primary Value Captured By:
• OEMs and Service Providers • Building Operators

Building & Equipment Management

Applications that manage equipment and building usage to identify inefficient operations and reduce operating expenses

Primary Value Captured By:
• OEMs and Service Providers • Building Operators

4.1 RESOURCE MANAGEMENT

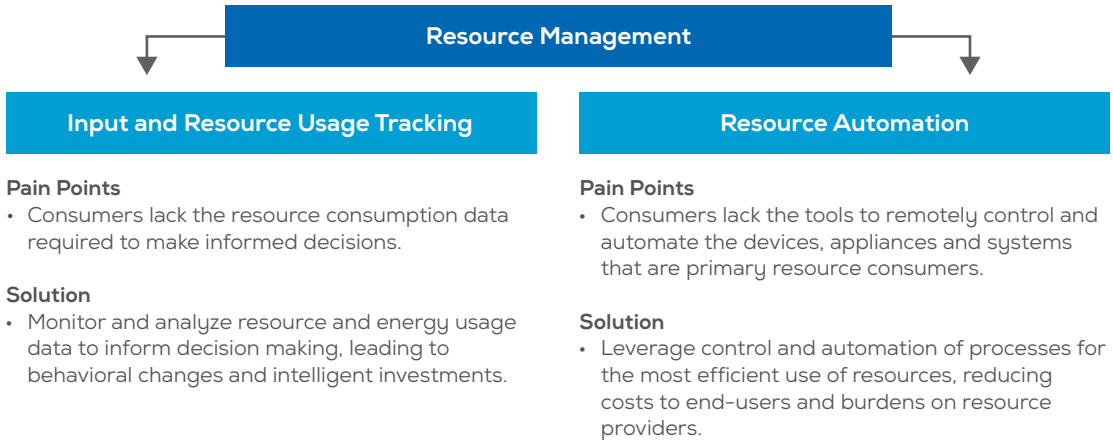
Resource management is a broad application segment, composed of multiple use cases that seek to reduce the cost of resource consumption by identifying and reducing system inefficiencies. These use cases solve two primary pain points surrounding MDU electricity, natural gas, and water usage: lack of consumption pattern visibility and lack of ability to remotely control and automate resource consuming. Resource consumption efficiency gains stand to benefit MDU occupants, property managers, and resource suppliers.

Consumer lack of awareness of resource consumption habits, a result of consumption data either not being shared with resource users or not collected at all, leads to inefficient usage. To address this challenge, "Input and Resource Usage Tracking" use cases promote data capture and visibility, allowing users and suppliers to monitor and analyze resource consumption to make informed decisions about usage. In addition, analytics based on consumption patterns have the potential to drive behavioral changes by identifying steps that can reduce utility bills. These behavioral shifts produce increases in the efficiency of both resource consumption and the overall delivery system, from generation to use, thereby benefitting both users and suppliers of resources.

> "We're seeing a big opportunity as various players seek to gain greater understanding of how energy is used by consumers. Solar producers need to work with consumers to match production and consumption, and utilities looking at DR need to control user loads. Ultimately, it's on them to get the hardware into end-user environments so they can take advantage of it, which is why we're seeing them subsidize adoption of these devices."
>
> - Executive, SafePlug

Larger efficiency gains, and thus greater system benefits, are achieved when consumption pattern analytics are leveraged to automate resource consuming systems in such a way as to maximize occupant value from the services these systems provide while minimizing wasted resources. These "Resource Automation" use cases provide occupants and property managers remote control over energy and water delivery and consuming systems, providing additional convenience benefits to users beyond the cost savings that accrue from reducing utility bills.

Figure 4.4 Resource Management Overview



Within the context of electricity usage, a special case exists for building integration with electric utilities. Utilities are seeking opportunities to expand visibility and control over their distribution systems as distributed energy resources, especially solar panels, and on-site battery storage make traditional energy consumers also energy producing assets.

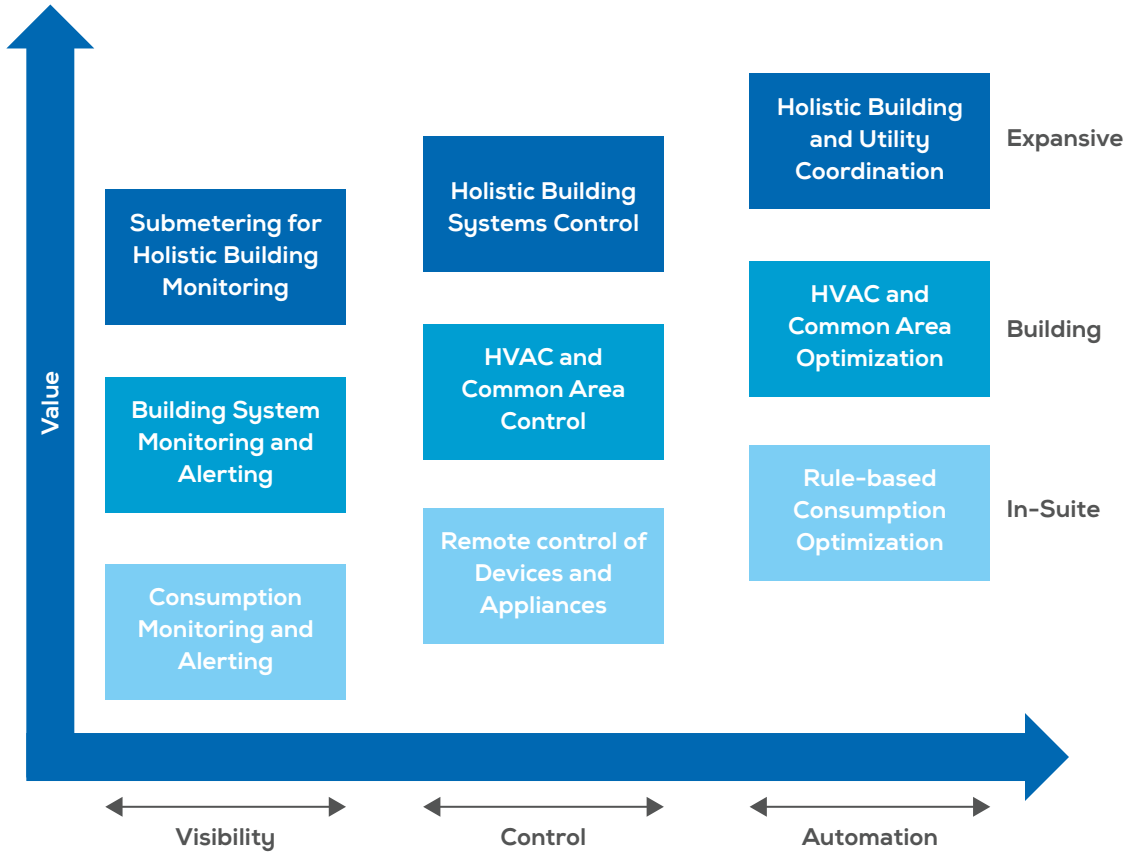
One opportunity for utilities to capture value from the changing grid dynamic is via demand response (DR) programs, which leverage major energy consumers as flexible assets that grid operators can call on to use less electricity when overall demand is high. By reducing peak grid electricity demand, utilities are able to defer investing in new generation, transmission and distribution capacity and "turn down" demand rather than turning on especially expensive and CO_2 intensive "peaker" plants.

Energy management use cases within MDU buildings exist across a spectrum of complexity and value creation, increasing in both breadth and depth. The breadth of use cases expands from managing in-unit energy consumption, to integrating in-unit and building systems to optimize building HVAC operations, and finally integrating holistic building management in with utility operations to maximize energy distribution systems.

> "Within MDUs, there's potential to get the common area loads enrolled in our DR programs, get operators receiving performance payments for cranking down common area HVAC or precooling at certain times. Ultimately, the opportunities in commercial are just far larger, way simpler. If we could get all the units in an apartment building and common areas, then it'd be worth our while."
>
> - DR Specialist, ConEdison

At the same time, use cases expand in depth; from simple, providing energy consumption data visibility to end-users; to compound, enabling remote control of major resource consuming systems; and finally complex, with automation and optimization of these systems. The most complex implementations provide: building operators control and automation of high-consuming systems, increase comfort and convenience for occupants while reducing their utility bills, and reduce costs for electric utility managers.

Figure 4.5 Energy Management Use Case Spectrum



The breadth and depth of resource management offerings determine the extent of value creation, the stakeholders who stand to benefit, and thereby the key drivers of adoption. Depending on the design of the solution and the building management model, resource consumption visibility, control and automation offerings can create value to MDU occupants alone, occupants and building operators, or occupants, operators and the resource suppliers.

Generally, MDU occupants stand to reduce the cost of their utility bills through the implementation of resource management use cases. This is accomplished either with customized behavioral suggestions, based on occupant consumption patterns or efficiency gains from adoption of control and automation tools. Tools to deliver this value to MDU occupants closely resemble home management systems (HMS), which provide holistic management of the major energy and water consumption systems of the home. Since thermostats must typically be installed by owners or operators, MDU-focused resource management offerings must create value to these stakeholders that justifies the upfront and ongoing costs of hardware, a requirement that has challenged HMS providers seeking to enter the MDU market.

Building operators stand to benefit from traditional building management systems (BMS), which increase the efficiency and operational visibility of heating, ventilation, air-conditioning (HVAC), and water distribution and heating systems that serve the entire building. Such tools have been proven effective in commercial and industrial buildings, which share many physical characteristics with mid and high-rise MDUs.

> "Ideally, we're providing finance and regulatory structure, ESCOs provide all the equipment, control systems, and strategy. We're looking to software platforms, DR aggregators and analytics players, as key components in getting DR programs underway. We've seen cases of operators doing this manually, literally running around and shutting things down when we give the call, but its all heading towards advanced BEMS systems integrated in the platform. It has to for the system to run efficiently. To keep all these guys involved, we really need the incentives as high as possible, so we get customers and third-party guys selling services to their customers, making money themselves to fund reinvestment."
>
> - DR Specialist, ConEdison

Further, tools to manage the energy and water consumption of common area appliances, including washers, dryers, and refrigerators, as well as common area lighting, stand to provide significant resource cost savings for building managers. Offerings that integrate management of lighting systems and appliances with traditional building are particularly valued, as they enable holistic building resource management from a single interface.

In scenarios in which building managers are financially responsible for occupant utility bills, as in student housing, elderly care facilities, and buildings with "all-inclusive" rent, building managers are incentivized to utilize tools that increase occupant resource consumption efficiency. However, most MDUs operate in such a way that building managers have no incentive to install the infrastructure required to enable resource management use cases, as utility costs are passed directly on to occupants. The primary motivation to install hardware and devices that increase occupant resource consumption efficiency is marketing driven, enabling managers to differentiate their units with new technology with brand recognition.

> "We're seeing more residents looking for certain devices, certain brands, and that's driving property managers to look into these things. It's critical we make this about more than the sale. We have managers who bought smart thermostats from someone, installed them, and have a building full of unprogrammed devices that don't talk to central HVAC systems. That's an expensive marketing move."
>
> - Vice President, Embue

Utilities stand to benefit in numerous ways from IoT-enabled resource management devices and services in buildings, which offer the means to interact with end-users of resources. While this is equally true for natural gas and water utilities, North America is predominantly seeing progress in the development of new tools from electric utilities, who are facing pressure to decrease environmental impacts by increasing efficiency with a modernized distribution system.

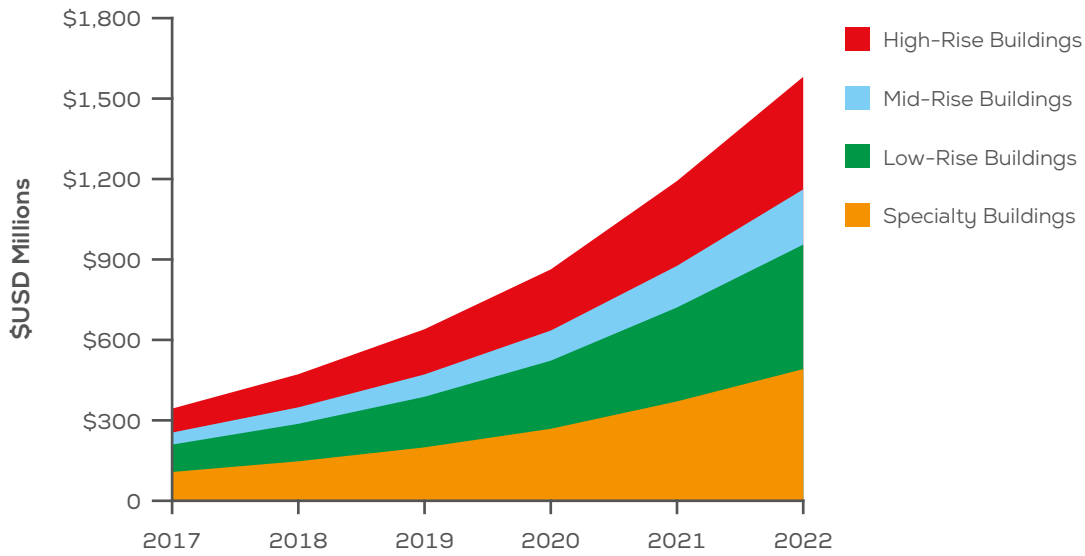
Investments in grid modernization are proving to provide long-term cost savings for utilities. Usage visibility, when tied to recommendations for device choices or behavioral shifts, can promote efficient decision-making and result in modest demand reductions, allowing utilities to defer investments in new generation, transmission and distribution infrastructure. The devices and services that enables usage visibility can be further leveraged as part of demand response programs, in which agreements between end-users and the utility can result in significant peak demand reductions, reducing the need for costly and inefficient "peaker" plant electricity generation. Finally, increased coordination and communication with major energy consumers, including large MDUs, enable utilities to increase their integration of distributed energy resources and variable renewable energy in order to reduce emissions while maintaining system reliability.

4.1.1 Scale of Resource Management Opportunity

The total Resource Management application revenue opportunity in MDU buildings is forecasted to rise from $344 million in 2017 to $1,581 million in 2022, representing a compound annual growth rate

(CAGR) of 34.2 percent. Specialty buildings dominate the current revenue opportunity due to the significant share of the MDU market that this building type makes up. By 2022, growth in market share and growth of opportunities within both low and high-rise buildings are expected to make all three of these building types exceed Smart Systems revenues of $420 million per year.

Figure 4.6 Resource Management Application Revenue Opportunity by Building Type, 2017-2022



4.1.2 Trends & Forces Affecting Resource Management Opportunities

Greater connectivity and granular metering, cost-conscious customers and the proliferation of distributed energy resources are all driving an increased focus on Resource Management opportunities.

Technology Forces & Impacts

- Traditional point solutions for increasing the visibility of and control over major resource consuming systems (e.g., heating, air-conditioning, and lighting) are now converging onto a common IT infrastructure, driving integrated Building Management Systems (BMS) that provide a centralized platform for holistic system visibility and control.
- Standardized communications protocols, such as BACnet, and data management conventions, including Haystack, Green Button and OpenADR, are making data sharing and use simpler, such that building managers and utilities can make use of resource consumption data from a range of systems.
- Advanced metering infrastructure (AMI), including smart meters, meter data management and two-way communications systems, is enabling a new line of connection between utilities and resource consumers.

Competitive Forces & Impacts

- Energy service companies (ESCOs) who have traditionally focused on commercial applications have struggled to develop MDU-focused offerings that create value across stakeholder types and work within the smaller capital budgets of MDU owner/operators.
- Providers are seeking to expand from point solutions and towards unified offerings that optimize holistic building resource consumption while enhancing the user experience.
- The smaller margins available in the MDUs relative to commercial buildings continue to

challenge the cost structure of incumbent automation and energy management players.

- Appliance and lighting OEMs are embedding sensing and connectivity into their equipment, and joining or building ecosystems of interoperable resource management services to differentiate their offerings.
- Network service and cable providers are leveraging their existing hardware and services in units to serve as platforms for in-unit energy management offerings, but have yet to successfully develop whole-building resource management solutions.
- Utilities are leveraging AMI to take advantage of regulatory incentives for avoiding new capacity investments with load shifting, demand response and frequency regulation, tools increasingly valued as variable renewable energy makes up a greater percentage of grid energy.
- Utilities, who have partnered with platform providers to successfully offer resource management services to commercial and single-family residential customers have struggled to develop solutions for rentals in the MDU market that create both occupant and building operator value.
- MDU and hospitality-focused automation innovators have found early success with bundling resource management offerings with adjacent services, including access management and occupant convenience offerings.

Customer Forces & Impacts

- Environmental awareness among energy users, especially in urban and progressive suburban regions with a high portion of young users, is increasingly a factor driving decision-making.
- Cost-focused building occupants are driven by uncertainty about resource consumption and associated uncertainty about monthly billing expenses, to adopt tools that increase the visibility of resource consumption.
- Occupants who experience energy price volatility as a result of market factors or time-of-use rate structures are further incentivized to control and automate energy consuming systems in such a manner as to minimize costs.
- Tech-focused occupants are environmentally conscious and interested in adopting technologies and living quarters that minimize their carbon footprints, with reduced electricity bills as a secondary benefit from adoption behind visualizing the environmental benefits resulting from more efficient energy consumption.
- Occupants are willing to shift behavior to achieve cost reductions and cut personal emissions, though more are interested in control and automation tools that achieve these goals without requiring behavioral changes.
- Building managers are motivated by reduced utility bills for building systems as well as common area appliances and services, including HVAC-R, water heating and distribution, and lighting equipment.
- Our research indicates that around 10 percent of MDU managers and operators are responsible for unit resource consumption in the US and Canada, leaving little incentive for investment in efficiency-enhancing devices and services.

Socioeconomic Forces & Impacts

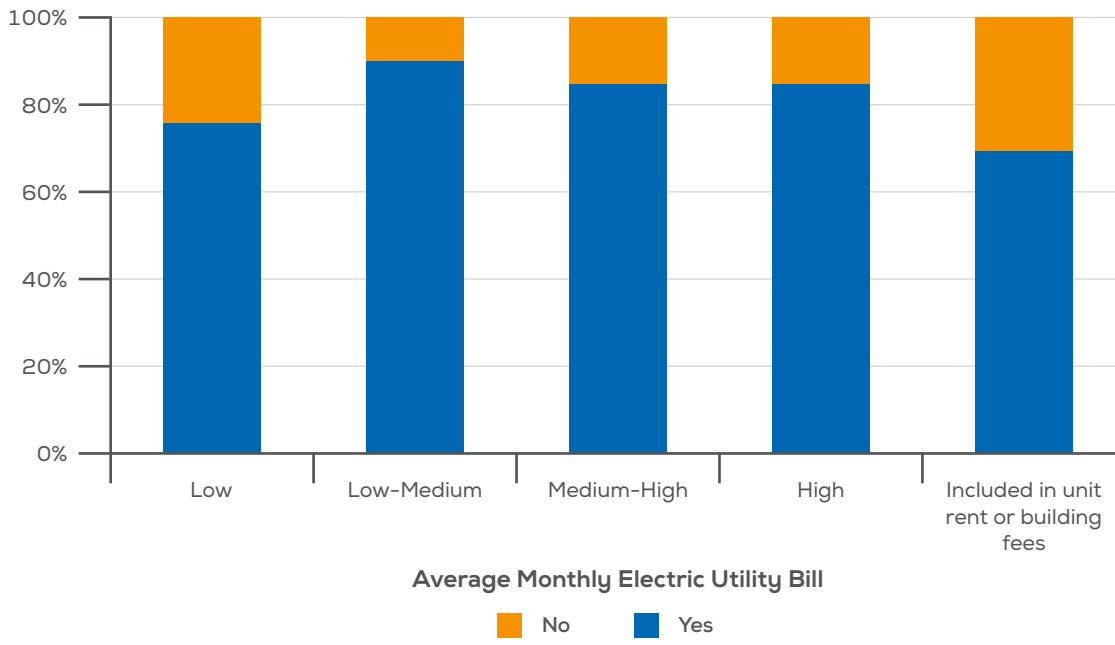
- Increasing global awareness of the environmental impacts of fossil energy exploration, refining, distributing and combusting has led to countless efforts, of both social and regulatory nature, to decrease the detrimental effects of energy systems.
- Regulatory mandates for energy efficiency improvements to existing buildings and requirements for new builds are encouraging not only passive design improvements but also active control systems that leverage sensors and analytics to optimize building energy consumption.

- Government funding of AMI programs has accelerated adoption of smart meters, providing the basis for occupant energy management use cases while enhancing grid visibility and control for grid operators.
- The economics of distributed energy resources (DERs), including solar energy and energy storage, have improved dramatically and increased the deployment of these resources by commercial and residential building owners/operators across utility grids, though adoption in MDUs remains low.
- Proliferation of DERs are making end-points on the grid increasingly a composition of both energy consumers and producers, demanding that grid operators leverage distributed energy resource management systems that communicate with and control IoT-enabled DERs.

4.1.3 Customer Interest & Adoption Indicators

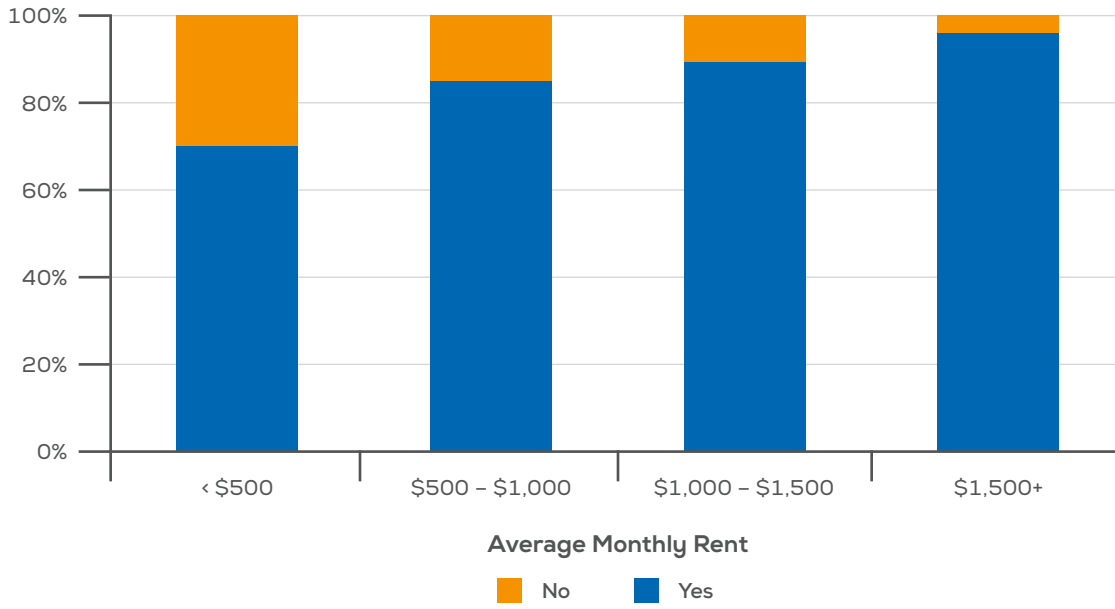
Occupants responded that they are least interested in connected devices and services that would increase resource utilization efficiency when their current expenses are low or nonexistent, as when they are included with their unit rent. The findings did not show a statistically significant difference between occupant interest amongst those responsible for average to high utility expenses.

Figure 4.7 Occupant Interest in Resource Management Applications by Unit Monthly Electric Bill, n=473



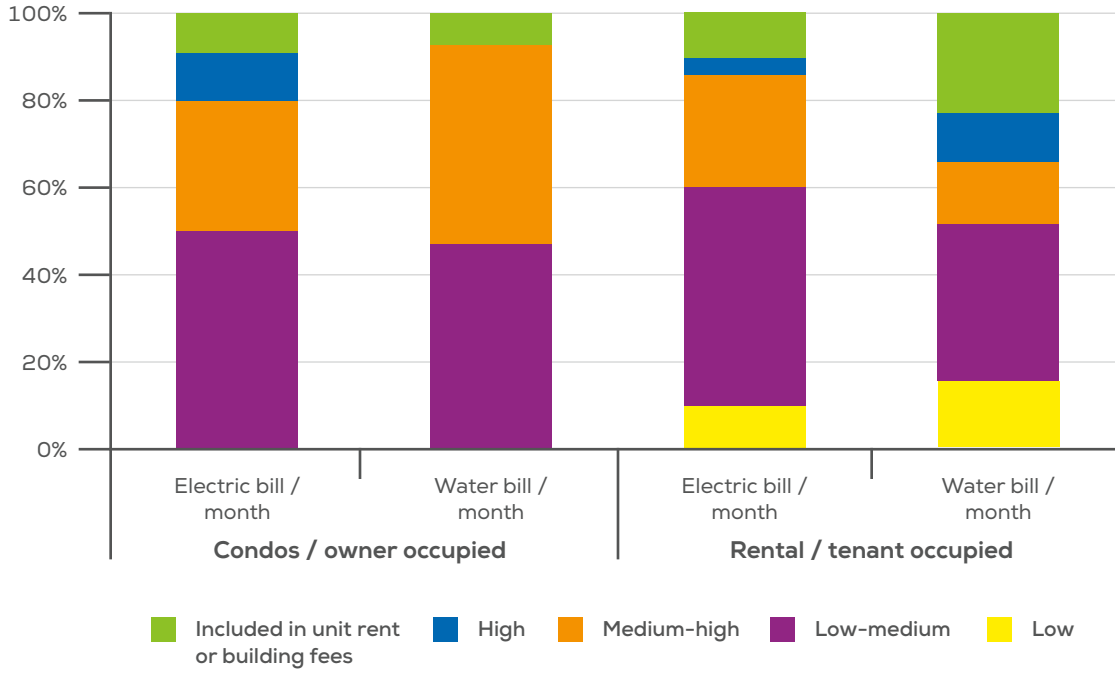
Further, the impact of overall unit expense is highlighted by the reduced interest of occupants with low rent, with those paying less than $500 per month showing a statistically significantly reduced interest in energy and water reduction use cases.

Figure 4.8 Occupant Interest in Resource Management Applications by Unit Monthly Rent, n=473



Findings further highlight that, while a greater portion of operators cater to condo occupants with higher electricity and water utility expenses, operators have no direct incentive in these buildings to invest in tools to reduce operating expenses that occupants are responsible for. In rental occupied MDUs, a greater portion of building operators include utility expenses in rent, and will therefore be incentivized to increase the efficiency of resource utilization.

Figure 4.9 Owner/Operator Utility Responsibility by Ownership Model, n=110



4.1.4 Case Studies

Several case studies demonstrate the value of these offerings:

- **Schneider Electric and Arcadia Power**
  - **What**: Through the partnership they are offering Schneider smart thermostats to utility customers for $0 upfront, with energy bills managed by Arcadia and energy savings over time paying for cost of devices.
  - **Result**: The program has just started, but is expected to reduce occupant energy costs by 30 percent and providing platform for future ToU and demand response offerings.
- **Enphase and Solaray Energy**
  - **What**: The collaborative effort has provided an integrated rooftop PV, battery storage, and BEMS offering for a student housing co-op, leveraging government energy efficiency incentives.
  - **Result**: The program has just started, but is expected to provide 80 percent of the energy demanded by the 40 MDU residents.
- **NextHome and WegoWise**
  - **What**: Implemented WegoWise's energy consumption analytic tools to identify building system inefficiencies in water, gas, and electricity consumption across portfolio of 25 buildings.
  - **Result**: By targeting the greatest opportunities for efficiency gains, NHR reduced water and energy costs by 40 percent and 15 percent, respectively. NHR's return on these investments was less than one year.
- **FirstService**
  - **What**: The property manager replaced master metering in a 1,000-unit apartment complex with electric submetering to enable residents to pay for personal energy usage.
  - **Result**: Residents awareness of consumption and responsibility for billing resulting in shifting behavior and reduced occupant burden. Total building maintenance costs were reduced 15 percent.

- **Powersage**
  - **What**: Circuit monitoring solutions identify inefficient energy usage in multifamily units to predictively maintain appliances and building systems and reduce utility bills.
  - **Result**: Pilot implementation yielded 14 percent energy savings, mostly in common areas and vacant units, as well as four percent maintenance savings from repairing rather than replacing equipment.
- **Leading international electric utility & energy management platform provider**
  - **What**: The opt-out behavioral modification program for multifamily occupants, developed by the platform partner administered by the utility, provides mobile access to consumption data and customized recommendations for cost savings.
  - **Result**: The utility saved 1TWh over the first year of the pilot program, deferring investment in new infrastructure and generating revenue for every kWh saved.

4.1.5 Channels to Market

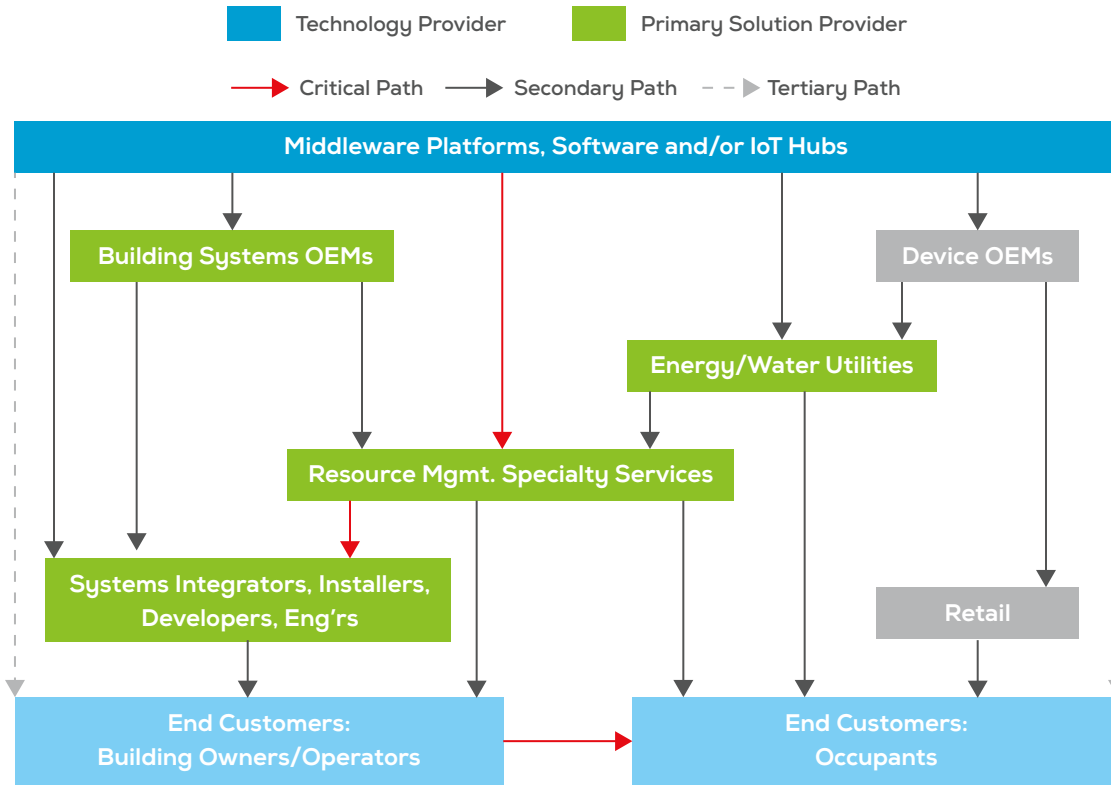
Resource management offerings are delivered to building operators and occupants most efficiently by specialty service providers, who use installers and systems integrators to provide platforms and services to end customers. Installers, system integrators (SIs), and engineers are important channel partners for specialty services providers, as ongoing maintenance and support is a critical element of successful offerings and challenging to provide as a standalone service provider as operations scale.

> "Distributors help us go to market with our products, but we market to engineers and contractors, and see them as key decision-makers in the process of choosing HVAC equipment."
>
> - General Manager, Navien

Energy and water utilities have the opportunity to leverage platforms and IoT hubs to directly provide resource management offerings to consumers, though this interaction is beyond the scope of their traditional functionality and challenges their organizational structure. Utilities that have successfully developed programs that increase MDU consumption efficiency have done so through specialty service providers.

Specialty providers offer a range of services to utilities, generally providing the software and analytics tools, often developing tailored solutions for participating end-customers, and occasionally aggregating resource consumption efficiency gains to effectively monetize these gains from the utility's perspective.

Figure 4.10 Resource Management Solution Channels to Market



4.1.6 Conclusions & Recommendations

Resource management presents one of the most classic split incentive problems. If a building owner or operator passes the cost of energy and water onto the occupants, there is little incentive for the owner or operator to reduce his or her use. Likewise, if energy and water bills are split equally amongst each household, individual households have little incentive to reduce their use.

Sub-metering can be leveraged to overcome this problem and is a key enabler of effective resource management initiatives. Resource management offerings must provide end-users either direct control of energy resource consuming systems or the ability to set policies within which optimization occurs to ensure users retain a feeling of control over the resource management system.

The central nature of energy around almost any activity within MDU buildings positions utilities, manufacturers and servicers of energy consuming equipment, uniquely well to develop an ecosystem of partners to deliver a suite of offerings that leverage energy usage and adjacent asset data.

MDU-focused technology start-ups seek to leverage the advantages conferred by their small size, particularly the agility which enables them to rapidly tailor solutions to fit the needs of property managers of different scale, with different building types and size, serving a range of occupant demographics. These new entrants, along with larger technology giants like Amazon and Google, pose a threat to slow moving utilities that do not organize effectively to deliver these types of solutions.

> "The issue is that we have all these suppliers trying to be the providers of everything to everyone, and this isn't a one size fits all environment. Open-source platforms that are IP or Niagara-framework compatible have been successful in commercial buildings because they allow users to stitch together solutions that meet their specific needs. That needs to happen in the MDU space too. We need platforms and gateways that enable users to easily and cheaply connect any type of device from any type of supplier. Flexibility and agility

> are what operators are looking for, that's what suppliers need to figure out how to deliver."
> – Executive, WhiteSpace Building Technology Advisors

Successful implementations provide end-users access to meaningful data, ensuring they are meeting their cost and environmental goals, and provide tailored, actionable suggestions for behavioral changes that will increase their resource consumption efficiency. Offerings that use open-source conventions for data modeling enable a wide community of developers to create value-adding applications for adopters of the offering, and offerings that analyze resource consumption data and autonomously optimize efficiency and cost create the greatest value for end-users with the least added complexity.

Recommendations

- Property managers with all-inclusive rents stand to significantly reduce operational expenses in their MDU buildings by installing resource management offerings that enable bounds on occupant resource consumption to be set and building systems to be run more efficiently.
- Among managers of buildings with occupant responsibility for utility bills, those with high occupant turnover rates are the most attractive targets as ROI from resource management offerings increases with vacancy.
- Specialty service providers are best positioned to deliver resource management solutions to MDU owner/operators as well as building occupants, leveraging partnerships with utilities, software and hub providers, and manufacturers of major resource consuming equipment.
- OEMs are best positioned to partner with specialty services and platform players with resource management solutions, ensuring that their products are interoperable with a wide range of potential partner offerings.
- Building developers, owner/operators, and third-party managers are leveraging independent installers, systems integrators and contractors to inform decision-making around connected devices and services, making these players important channel partners for OEMs and service providers.
- Utilities are best served by leveraging offerings from technology providers and specialist platforms rather than trying to develop connected offerings internally and bring them directly to customers. Purchasing from or partnering with these suppliers provides technology expertise and ongoing support of solutions that utilities are not well organized to deliver alone.
- Utilities and specialty providers can partner with electrical OEMs to develop programs that provide granular billing information to each unit in the MDU, enhancing the value that the occupant receives by reducing monthly bills and increasing the value that owner/operators and managers can charge.
- For electric utilities, this foundational offering can be expanded upon to offer significant value to grid operators by integrating the building's energy profile into grid operations as an asset in demand response, voltage and outage management programs.
- While the ability for platform players themselves to organize and support ecosystems providing holistic resource management offerings that create value for both operators and occupants has not yet been shown, the potential for disruptive moves from these firms is high.

Figure 4.11 Resource Management Recommendations for Service Providers

		Utilities	Telcos	Insurance Providers	Specialty Services	IoT Hubs, Platforms and Software
Primary Opportunity		Provide recommendations for conservation and direct price signals to MDU occupants and property managers	Provide the connectivity infrastructure required to enable IoT devices and services	Provide resource mgmt. tools to existing customers as part of broader risk mgmt. solution	Provide energy consumption and water distribution monitoring services, aggregation of demand response capacity	Unified platform that provides integrated energy delivery and management solution to building owners and managers for visibility into and control over both unit-level and building-wide resource consumption
Value Prop		• Increased end-user engagement and satisfaction • Increased operational efficiency • Reduced peak demand enables deferring capacity investments	Deliver wired or wireless means of securely connecting devices and enabling services	Home automation offerings which offer resource mgmt. capabilities reduce risk of events requiring insurer payout, enabling competitive premiums	Capture revenue from savings to occupants and building operators from reduced operating expenses	Single interface to monitor and optimize holistic building resource consumption provides end users maximal efficiency with minimal complexity
Targets	Occupant Persona	Cost Driven	Tech Focused; Cost Driven	Cost Driven; Service Centric	Tech Focused; Cost Driven; Service Centric	Tech Focused; Service Centric
	Owner/ Operator Persona and Supplier Targets	Large property mgmt. firms	All Owner/ Operator Personas	All Owner/ Operator Personas	Large and small property mgmt. firms; Utilities with EE and DR programs	All Owner/Operator Personas; Utilities with EE and DR programs or seeking tools to engage and increase satisfaction of end users
	Building Type	New or existing high and mid-rise buildings provide the greatest ROI	New buildings with exclusive network contracts, retrofits in need of network upgrades for IoT solutions	All Building Types	New or existing high and mid-rise buildings provide the greatest ROI	New or existing high and mid-rise buildings provide the greatest ROI
Partners		Specialty services; IoT Hubs, Platforms and Software	Utilities; Specialty services	Specialty services; IoT Hubs, Platforms and Software; HVAC-R & Water OEMs	Utilities; IoT Hubs, Platforms and Software; HVAC-R & Water OEMs	Utilities; Specialty services; HVAC-R & water OEMs
Secondary/ Long-term Opportunity		Demand response, voltage mgmt, outage mgmt, accelerated service restoration, and locational systems performance evaluation	Provide the platform from which IoT devices are connected and services are rendered	Provide the platform from which IoT devices are connected and services are rendered	Manage utility bills and capture revenue from reduced operating expenses	Develop ecosystem of value-adding application partners around platform offering to provide true "hub" for IoT services in MDUs

Figure 4.12 Resource Management Recommendations for OEMs

		HVAC-R and Water	Lighting	Appliances	Electrical	Security	Building Products
Primary Opportunity		Design, provide the equipment for, and service holistic building systems	Sense and detect occupants and ambient light to dynamically optimize lighting levels in real time and conserve energy use	Embedded consumption sensing and connectivity	Metering infrastructure provides basis for in-unit EE programs; circuit monitoring does likewise	–	Embedded consumption sensing and connectivity
Value Prop		Use data to provide efficient and personalized service	Increased hardware, software and services sales supported by new packaged bundles	Monitor equipment consumption to alert users to abnormal consumption for equipment within units and in common areas	Monitor unit or building system consumption to alert users to abnormal consumption for equipment within units and in common areas	–	Integrate with broader resource consumption management tools to enable efficient control
Targets	Occupant Persona	Cost Driven; Service Centric	Tech Focused; Cost Driven; Service Centric	Tech Focused; Cost Driven; Service Centric	Tech Focused; Cost Driven; Service Centric	–	Tech Focused; Cost Driven
	Owner/ Operator Persona and Supplier Targets	Large and small property mgmt. firms; Owner/ Managers; Developers, Engineers and Architects of new builds	Large and small property mgmt. firms; Owner/ Managers; Developers, Engineers and Architects of new builds	All Owner/ Operator personas; Developers, Engineers and Architects of new builds	All Owner/ Operator personas; Developers, Engineers and Architects of new builds	–	Large and small property mgmt. firms; Owner/ Managers; Developers, Engineers and Architects of new builds
	Building Type	Large portfolios of high-rises, new and existing buildings	Large portfolios of high-rises, new and existing buildings	Large portfolios of high-rises, new and existing buildings	Large portfolios of high-rises, new and existing buildings	–	All Building Types
Partners		Specialty services; IoT Hubs, Platforms and Software; other OEMs for ecosystem offerings	Specialty services; IoT Hubs, Platforms and Software; other OEMs for ecosystem offerings	Specialty services; IoT Hubs, Platforms and Software; other OEMs for ecosystem offerings	Utilities; Specialty services; IoT Hubs, Platforms and Software; other OEMs for ecosystem offerings	–	Specialty services; IoT Hubs, Platforms and Software; other OEMs for ecosystem offerings
Secondary/ Long-term Opportunity		Provide software platforms from which third-party services and building-to-grid integration are enabled	Optimize light settings based on time of use, occupant activities, and other information gained through usage and behavior analytics	Provide reactive and predictive services over the life of the equipment	Partner with OEMs to identify equipment anomalies that indicate consumption inefficiencies	–	Join suite of offerings that coordinate to optimize resource usage

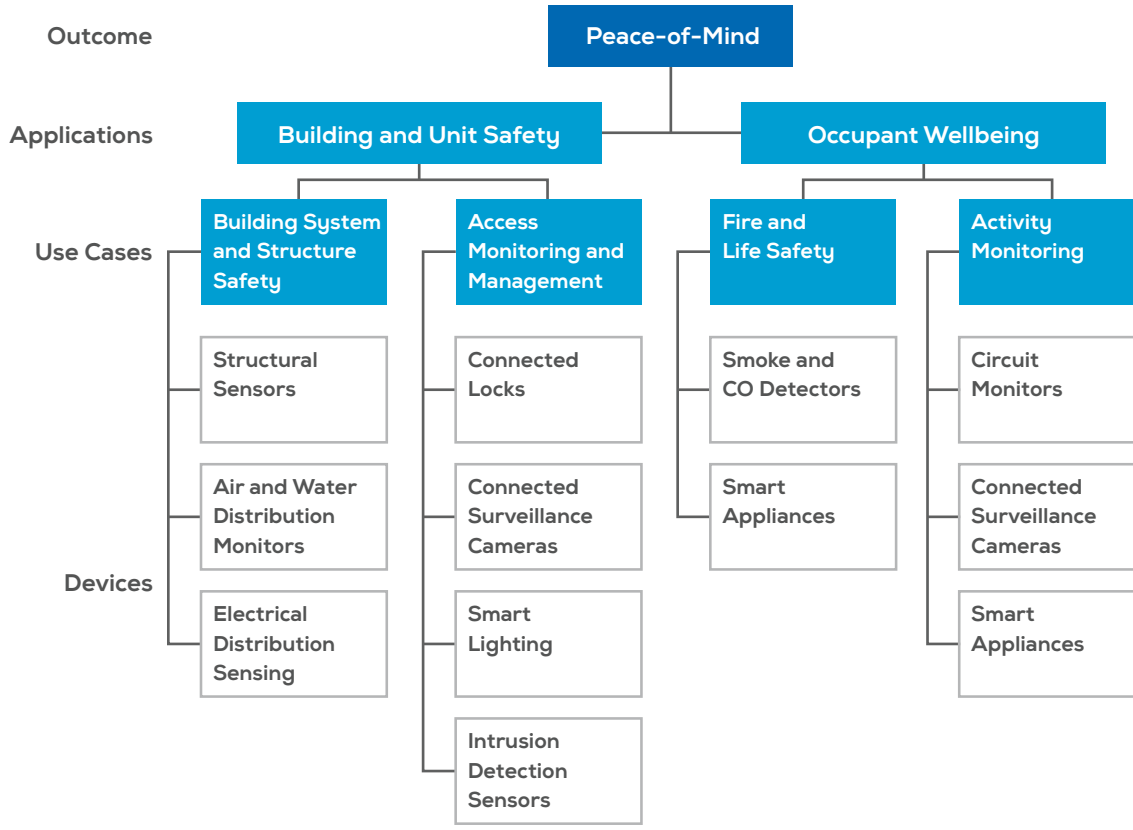
4.2 PEACE-OF-MIND

Safety and security offerings have been a major driver of connected device and service adoption in the single family residential market, serving as a stepping stone for providers of expansive home automation solutions. However, MDU occupants are generally less driven by physical security concerns, given the locked exterior entry of many buildings, the proximity of neighbors, and the lack of children or extensive belongings of many occupants. Ultimately, what occupants desire and property managers seek to provide is peace-of-mind, which is achieved by delivering a base feeling of safety within units and the larger building space as well as the tools for ensuring occupant personal wellbeing.

> "Peace-of-mind is driving the smart home market today. There's a range of needs among consumers in terms of what's needed to achieve this…younger demographic has a very different lifestyle and needs than older ones. Coming out of college, you don't have much to protect, and don't have the money for a professionally monitored system. Millennials are looking for DIY tools that they order online, shows up at their door, auto-integrates and provisions into the network and begins working out of the box. Aged 34 years and up, they're the market for monitored solutions. You have to come to the market with a range of tools to serve different occupant demos if you want to capture a large chunk of it."
>
> - Vice President, iControl

Within "Building and Unit Safety," the two primary use cases are "System and Structure Safety" and "Access Monitoring and Management." The former focuses on ensuring that core building systems are secure and do not harm occupants, while the latter enables operators to remotely manage and monitor building access and occupants to gain and grant access to the building and their units remotely. The application segment "Occupant Wellbeing" is similarly segmented into two use cases. "Fire and Life Safety" focuses on detecting and responding to fires or gas leaks within units or in common areas, while "Activity Monitoring" of elderly occupants is accomplished either directly with video surveillance or indirectly by evaluating electrical signals to ensure their health.

Figure 4.13 Peace-of-mind Application Overview



Property owners and operators seek to enhance occupant peace-of-mind to benefit the acquisition, satisfaction, and retention of MDU residents. Doing so decreases turnover, which lowers operating expenses and increases revenue, while increasing property value, allowing them to charge higher rent. While there are an increasing number of DIY options for in-unit video surveillance and smoke or gas detection, many of the devices critical to these use cases must be installed by unit owners or building managers. Their decision to invest in these offerings is determined by the perceived ROI from enhanced occupant peace-of-mind, a challenging metric to quantify.

> "Indoor air quality monitoring and control has gotten a lot of attention lately, especially in big cities with relatively high levels of pollution, and as a driver of increased productivity and occupant satisfaction."
>
> - Senior Product Manager, Johnson Controls

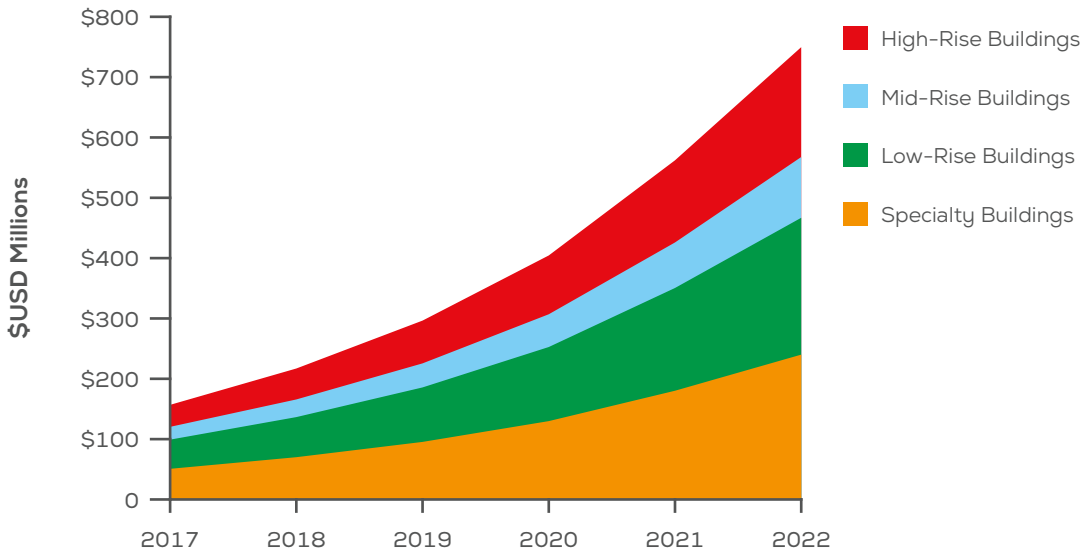
In specialty housing arrangements where occupant health is of utmost concern, as in assisted living facilities, occupant wellbeing solutions enable building operators to provide a higher level of care while also affording family members peace-of-mind via remote monitoring.

> "Our initial focus has been on age-in-place applications and on improving care, monitoring and services for people with disabilities. No one wants to live in an assisted living facility, due to the foreign nature of the living space, the lack of privacy and the cost. We see the applications of the smart home that allow you to live in your own home longer as having a more tangible ROI than some of the other applications out there today."
>
> - Executive, BuildingBrains

4.2.1 Scale of Peace-of-Mind Opportunity

Smart Systems revenues from Peace-of-Mind applications in MDUs are forecast to rise at a 35.2 percent CAGR from $230 million in 2017 to $750 million in 2022. The challenge to monetize holistic MDU building systems has suppressed the opportunity for these offerings to date, though we anticipate innovative business models to align with technological developments to rapidly increase the opportunity in the coming years.

Figure 4.14 Peace-of-Mind Revenue by Building Type, 2017-2022



4.2.2 Trends & Forces Affecting Peace-of-Mind Opportunities

Operators require centralized control over access management systems, enabled by cloud-based, mobile-accessible offerings, however, access and security system requirements vary greatly depending on the location and type of building. Regardless of the specific deployment needs, access management and video surveillance systems, with advanced and distributed analytics, are increasingly integrated into holistic building management systems.

Technology Forces & Impacts

- Access management offerings, traditionally standalone systems controlling exterior building entryway access, are increasingly integrated into holistic building systems that manage exterior building and unit access permissions.
- Increasing demand for access management has driven advances in CCTV camera systems, which are shifting to digital networked systems connected to cloud services to enable real-time video monitoring and two-way video intercom use cases.
- Processing advances in cameras is enabling feature and face recognition with distributed analytics, opening new access management and security use cases.
- Enhanced compression and storage capabilities, along with edge processing advances, are enabling surveillance systems to operate uninterrupted in the event of a power outage and enhancing the viability of wireless solutions.

Competitive Forces & Impacts

- The variability across building portfolios, including building structure, size, community type and occupant demographics, leads to varying security needs to provide occupants with a base feeling of safety to enable peace-of-mind.

- Adopter fragmentation has limited the ability of established suppliers, with cost structures that demand high margins and large scale, to develop customizable MDU offerings that meet internal needs.
- NSPs and insurance providers are seeking to leverage their existing relationships with building occupants to expand into providing peace-of-mind offerings, though this requires an evolution from business models based on long-term contracts to ones that can tolerate annual occupant turnover.
- Internet and cable providers especially are seeking to repurpose their hardware already deployed in units as hubs for connected offerings, partnering with device manufacturers and software providers to provide holistic solutions.
- Partnerships between building automation players and IoT solution providers are delivering integrated offerings to building operators that encompass building access management as well as asset and energy management.

Customer Forces & Impacts

- Building operators seeking to provide remote access management to occupants require centralized control over rights assignment to ensure that unit and building access is not provided outside of the lease terms.
- Cloud-based management systems are desired to enable managers easy and inexpensive provisioning tools, while providing a platform for integration of adjacent asset and energy management systems into a holistic dashboard.
- Property managers with limited capital budgets are struggling to attract the interest of commercial security providers whose traditional cost structures demand targeting projects of substantial capital expense.

Socioeconomic Forces & Impacts

- NSPs have faced uncertainty about their legal ability to develop exclusive network contracts with property managers, without which the network backbone infrastructure investment required to support connected MDUs can be prohibitive.
- Increasing security concerns on university campuses is driving enhanced access management adoption in student housing, enabling housing managers to assign individualized access plans and remotely lockdown buildings in the event of an emergency.

4.2.3 Customer Interest & Adoption Indicators

Occupants are largely aware of and interested in Peace-of-Mind applications, with nearly a quarter of interested respondents already having connected smoke and gas detectors and eight percent with keyless entry or home surveillance. Keyless entry represents the largest service that occupants and operators are interested in, reflecting the perceived value that a holistic Access Management application can provide to both parties. Wellness monitoring devices and services are of significant interest to both stakeholders as well, presenting a significant and almost wholly untouched opportunity for suppliers of such solutions to other Buildings Customer Segments.

Figure 4.15 Occupant Interest in Peace-of-Mind Applications

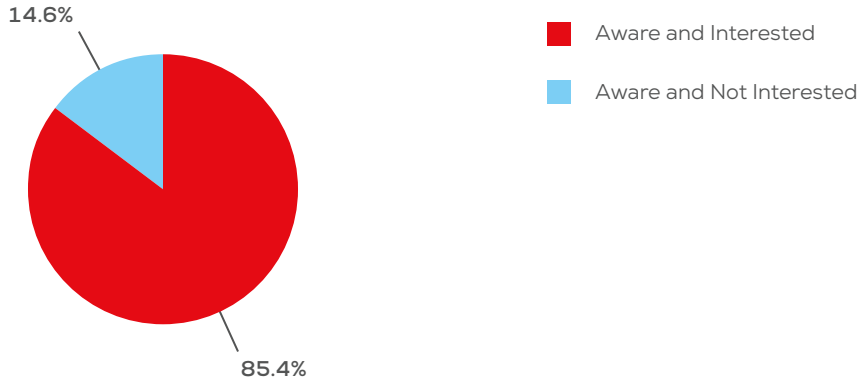


Figure 4.16 Occupant Interest in Peace-of-Mind Devices & Services, n=450

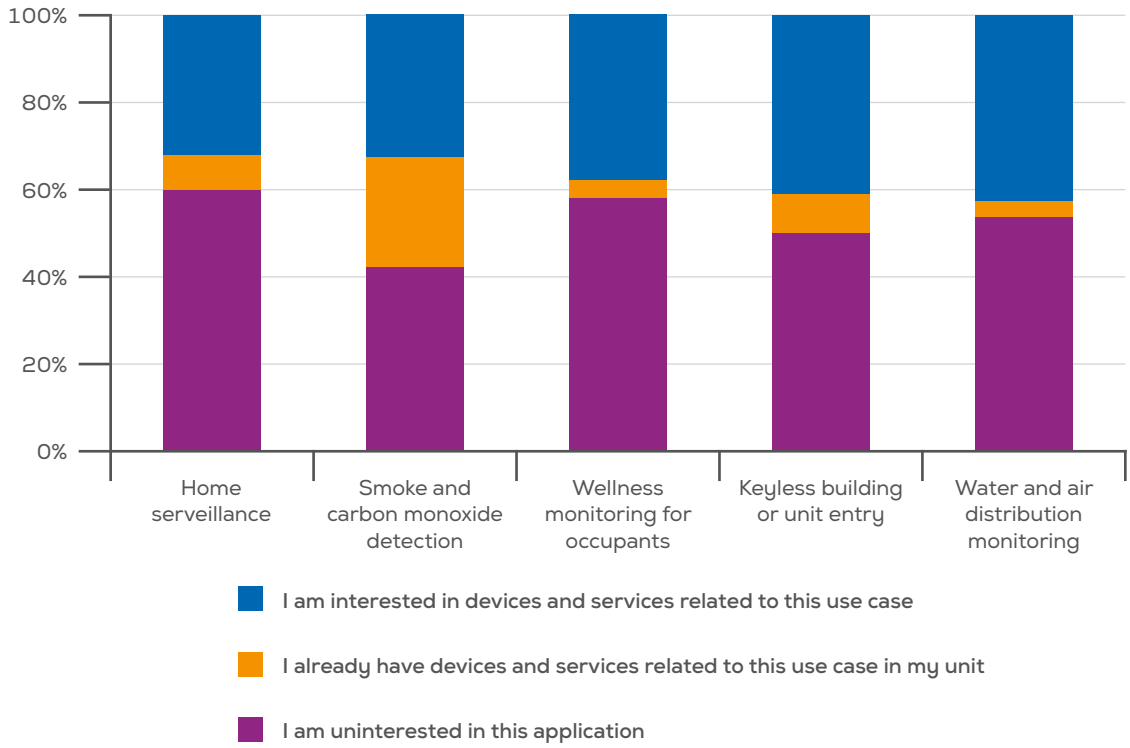
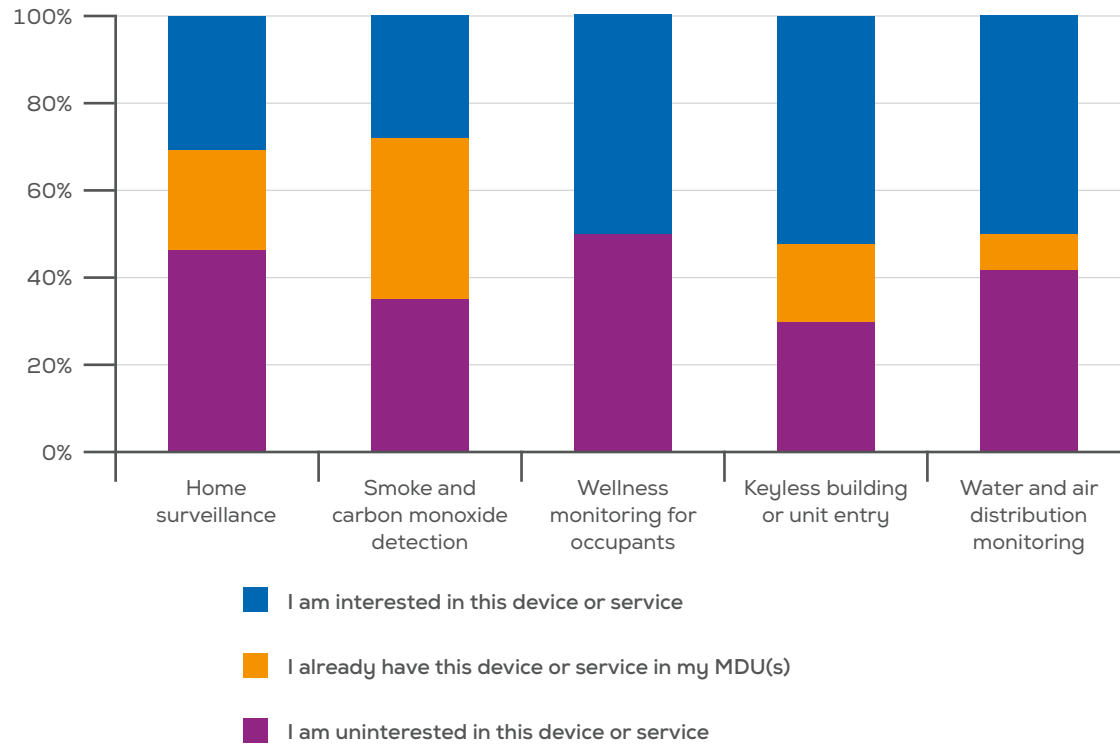


Figure 4.17 Operator Interest in Peace-of-Mind Applications, n=450



Our findings highlight that occupant interest in Peace-of-Mind applications is closely linked to socioeconomic status, especially as reflected in unit rent and household income. Occupants residing in units where rent is less than $500 a month, or who have a household income of less than $50,000 are significantly less likely to be interested in these applications. While this trend is highlighted by this survey's respondents, it is unclear if this would prove true across all regions, building structures and community types.

Figure 4.18 Occupant Interest in Peace-of-Mind Applications by Unit Rent, n=473

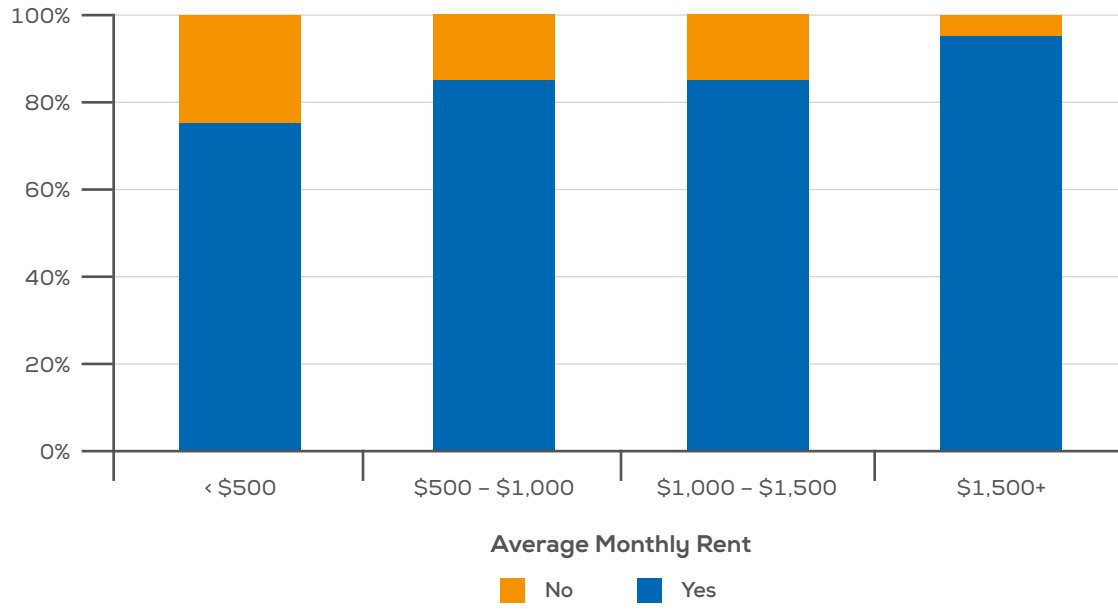
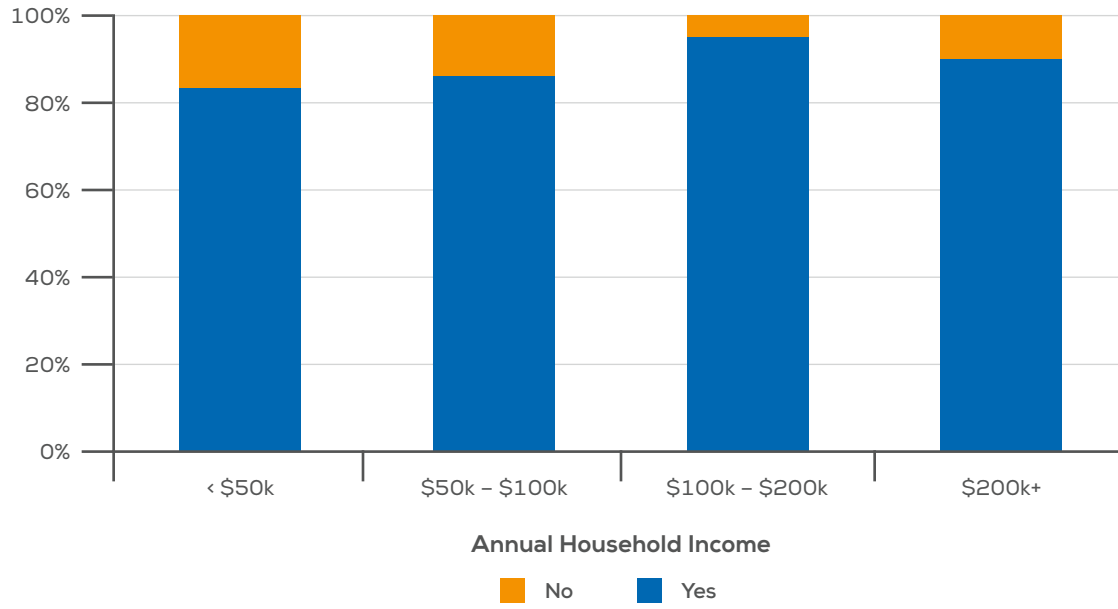


Figure 4.19 Peace-of-Mind Interest by Household Income, n=473



Ultimately, Peace-of-Mind is provided by enabling a feeling of safety for building occupants. The security services that are required to enable a feeling of safety depends on multiple factors. Buildings located in high crime neighborhoods will have to provide enhanced security services relative to those in safer ones, as will buildings housing luxury units with occupants that have high-value goods in their units. Similarly, occupants with young children or who have experienced break-ins in the past will require more services to reach a base feeling of safety in their unit. This variability demands that building operators work with suppliers to develop offerings that prioritize flexibility and extensibility to meet a range of needs.

4.2.4 Case Studies

Several case studies demonstrate the value of these offerings:

- **Brivo**
  - **What**: St. John's implemented a Brivo access management solution across dormitories on its 27-acre Washington, DC campus housing 1,100 students to replace a lock and key system.
  - **Result**: Remote access monitoring and control enabled the school to grant access to certain users at certain hours, restricting dorm access to residents during set hours, and implementing emergency controls to lock- down all buildings with a single button.
- **BuildingBrains**
  - **What**: Devices and software monitor in-unit circuits against historical patterns to provide family members and caretakers with mobile notifications regarding elderly occupant activity.
  - **Result**: Cloud-based activity monitoring tools provide peace-of-mind for family members to enable elderly occupants to age-in-place rather than needing to relocate into an assisted living community when health concerns arise.
- **Yale**
  - **What**: Multifamily set of solutions provide a scalable lock management system, including cloud-based access management software with credential assigner for maintaining access rights and establishing audit trails.
  - **Result**: Solutions enable property managers to assign unit and common area access to occupants upon arrival, limiting transmittance of keys to non-tenants, and reduce the burden of rekeying upon unit turnover.
- **SmartVue**
  - **What**: Video surveillance from a wide range of available cameras is managed via a cloud service to enable cost effective security management remotely.
  - **Result**: Smartvue's system is utilized by major telcos including TWC and Cox to enable them to provide cost effective, end-to-end surveillance solutions as part of smart home packages. Their tools are utilized within commercial office and research facilities in 140 countries.
- **Xfinity Multifamily**
  - **What**: Multifamily focused offering from the telco leverages fiber connectivity to provide wide range of entertainment offerings as well as individualized home security services for MDU occupants.
  - **Result**: Residents can arm their unit security system, check a live video surveillance stream of their unit, control lighting, and receive alerts when doors and windows are opened via a mobile app. They can also sign up for professional monitoring services if they choose.
- **Protection1**
  - **What**: Focused offerings for apartment managers that provide scheduled access management and remote monitoring solutions that integrates with enterprise property management software.
  - **Result**: Managers are able to increase rent by offering enhanced peace-of-mind, while reduced operating expenses from personnel management and rekeying increases installation ROI.

4.2.5 Channels to Market

IoT-enabled security and life safety devices and equipment are brought to end-customers most efficiently via specialty security providers who offer various solutions to increase peace-of-mind. These

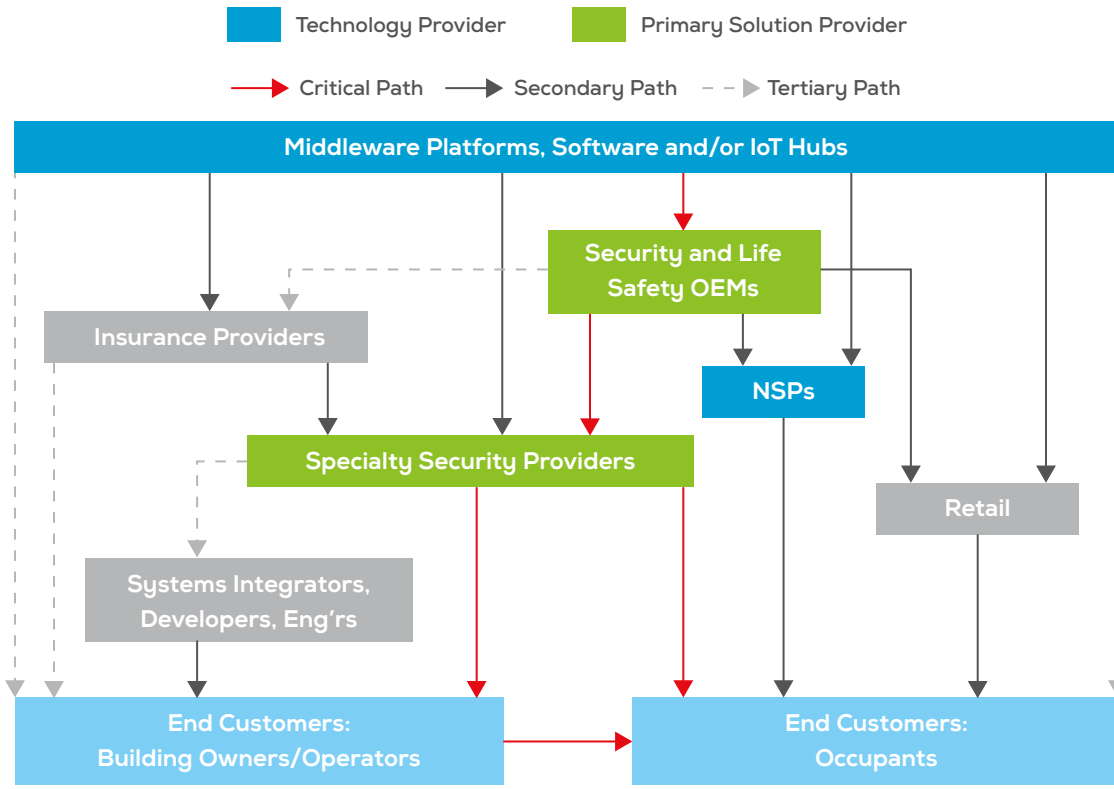
providers typically source devices and equipment from specific OEMs, however, some offer their own brands of equipment.

NSPs and cable providers are well-positioned to leverage existing hardware and services in units to expand into the role of peace-of-mind solution providers, working with OEMs to deliver complete solutions directly to MDU occupants. Their presence in the unit and familiarity with customers, as well as the ability to charge an incremental service fee for added security capabilities make NSPs a significant threat to traditional security services. However, laws in the US against lock-in contracts for whole MDU buildings means specialty security providers may still find traction with owners and operators.[1]

Insurers that are offering discounts on premiums for the use of smart home offerings are becoming a new channel for security providers. While this channel is still nascent, integrated offerings with insurance companies may help security service providers drive greater peace-of-mind with potential customers than traditionally entertainment-focused NSPs.

> "Insurance providers have shown some interest in providing smart home services as a way to identify potential equipment failures, leaks, and other payout-driving factors early so that they can be fixed before they become an expensive problem. This allows insurers to charge less for premiums and more than make up for it by paying out less, increasing margins while providing better services to their customers."
>
> - Manager, Ayla Networks

Figure 4.20 Peace-of-Mind Channels to Market



4.2.6 Conclusions & Recommendations

While security has been a key driver of home automation systems, the risks felt by MDU occupants are generally lower due to proximity to neighbors, on-site staff at larger buildings and the majority of units being above ground level. Peace-of-mind with regards to safety is likely to be a more critical driver than physical security risk in these types of buildings. As a specialty case, safety and security of students is a key priority, with lighting being used to create safe environments, improve camera resolutions and provide warning indicators in student multi-dwelling units

Suppliers have struggled to find the appropriate business model which offers peace-of-mind to occupants while retaining control for owners and managers, especially given the varied building types and management models across the market. Players who have found success in the commercial security space are struggling to make the cost structure of MDUs work, where margins are much tighter. Similarly, traditional security providers to the Smart Home, including dedicated service providers and NSPs, have been unable to scale their services for MDUs to this point.

> "Traditional players have really struggled with this space. Telcos have struggled, we saw Verizon and AT&T both flop because they failed to create value for property managers. ISPs are pushing building-wide Wi-Fi, Google looking to bring fiber to buildings and help managers control them. The traditional BAS guys just don't have the cost structure required to sell unit by unit offerings. Even if the system is set up for an entire building, those guys will quote $10k to monitor within an apartment. Even the smart apartment guys are focusing only on residents, missing opportunities to reduce building OPEX. Huge opportunities to create value across the chain are being overlooked or missed."
>
> – Executive, WhiteSpace Building Technology Advisors

Many platform and device providers are successfully leveraging B2B channels to white label offerings and sell to security service providers and NSPs working with professional installers. Rather than focusing on product differentiation, successful service and platform providers are focusing on process differentiation, including customer service, supply chain, delivery, and support. A major success driver for suppliers is ensuring device installers make a greater margin on IoT-based security offerings relative to traditional ones, regardless of whether a building owner was saving money. Installers and system integrators (SIs) are a key channel partner, providing suppliers with a route to end-users, and ensuring that the incentive exists for these partners to install and support new connected offerings is key to long-term viability.

> "These days, we've got way too many companies focusing on product differentiation. From a customer point of view, a dealer's ability to differentiate their processes, like customer service, supply chain, delivery and support, are far more valuable."
>
> – Vice President, Alarm.com

Insurance providers have a major opportunity to lead the deployment of solutions that increase building safety and occupant wellbeing as a means of collecting data that will enhance their ability to accurately price risk. With deep pockets and a direct channel to end-users, insurance firms are highly attractive targets for device and service suppliers.

> "The most important piece is data- the more information we have, the better rates we can provide. Predictive analytics is transforming the industry. This will definitely disrupt traditional models as premiums fall, but risks and incidents will decrease as well. I think those that can provide additional services on top of insurance will be the best positioned."
>
> - Manager, Ironshore

Recommendations

- Specialty security providers serve as an excellent facilitator for peace-of-mind offerings, integrating OEM offerings with the platforms and hubs required to connect and monitor systems and serving as the respondent in the case of an event or triggered alert.
- NSPs have the opportunity to use their existing relationship with occupants to provide new safety-enhancing services through a business model that doesn't rely on occupants staying in a unit for multiple years to recoup hardware costs. These models should focus either on providing services to the unit, regardless of occupant, or on providing devices and services that can move with the occupant.
- Insurance providers stand to benefit from the installation of offerings that enhance building system and unit safety as well as occupant wellbeing, and partnering with OEMs as well as service providers or in-unit hubs provides a straightforward means to differentiate policies while reducing likelihood and magnitude of payouts.

Figure 4.21 Peace-of-Mind Recommendations for Service Providers

		Utilities	Telcos	Insurance Providers	Specialty Services	IoT Hubs, Platforms and Software
Primary Opportunity		–	Provide devices and services for access mgmt., smoke/CO and intrusion detection atop existing services	Subsidize purchase of devices to reduce likelihood of personal harm or building damage	Install, maintain, and respond to alerts from building security and occupant safety monitoring systems	Provide single interface for property managers, occupants, & specialty service providers to access and control connected devices
Value Prop		–	Increased service charges and payback over multi-year contract, increased customer satisfaction and retention	Reduced payouts due to event avoidance allows lower premiums for competitive positioning	Sell services to building managers or occupants as third-party safety and security responder	Sell integrated offering B2C or B2B for white-labelling by specialty providers, telcos or insurance providers
Targets	Occupant Persona	–	Security Driven; Service Centric	Tech Focused; Security Driven	Security Driven; Service Centric	Tech Focused; Security Driven
	Owner/Operator Persona and Supplier Targets	–	Large and small property managers of new builds; Owner/Managers and Occupants of retrofits	Owners/Operators; Occupants	Large and small property managers of new builds; Owner/Managers and Occupants of retrofits	All Owner/Operator Personas; Installers and Integrators; Specialty providers; Telcos; Insurance providers
	Building Type	–	New high and mid-rise builds with exclusive network contracts; Any retrofit building types	All Building Types	New or existing high and mid-rise builds	All Building Types
Partners		–	Specialty services; IoT Hubs, Platforms and Software; OEMs; Installers and Integrators	Specialty services; IoT Hubs, Platforms and Software; OEMs; Installers and Integrators	IoT Hubs, Platforms and Software; OEMs	Specialty services; OEMs; Installers and Integrators
Secondary/ Long-term Opportunity		–	Provide safety and security services from integrated platform for energy management and entertainment control	Provide asset management services through partners atop insurance services	VSaaS for common areas to reduce security guard labor expenses; Building usage analytics and services	Analytics solutions to optimize building utilization

Figure 4.22 Peace-of-Mind Recommendations for OEMs

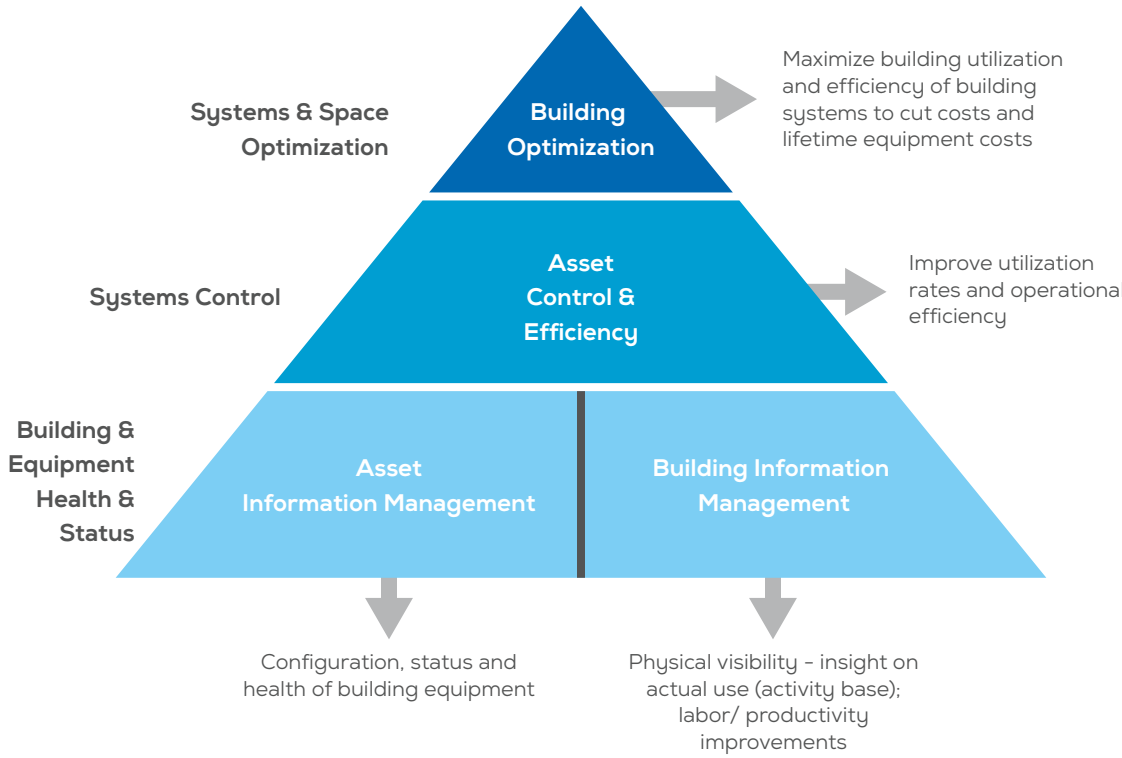
		HVAC-R and Water	Lighting	Appliances	Electrical	Security	Building Products
Primary Opportunity		Air and water distribution monitoring for quality and leak detection	Integration with video surveillance system to ensure incidents are traceable	Embedded connectivity for integration with life safety and activity monitoring systems	Circuit monitoring for real-time activity monitoring; remote shut-down in event of emergency	Locks, cameras, fire and life safety devices leveraging open protocols and range of wireless options to interoperate with existing systems and be managed remotely	Embedded intrusion detection sensors in windows and doors; Electronic access management in elevators
Value Prop		Reduce risk to building manager of critical system failure causing building damage or occupant harm	Integrate with video surveillance	Connect to in-unit management safety systems to enable remote shut-down in event of malfunction	Monitor elderly occupant activity from electricity monitoring; Enable safer response by emergency crews	Offer standalone cloud and mobile security management tools or use partner platform to manage devices and services	Differentiate offerings by offering integration into popular security and building management systems
Targets	Occupant Persona	Security Driven; Service Centric	Tech Focused; Security Driven; Service Centric	Tech Focused; Security Driven; Service Centric	Tech Focused; Security Driven; Service Centric	Security Driven; Service Centric	Security Driven; Service Centric
	Owner/ Operator Persona and Supplier Targets	Large and small property mgmt. firms; Developers; Architects and Engineers	All Owner/ Operator Personas; Developers; Architects and Engineers	All Owner/ Operator Personas; Developers	All Owner/ Operator Personas; Developers; Architects and Engineers	All Owner/ Operator Personas; Developers; Architects and Engineers	All Owner/ Operator Personas; Developers; Architects and Engineers
	Building Type	Mid and high-rise new builds	Mid and high-rise, external entry low-rise buildings	New and existing buildings with in-unit appliances	New and existing buildings, especially specialty housing	Mid and high-rise new and existing builds	External entry low-rise and specialty buildings
Partners		Insurance providers; Specialty services; IoT Hubs, Platforms and Software	Specialty services; IoT Hubs, Platforms and Software; Security OEMs	Specialty services; IoT Hubs, Platforms and Software; Security OEMs	Specialty services; IoT Hubs, Platforms and Software; Lighting and Appliance OEMs	Insurance providers; Specialty services; IoT Hubs, Platforms and Software	Insurance providers; Specialty services; IoT Hubs, Platforms and Software
Secondary/ Long-term Opportunity		Remote control and preventative maintenance services for captive equipment	Space usage and activity monitoring via embedded sensors to optimize building usage and monitor elderly occupant activity			VSaaS and data brokering applications; building space optimization analytics and services	

4.3 BUILDING AND EQUIPMENT MANAGEMENT

Building and equipment management applications monitor and manage building system performance and common space utilization, providing greater visibility and control of operations to reduce operating expenses and minimize downtime. These use cases are progressive and build upon each other, beginning with building and equipment health and status monitoring solutions for capturing asset data to provide transparency into operational status. The next solution layer provides systems control, increasing uptime and minimizing costs through more efficient operations or reduced maintenance and downtime costs, providing significant benefits to property managers and building owners. Finally, systems optimization solutions optimize space utilization and building system efficiency by integrating operational control with occupant and operator preferences to minimize lifetime operational costs.

> "Virtual machine technologies allow us to test and analyze the performance of our products, both before they are in the customer's environment, but also when this equipment is installed and we need to check out how it is functioning. We incorporate this information into the design of the products to decrease response times for maintenance."
>
> - Director, EMB Pabst

Figure 4.23 Progressive Building and Equipment Management Cases



These cases have benefits across MDU stakeholders. Identifying and eliminating building system inefficiencies reduces expenses for property managers, allowing them to maintain operating margins while reducing rents to remain competitive in tough market conditions. The value of these offerings to owners and operators is tempered, however, by several factors, the most important of which is building structure and location. Buildings lacking centralized systems, especially HVAC systems, based on the building structure or lack of demand in the regional climate, are less attractive for holistic building management systems. The property manager persona also drives demand, with off-site managers of

multiple, smaller properties without on-site staff experience the greatest benefit from remote monitoring and management offerings.

Developers and building owners increase the value of their buildings by installing devices that reduce operational expenses, differentiating from and providing a market premium over buildings with less efficient operational systems. This new build installation is key for the large, expensive, centralized building systems, and must be supported by OEMs or their actors.

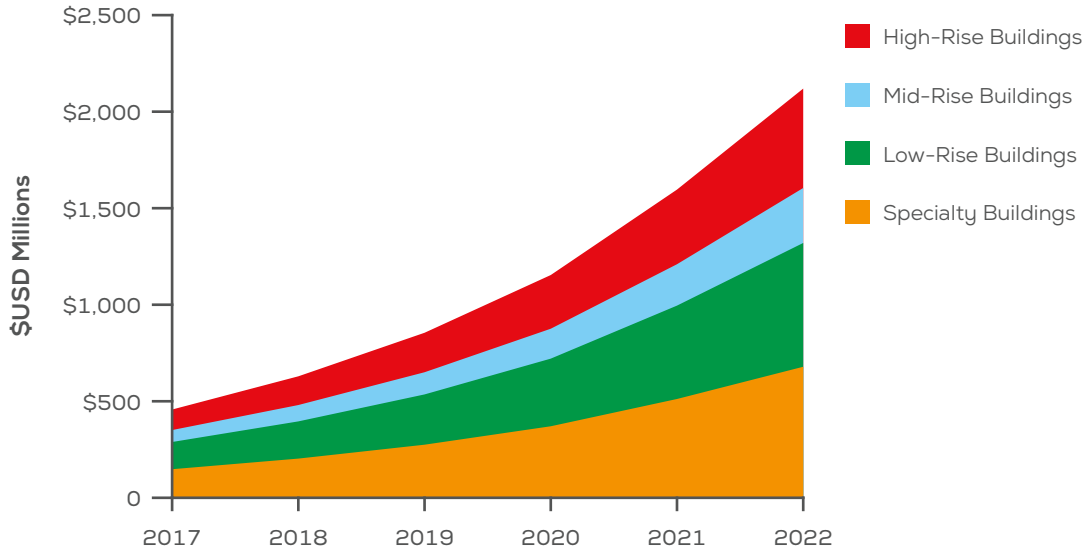
> "Architects play an important role in coordinating decision-making, balancing occupant needs with developer priorities. Developers often don't have sense of user needs and generally don't have a close eye on tech options to meet them. It's important that we develop a relationship with providers so we understand offerings available for projects. We don't want to recommend that our customer use unproven tech, put our name on an offering that we can't stand behind. We're looking for proven history, solutions that have managed complexity of multiple interrelated building systems with a successful track record. We aren't looking to be guinea pigs."
>
> - Project Manager, GSA

Equipment manufacturers of devices, appliances, and buildings systems that offer standalone monitoring and management tools or interoperate with broader asset management systems, and support on the installation of these systems, differentiate themselves from providers of unconnected equipment.

4.3.1 Scale of Building and Equipment Management Opportunity

Smart Systems revenue from Building and Equipment Management applications are expected to rise with a CAGR of 34.4 percent from $457 million in 2017 up to $2,119 million in 2022. While the opportunities in individual specialty and low-rise buildings are smaller than those in larger buildings with expensive, centralized systems, the sheer scale of the opportunity that these smaller buildings present make them attractive targets. There are 32 times more specialty than high-rise MDU buildings in the United States and Canada, representing a total Smart Systems revenue opportunity of only 1.3 times greater in specialty buildings, highlighting the attractive scale offered by high-rises. Given the traditional building automation supplier focus on buildings of this scale, we expect that, when their focus turns to MDUs, mid and high-rises will be their primary targets, leaving specialty and low-rise buildings for smaller, nimble suppliers.

Figure 4.24 Building & Equipment Management Revenue by Building Type, 2017-2022



4.3.2 Trends & Forces Affecting Building and Equipment Management Opportunities

Varying needs and lack of upfront capital across the MDU market have challenged traditional suppliers, who are deterred by the resulting lower margins compared to commercial buildings. Advances in technologies, including smaller and less expensive, modular systems can help to meet the needs of owners and operators, and set up suppliers for extended relationships with customers.

Technology Forces & Impacts

- The decreasing size and cost of processing and communication technologies, coupled with the increase in power, bandwidth and back-end cloud processing and storage have opened the door to smaller, modular systems that make it easier to start small and expand these systems slowly.
- Though standards such as BACnet have emerged to facilitate interoperability of building systems, an increasing number of gateways are coming to market expressly with software tools to integrate in-unit offerings with a range of communications protocols including Z-Wave, ZigBee, Bluetooth, and Wi-Fi.
- Data formatting and tagging conventions, such as Project Haystack and BrickSchema, are gaining popularity as enablers of advanced analytics across building systems and vendors, a critical step to providing the background data required for machine learning offerings to create new value in MDU operations.
- An increasing number of cloud vendors are providing advanced analytics and machine learning-as-a-service and at low cost, enabling ease of use for property managers with no data science background.

Competitive Forces & Impacts

- Suppliers have struggled to develop successful horizontal offerings due to the diverse needs of the range of manager segments and building types within the MDU market.
- Traditional building management and automation players have struggled to develop offerings for the MDU market, where smaller CAPEX budgets demand smaller offerings which offer a smaller margin than commercial building solutions.
- Providers of platforms enabling both building system automation and control as well as

in-unit asset monitoring, especially when paired with adjacent energy management tools, are experiencing successful adoption.

Customer Forces & Impacts

- Heavy investment in BMS systems in the past, plagued by a lack of interoperability and management headaches, have left decision makers cautious about new technologies.
- MDU owners/operators and property managers are seeking building management systems that are inexpensive to install and operate and enable easy expansion as new applications become available.
- To reduce "app fatigue," operators and managers prefer equipment and building management offerings that interoperate with energy and access management tools to enable building monitoring and control from a single interface.

Socioeconomic Forces & Impacts

- Increasing environment-focused government policies is leading to more investment in asset and building system monitoring, as well as building utilization technologies to increase overall operational efficiency in new builds, especially as MDU construction has accelerated since 2013.
- Urban migration has led to a focus on mid and high rise buildings in the last few years, which present significant opportunities for efficiency gains from control and optimization of central buildings systems.
- Meanwhile, low-rise buildings, which generally have central building systems but lack the scale required to attract the attention of major automation and controls players, represent the largest portion of MDU buildings developed prior to 2015 and therefore a significant, underserved market for retrofit solutions.

4.3.3 Customer Interest & Adoption Drivers

Operators indicate a large, predominately untapped opportunity for Building and Equipment Management applications, especially providing energy management services and leveraging connected appliances to reduce downtime and maintenance costs.

Figure 4.25 Operator Interest in Building and Equipment Management Applications, n=52

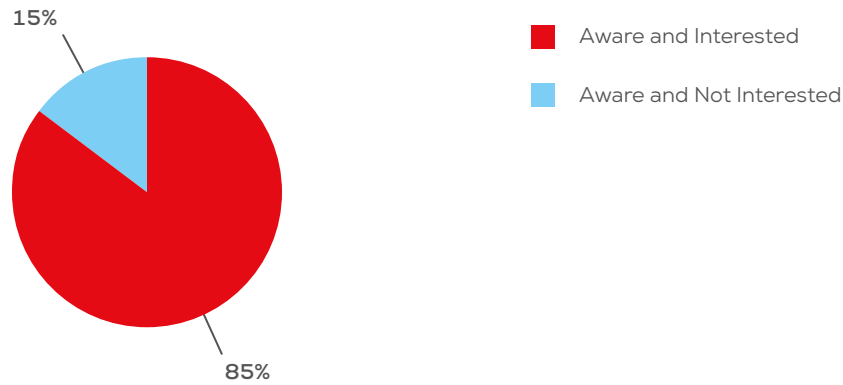
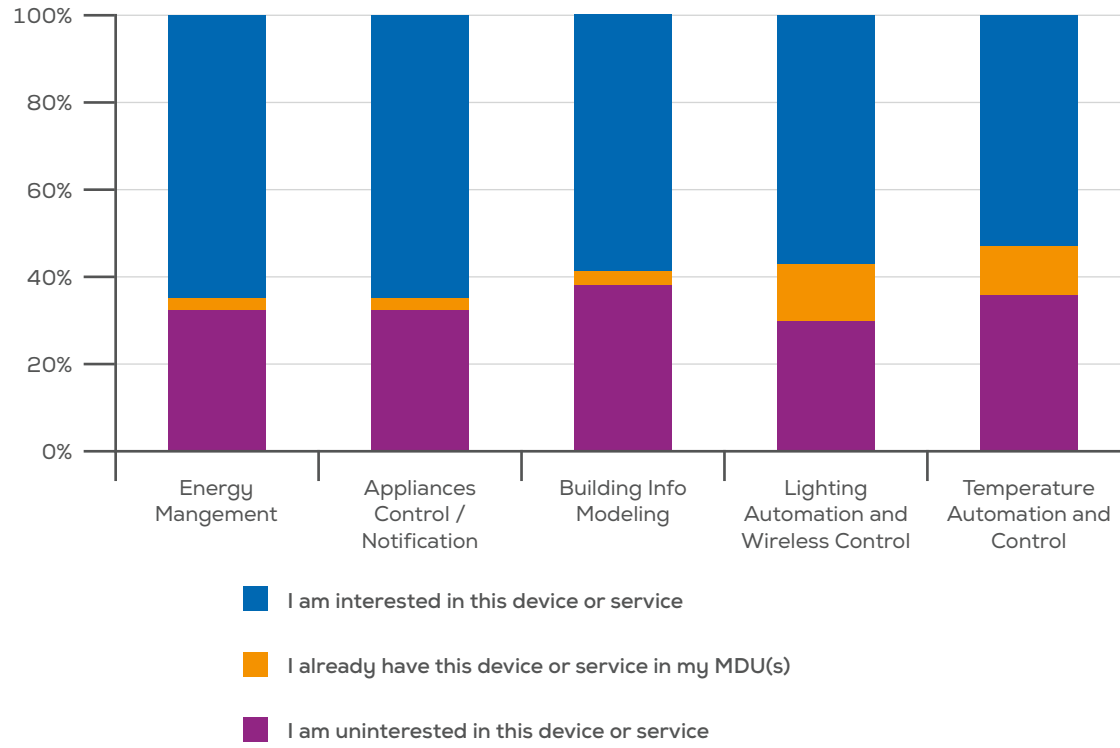
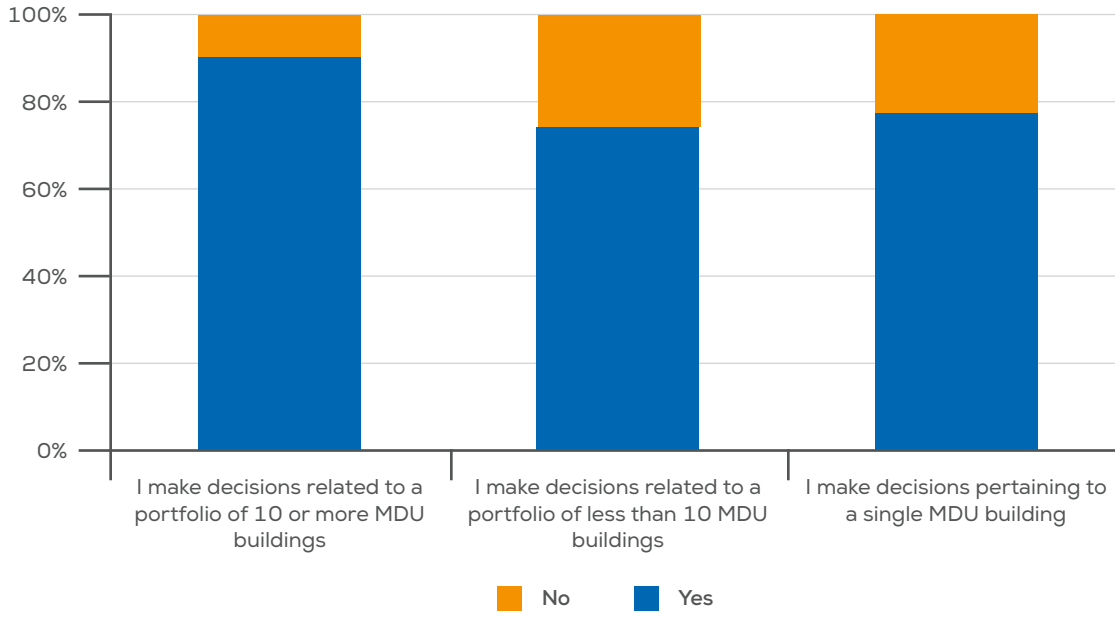


Figure 4.26 Operators' Top Interests in Building and Equipment Mgmt. Devices and Services, n=44



Among building operators, developers, engineers and architects who are aware of these applications, our findings indicate that those who make decisions regarding portfolios of greater than 10 buildings are more likely, by a statistically significant margin, to be interested in adopting these offerings. This reflects that greater value is achieved across a larger portfolio of more efficiently managed buildings, as well as the potential for greater technical fluency among managers in dedicated property management firms with larger portfolios.

Figure 4.27 Operator, Developer & Designer Interest in Building and Equipment Mgmt. Applications by Portfolio Size, n=52



4.3.4 Case Studies

Several case studies demonstrate the value of these offerings:

- **StratIS**
  - **What**: The firm worked with a 1,200 unit, campus style apartment complex to install an access management system, coupled in this case with an energy management offering.
  - **Result**: By removing the need for a dedicated access manager job function to service the large campus, management was able to reduce and transfer staff workload, saving $40k per year since the installation.
- **IBM and ISS**
  - **What**: Partnership enables the facilities manager to leverage the Watson IoT platform to integrate and analyze data from sensors in millions of doors, windows, rooms and HVAC systems across the ISS portfolio.
  - **Result**: Granular asset and building usage data provide managers with a real-time view of the services in their buildings, enabling them to optimize building operations and using cognitive computing to personalize service delivery.
- **Johnson Controls and Cisco Systems**
  - **What**: Joining Cisco's Digital Ceiling community provides Johnson Controls a platform on which to integrate IT and building tech, including HVAC, lighting, and security management systems.
  - **Result**: Building managers are able to reduce operating costs, while reducing the risk involved and increaing the ROI from investing in technology by integrating previously disparate building management systems onto a single platform.

4.3.5 Channels to Market

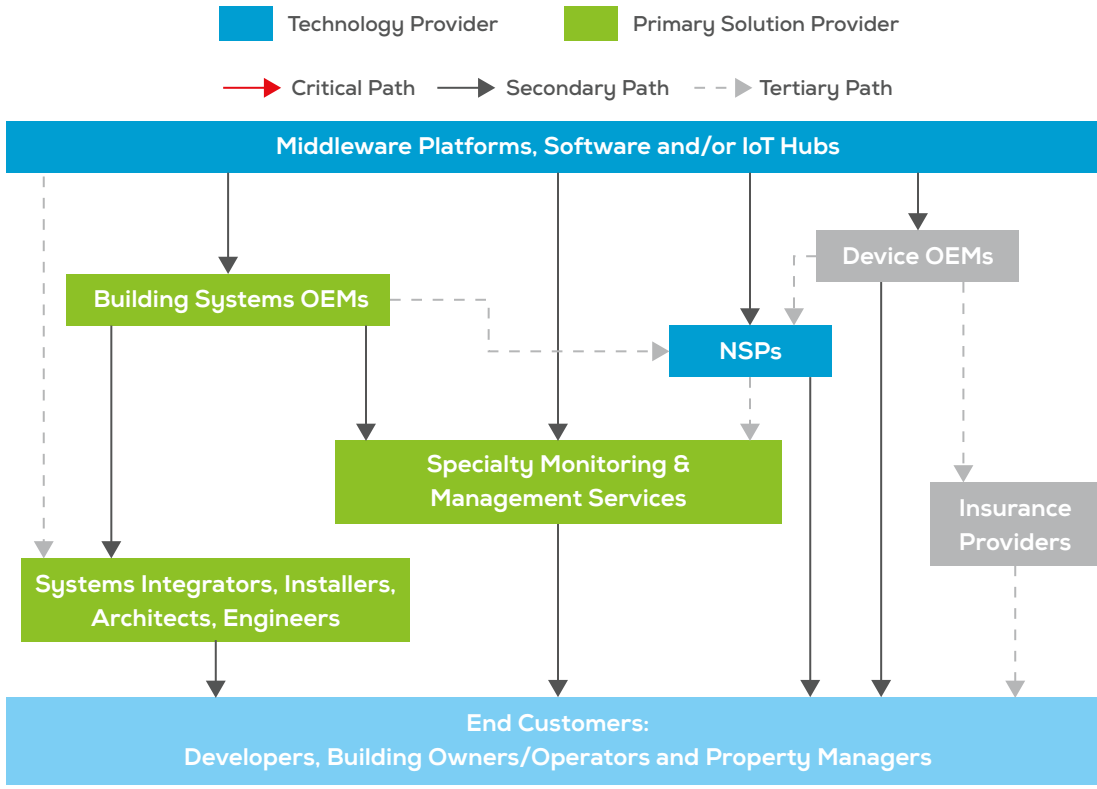
Building system equipment manufacturers are a critical element in the development of asset management offerings, especially in new builds where equipment can be installed with embedded sensing and connectivity. While there are aftermarket solutions that are attractive for retrofit applications, which

can be provided by electrical, automation and control and focused device suppliers, native smarts and connectivity are necessary to push this market forward and this must be driven by OEMs.

Specialty providers of monitoring and management services are best equipped to serve building owners and operators with these solutions, though systems integrators and installers are seeking to expand on traditional services to include these capabilities. Operations technology-focused systems integrators are key partners or acquisition targets for OEMs, as they can help the customer set up and run these systems, taking the burden of this support off of the OEM.

NSPs and insurance providers are viewing solutions in this application segment as an opportunity to expand upon traditional services to owners and operators by partnering with OEMs and technology providers. For insurers, these types of solutions are a natural fit from a risk management standpoint, and partnerships with device suppliers could result in a market shakeup. Hartford Steam Boiler, although providing insurance services to larger, more industrial customers, acquired a device supplier focused on equipment management in 2016 to extend the value of these solutions to its customers while reducing the risks the company faces from high outlays.[2]

Figure 4.28 Building and Equipment Management Channels to Market



4.3.6 Conclusions & Recommendations

Monitoring and remotely controlling the operations of critical building systems, especially HVAC-R and water distribution, enables property managers to realize significant efficiency gains in normal operation and reduce system downtime. Property managers are seeking solutions that expand the monitoring and control beyond that achievable with traditional building management systems, integrating disparate HVAC-R, water and air distribution, lighting, electrical distribution, and access management systems onto a single IP-based platform.

> "All of our HVAC systems are based on the Niagara framework so we integrate with other devices based on that framework. We don't get much push from customers to guarantee this type of integration. However, we think interoperability, especially amongst our own products will be a key adoption driver as we begin to make more smart home appliances."
>
> - Manager, LG

Operators with portfolios of smaller properties that lack on-site staff realize significant cost and time savings from remote access and equipment management offerings. Managers of buildings with on-site staff are able to utilize personnel more efficiently and reduce the overall workforce required to manage the building, however, supplier support is still required in these cases, at least to get these systems up and running.

> "The value of remotely managing the building and systems in it goes way up if you are not on site to begin with…smaller PMs, rather than having to drive around to a dozen small properties around town to rekey doors or check out an HVAC issue can manage these from a central office or mobile phone. Bigger PMs, they might be able to drop the number of on-site staff at large properties by centralizing ops and management, huge savings for them too, just of a different variety. The middle-sized guys certainly boost staff efficiency, but might see less significant benefits."
>
> - Executive, Dwelo

Varying building needs preclude the development of horizontal solutions at a scale required for many major control and automation players to get involved. Traditional OEMs and larger IT player partnerships are driving innovation in the commercial space, with the MDU market on their horizon once they find a sustainable business model for this lower-margin market. These players are developing new service and maintenance contracts leveraging data, while also using data to improve product development and sales.

Smaller, focused suppliers, systems integrators and other service providers therefore have the opportunity to corner this market, however, high installation costs to add connectivity and sensing capabilities in retrofit projects, particularly in low-rise and specialty buildings, may stall adoption of these solutions in the near term. Further, a lack of network and device management interoperability across wirelessly connected devices requires advanced knowledge of these technologies for systems integrators, especially as these integrators shift from implementation to ongoing service and support.

> "BACnet provides the direction between two different systems, which used to be proprietary, but now have to be open protocol. Everything on BACnet means they can communicate, but doesn't mean we can use all the data right away. On a small project where we're connecting lights from a different vendor into our front end, we still have to do about 1,200 man hours of programming to get all of the systems sharing information in a meaningful way. When you plug in two systems from different vendors, yes, they're compatible with BACnet, but the system pulls all of this info over, we have to unbundle it, figure out what to do with it, and how to code it."
>
> - Account Executive, Siemens

Cloud-based building analytics solutions, designed to scale across unlimited devices and buildings, are enabling efficient portfolio management for third party property managers. Specialist platform providers are collaborating with large property managers to integrate individual BASs in order to deliver a unified facility management solution.[3] Successful platform players are developing large, open ecosystems to expand the value of their offerings with partner equipment manufacturers and service providers, and these ecosystems of traditional and non-traditional suppliers will help drive market acceptance and adoption of newer solutions.

Recommendations

- Manufacturers of building critical systems, including HVAC-R and air/water distribution systems, have an opportunity to enhance the value of their offerings by embedding sensing and connectivity in their equipment to enable integration in monitoring and management services.
- Specialty service providers integrate multi-vendor equipment into a single platform from which building operators can monitor, control, and automate the operation of building systems to enhance overall system efficiency and reduce operating expenses for owner/operators.
- Insurance providers have an opportunity to expand from current capabilities and offer asset and building management solutions, which provide new revenue streams while reducing the likelihood of events that would trigger policy payouts and therefore enabling more competitive premium pricing.
- Installers and systems integrators can also expand their roles to leverage IoT technology to not only provide value during the initial equipment and device deployment stage but provide management services over the asset's life.
- IoT hub and platform players should focus on identifying new devices and services to integrate into their ecosystem of interoperable application services that support building management systems.

Figure 4.29 Building and Equipment Management Recommendations for Service Providers

		Utilities	Telcos	Insurance Providers	Specialty Services	IoT Hubs, Platforms and Software
Primary Opportunity		–	Offer platform for building and equipment management applications	Subsidize upfront cost of monitoring systems that reduce risk of building system failure	Monitoring, management, and predictive maintenance of building systems and appliances	Connect diverse building systems and appliances to sole interface from which to provide monitoring and management
Value Prop		–	Extend beyond current in-home offerings and prove the viability of building-wide mgmt. tools in commercial building setting	Critical building systems that are monitored are less likely to fail, reducing odds of insurance payouts	Remote management of assets to reduce downtime for managers	Single interface from which to monitor and manage equipment and building operational efficiency
Targets	Occupant Persona	–	–	–	–	–
	Owner/Operator Persona and Supplier Targets	–	Large and small property mgmt. firms; Owner/Managers; Developers, Engineers and Architects of new builds	Small property mgmt. firms; Owner/Managers; Developers	Large property mgmt. firms; Developers	All Owner/Operator personas; Insurance providers; Specialty providers
	Building Type	–	All Building Types	All Building Types	Mid-and high-rise new and existing builds	All Building Types
Partners		–	IoT Hubs, Platforms and Software; HVAC-R and Water OEMs	IoT Hubs, Platforms and Software; HVAC-R and Water OEMs	IoT Hubs, Platforms and Software; HVAC-R and Water, Appliance, & Lighting OEMs	Specialty services; HVAC-R and Water, Appliance, Lighting OEMs
Secondary/ Long-term Opportunity		–	Offer asset management or insurance services on top of building network services	Offer asset management services through third party on top of building insurance coverage	Offering asset or building insurance services on top of asset monitoring and management	Analytics for asset operational and building usage optimization

Figure 4.30 Building and Equipment Management Recommendations for OEMs

		HVAC-R and Water	Lighting	Appliances	Electrical	Security	Building Products
Primary Opportunity		Embedded connectivity, sensors to capture operational data for use internally or by third-party service providers	Embedded connectivity, sensors for remote lighting asset management and space utilization monitoring	Embedded connectivity, sensors to identify operational abnormalities and remotely manage	Circuit monitoring to evaluate building system and appliance operational abnormalities and inefficiencies	Access management data feeds building utilization optimization tools	Embedded connectivity, sensors to identify operational abnormalities and remotely manage
Value Prop		Higher efficiency offerings and capture of usage data to improve sales and future offerings	Reduced energy OPEX and more efficient usage of building capacity	Reduced downtime and increased operational efficiency	Identify and react to building systems that are operating outside of normal bounds	Increase efficiency of space utilization	Increased response time to issues, reduce likelihood of events
Targets	Occupant Persona	Cost Driven	Cost Driven	Cost Driven	Cost Driven	Security Driven; Cost Driven	Cost Driven
	Owner/ Operator Persona and Supplier Targets	Large and small property mgmt. firms; Owner/ Managers; Developers, Engineers and Architects of new builds	All Owner/ Operator types; Developers, Engineers and Architects of new builds	All Owner/ Operator types; Developers, Engineers and Architects of new builds	Small property mgmt. firms; Owner/ Managers; Owner/ Occupants	Large and small property management firms	All Owner/ Operator types; Developers, Engineers and Architects of new builds
	Building Type	New and existing buildings, especially mid- and high-rises managed by off-site property managers	All Building Types	New and existing buildings with in-unit appliances	Retrofits, especially with minimal capital budgets	All Building Types	All Building Types
Partners		Installers and Integrators; Specialty providers; IoT Hubs, Platforms and Software	Specialty services; IoT Hubs, Platforms and Software	Specialty services; IoT Hubs, Platforms and Software	Specialty services; IoT Hubs, Platforms and Software	Specialty services; IoT Hubs, Platforms and Software	Specialty services; IoT Hubs, Platforms and Software
Secondary/ Long-term Opportunity		Analytics for predictive equipment maintenance and operational optimization	Monitor the status of lighting assets and analyze status data to predict failures, schedule maintenance and upgrades	Analytics for predictive appliance maintenance and operational optimization			

4.4 COMFORT AND CONVENIENCE

Comfort and convenience application segment encompasses a diverse set of use cases that enable remote monitoring and access, control and automation of devices and interaction with services via intuitive means. These use cases leverage both new and repurposed existing hardware within units and in common areas. By providing these offerings as an amenity to building occupants, property managers are able to increase satisfaction to decrease turnover while differentiating units to enhance occupant acquisition. From a building owner or developer point of view, investments in devices and connected services that increase monthly rental income for the building enhance the lifetime value of the property, and thus, the sale price.

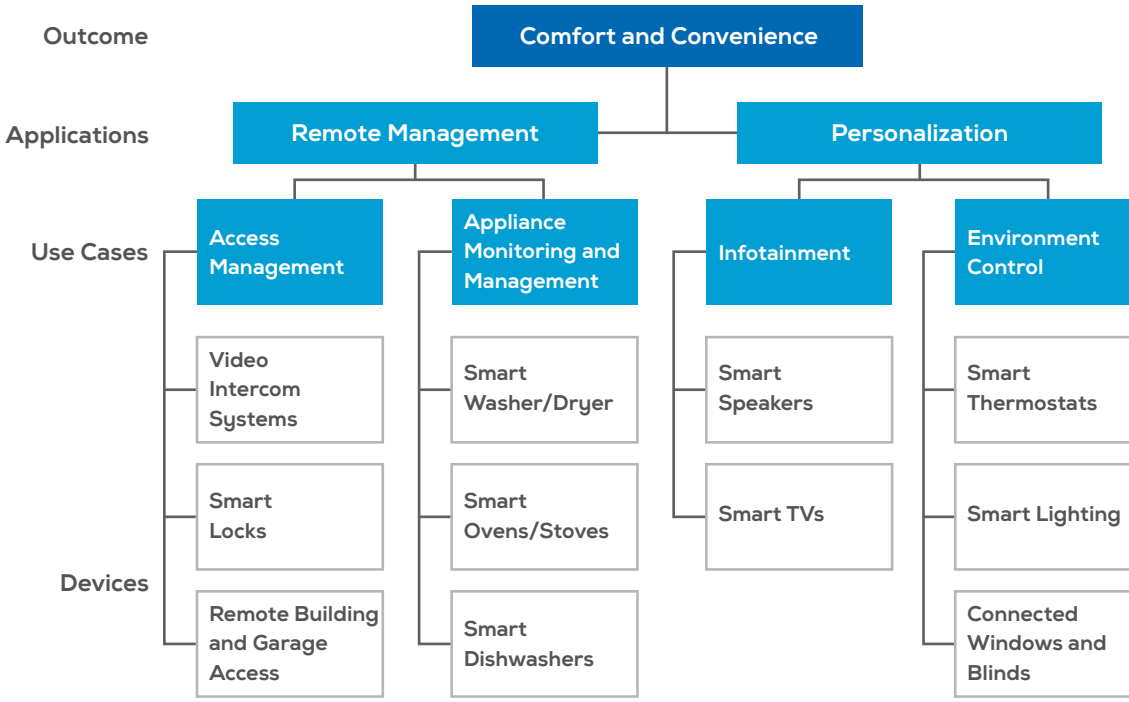
> "The focus from automation players has long been on energy and comfort, and now we're seeing a push towards satisfaction and productivity. Millennials' expectations around their phones and mobility are changing what's occurring in buildings as they have to develop new interfaces, and new means of interacting with occupants. If building managers can provide this with IoT tools, regardless of whatever else they get out of it, they can attract a higher tier of renters."
>
> - Editor, AutomatedBuildings.com

Access management in MDUs creates as much convenience value to building occupants as it does peace-of-mind. Enabling occupants to remotely enable building and unit access, by assignment or in real-time via intercom systems, and keyless occupant access enhance the ease with which access is granted and controlled. Similarly, appliance monitoring use cases give occupants notifications and remote control over washers and dryers, ovens and stoves, dishwashers and other equipment within their unit or in common areas.

> "In MDUs, access management is an issue of convenience. Managers want to be able to let people into vacant units for showings, occupants want to be able to grant access to visiting friends and family, in addition to making easier for themselves to access the building, their unit, and particular building services like laundry or the pool."
>
> - Manager, Lockstate

Within the "Personalization" application, infotainment includes new services offered via smart speakers and TVs, including control of multi-room streaming AV services via mobile devices. "Environment Control" use cases provide occupants control over lighting and temperature to increase in-unit comfort on a highly-individualized basis. These cases may also offer cost savings or increased sustainability but are primarily marketed around the enhanced experience that customers will enjoy in units with these offerings installed.

Figure 4.31 Comfort and Convenience Application Overview



Occupant preferences and experience with their unit and MDU building common spaces is the primary consideration in the development of IoT solutions in MDUs by owners and operators, and comfort and convenience use cases provide occupants a controllable and individualized experience. Given this, the makeup of successful offerings, including types of devices and the scope and scale of services provided, varies significantly by occupant demographics.

> "Smart TVs are standard issue these days, and represent a good opportunity to organize some smart home services. In the studies we've done, however, the value proposition and price of other smart appliances doesn't line up with consumer needs yet. We see this changing as incomes increase and people want more convenience in interactions with home devices."
>
> - Manager, LG

Property managers who choose to provide devices and services as an amenity to building occupants are able to increase satisfaction, decrease turnover, and differentiate units to enhance occupant acquisition. From a building owner or developer point-of-view, investments in devices and connected services that increase monthly rental income for the building enhance the lifetime value of the property, and thus the sale price.

> "[Property managers and building owners] are looking for differentiators. They want what their competitors have, driving an amenities war. This is mostly for marketing to potential occupants, but we are seeing a slow movement towards a more holistic building management model that leads to efficient and optimized systems."
>
> - Vice President, NMHC

Traditional service providers, especially network but also insurance providers and utilities, are seeking new revenue opportunities in comfort and convenience use cases that leverage existing relationships

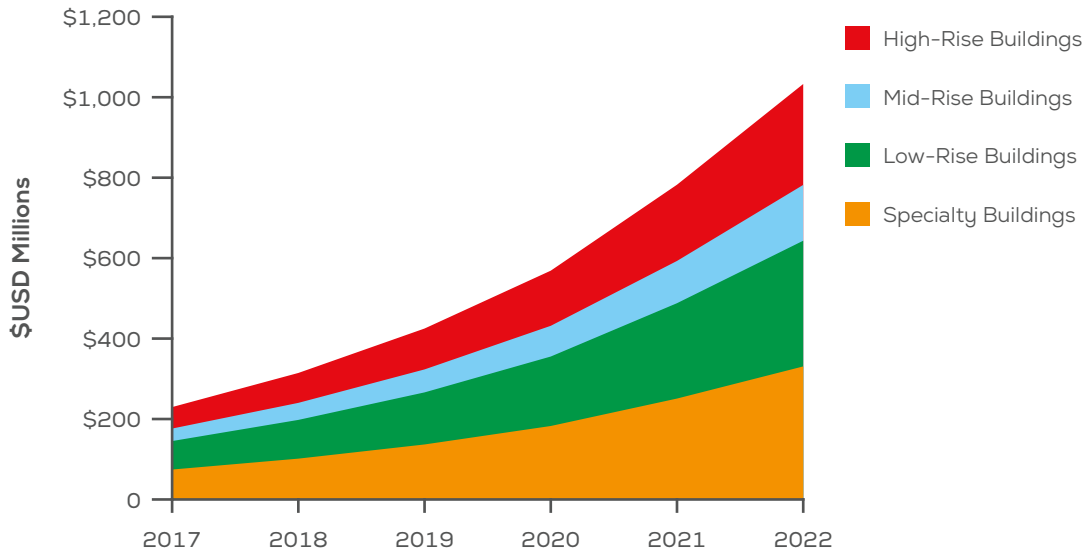
with occupants. NSPs are uniquely well-positioned in this regard. Network-demanding new connectivity offerings directly increase the demand for communications capability, and Internet and cable companies can use their existing business model of subsidizing hardware costs with service contracts to accelerate IoT tech adoption stalled by high upfront costs. These providers are generally trusted by occupants, reducing another major barrier. Further, existing gateways and set-top boxes have all the functionality required to serve as hubs from which to connect a range of in-unit devices and deliver new automation offerings.

> "Of course we're watching the movements of the Googles and Amazons. Our focus has been on our services, delivering the highest quality of service and utilizing our guys in trucks, which those players don't have. You need someone that will provide ongoing support and service."
>
> - Vice President, ADT

4.4.1 Scale of Comfort and Convenience Opportunity

Smart Systems revenue from Comfort and Convenience applications is forecast to rise at a CAGR of 33.6 percent from $230 million in 2017 to $1,033 million in 2022. Similar to other applications, the number of specialty and low-rise buildings make offerings for these building segments particularly attractive. Relative to Resource Management or Building and Equipment Management applications, Comfort and Convenience offerings are more likely to find applications across building types and enable suppliers to develop horizontal offerings that find success across the MDU market.

Figure 4.32 Comfort & Convenience Revenue by Building Type, 2017-2022



4.4.2 Trends & Forces Affecting Comfort and Convenience Opportunities

A main driver of convenience is interoperability between in-unit systems and suppliers. Existing relationships and trust between suppliers and occupants provides a critical advantage, especially when it enables the delivery of enhanced services over already installed equipment, however, higher-end suppliers have found success utilizing home automation-specific gateways and software to integrate systems. While entertainment serves as an effective base for comfort and convenience offerings, consumers will increasingly look for additional services that extend this value.

Technology Forces & Impacts

- Competing standards for device connectivity, including Zigbee, Z-Wave, Thread, Bluetooth and Wi-Fi are challenging device and service interoperability and forcing end-users to carefully select compatible offerings.
- Software platform and hardware "hub" offerings are bridging devices with disparate connectivity protocols, with partner programs defining which devices and services can communicate and work together to enhance occupant comfort and provide convenient services.
- Software tools translating communications between devices and systems designed with different communications and data transfer protocols are removing the reliance on C-suite decision-making to enable interoperability and increasing end-user choice of devices.
- Platform/hub offerings are taking advantage of data collection capabilities in many consumer offerings with advanced communications and processing tools, enabling occupants to monitor and manage devices and services from many vendors from a single interface.
- Touch screens have dominated end-user interfaces with electronics for the last decade, though advances in natural language processing is enabling vocal interfaces with machine systems.
- Advances in machine learning are leading to incorporation of learning capabilities into a broad range of offerings, which can then deliver customized convenience services to occupants with minimal added complexity.
- Artificially intelligent virtual assistants are increasingly at the core of home control platform offerings from a number of consumer electronics companies. Such tools are leveraging end-user data to deliver customized home automation services from third-party providers that have joined the ecosystems forming around these platforms.

Competitive Forces & Impacts

- Consumer-focused companies (Amazon, Google, Apple, Microsoft, Samsung, etc.) are developing virtual assistants and hardware and software offerings designed for home automation, viewing an opportunity to lead in the next frontier of consumer data collection.
- Network service providers are leveraging existing relationships with occupants to expand Internet, cable, and voice services to provide not only new infotainment services but home automation as well.
- Consumer electronic companies and NSPs both are partnering with platform providers to offer home automation services through existing and new hardware offerings including PCs, tablets, speakers, TVs, game consoles, set-top boxes and Internet gateways.
- Success is increasingly enabled through the use of innovative business models that focus on ongoing revenue from support for services provided (performance contracts, subscriptions) as opposed to technology offerings alone.[4]
- Specialist platform providers are offering turnkey smart MDU solutions encompassing maintenance, training and support, and value adding applications for analytics and optimization.

Customer Forces & Impacts

- Adoption of streaming audio/visual devices and services is driving connectivity within units, as devices and services are designed to be interacted with from smart phones, tablets, and smart speakers.
- Consumer electronics offerings, including TVs and speakers, PCs and game consoles, tablets and smartphones that consumers already own are the desired interface for managing and personalizing in-unit infotainment and automation services. Adoption of new devices like Amazon's Echo and Google Home are demonstrating that users are willing to purchase new

offerings that provide voice interfaces, preferring to limit smartphone use in the home.
- Younger and tech-savvy older renters are seeking units that have the infrastructure required for them to bring in the devices and connected services that they wish.

Socioeconomic Forces & Impacts

- Millennials are making up an increasing number of renters and, having grown up in the Internet age, are more comfortable using technologies and have "always-on" expectations of all services in their lives.[5]
- Baby boomers are increasingly moving back into apartments and condos in coastal and in-land cities, often following the movement of their children.[6]
- Corporate moves away from coastal destinations due to increasing rents is bringing young, tech-savvy workers in-land where competitive buyers-markets are driving adoption of new, differentiating technology in MDUs.[7]
- Occupant demographics are a key factor in determining the appropriate scope of comfort and convenience solutions, but are not a defining factor in whether these use cases are applicable or not.

4.4.3 Customer Interest & Adoption Influencers

Of occupants who expressed an interest in connected devices and services, over 91 percent are aware of and interested in Comfort and Convenience applications. Streaming AV has the highest current adoption, while remotely controlled appliances have the least. Keyless entry and lighting control are identified as the services with the most interest and least current adoption, highlighting a large potential opportunity for suppliers.

Figure 4.33 Occupant Interest in Comfort and Convenience Applications, n=483

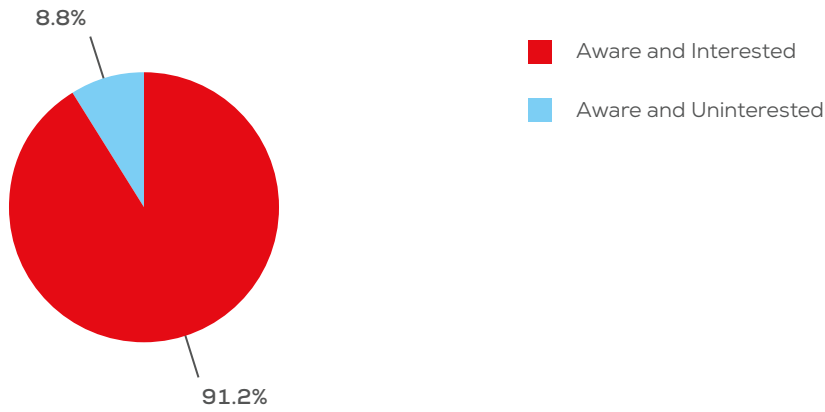
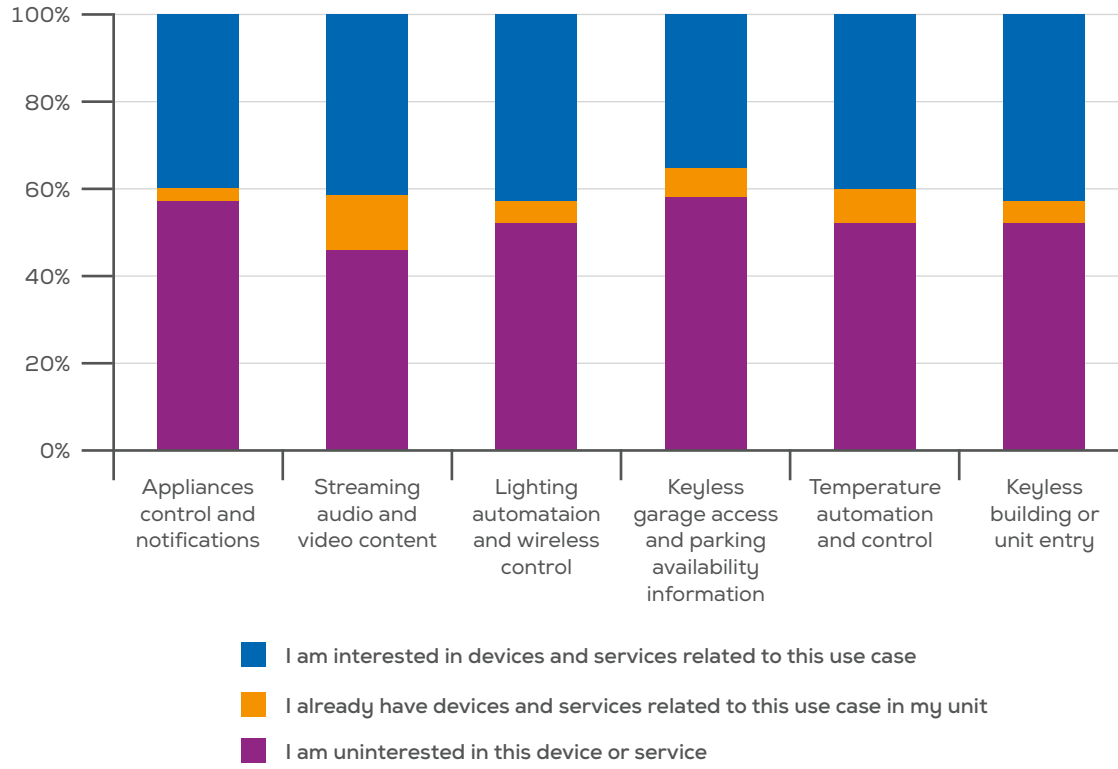


Figure 4.34 Occupant Preference for Comfort and Convenience Devices and Services, n=483



Occupant interest in Comfort and Convenience applications is lower by a statistically significant margin for those paying less than $500 per month for their unit. The largest portion of low-rent unit occupants have household incomes of less than $50,000 per year, and are least likely to spend disposable income on devices that enable these applications.

Figure 4.35 Occupant Interest in Comfort and Convenience Applications by Monthly Rent, n=473

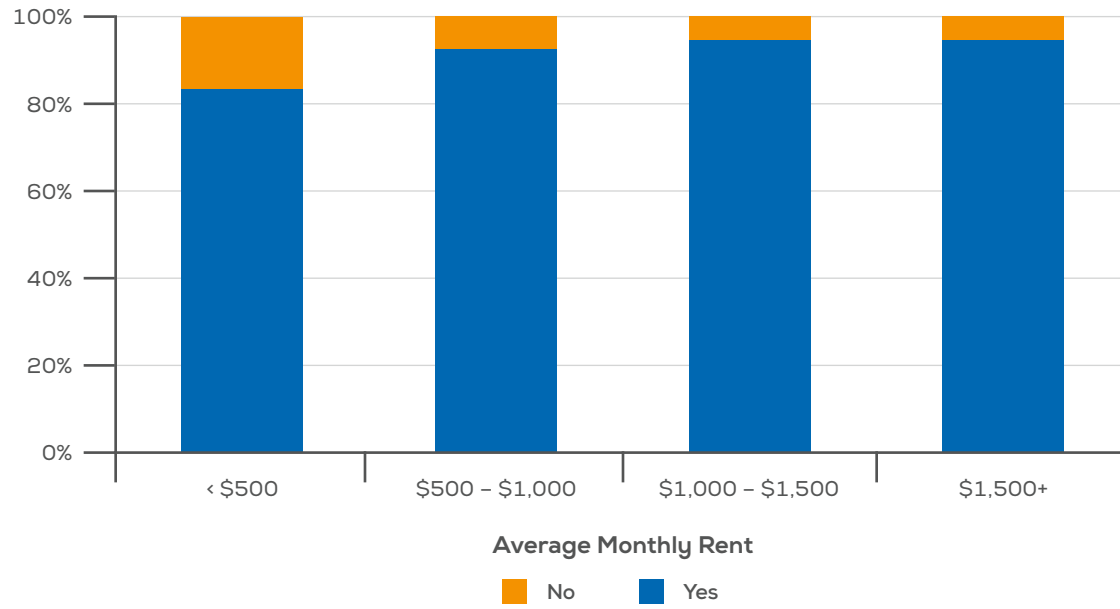


Figure 4.36 Occupant Monthly Rent and Household Income, n=1140

4.4.4 Case Studies

Several case studies demonstrate the value of these offerings:

- **IOTAS**
  - **What**: The holistic smart apartment provider partners with MDU developers to outfit rental units with temperature and lighting automation as well as building access management offerings.
  - **Result**: Rental units increase in value while differentiating amongst amenity-focused buildings targeting millennials. Further, occupant satisfaction is increased by way

of reducing energy bills, while managers capture valuable data from space and equipment usage.

- **Deutsche Telekom**
  - **What**: The NSP's Qivicon smart home platform combines a secured network with reliable control to offer comfort and convenience to end-users with over 40 partner vendors including other NSPs, OEMs, utilities, and insurance providers.
  - **Result**: The white label offering enables B2B customers to utilize the platform to provide connected services with low upfront investment, leading to rapid growth.
- **Comfy**
  - **What**: The firm's mobile app connects building occupants to existing building management systems and provide input about their comfort in the room they are in, which machine learning algorithms use to co-optimize HVAC systems and occupant comfort.
  - **Result**: Sixty percent of occupants report greater comfort, while managers receive 90 percent fewer hot/cold calls and cut energy costs by 25 percent to stretch operational budget by 10 percent.
- **Embue**
  - **Offerings**: A comprehensive suite of solutions for multifamily buildings, including temperature, humidity, and occupancy sensing, smart thermostats, HVAC control modules, edge processing modules, and mobile control applications for occupants and building operators.
- **Dwelo**
  - **Offerings**: Holistic apartment building offerings enable occupants to control in unit HVAC systems, lighting, and access control while giving operators the tools to manage building access permissions to reduce turnover costs while streamlining day-to-day operations.
- **Cytexone**
  - **Offerings**: Integrated MDU building solutions that provide operators with integrated building system monitoring and management, motion detection and video surveillance, and access control with a virtual doorman. Occupant amenities including lighting and shade control, remote control of streaming music services, as well as temperature and access management.

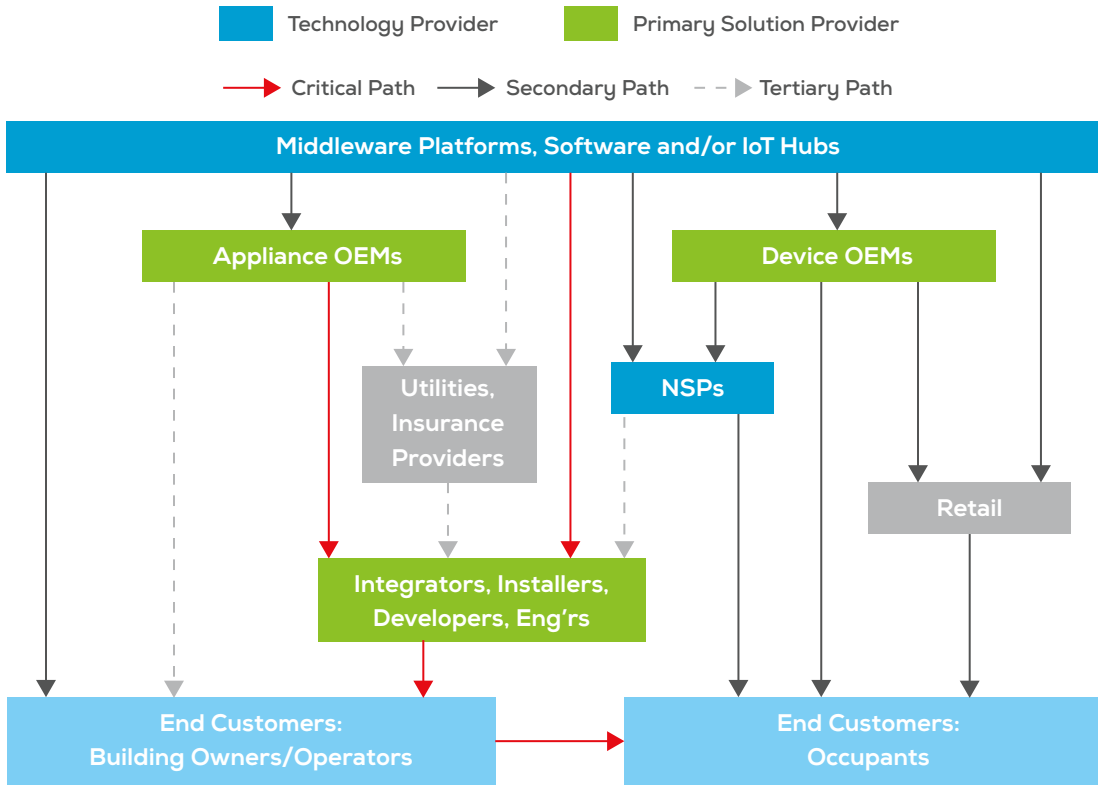
4.4.5 Channels to Market

NSPs, including both Internet and cable providers, are delivering technology to occupants by way of existing and new hardware offerings to connect in-unit offerings from an ecosystem of OEM partners. With extensive customer bases, these types of suppliers have somewhat of a head start on others trying to serve comfort and convenience use cases.

With this said, Amazon has come out of nowhere to offer a suite of offerings including its Echo and Alexa products, DASH buttons and smart home integration services that make it a threat to traditional suppliers while offering a channel opportunity for specialty device OEMs and service providers. These and other retail channels increase the chance of device OEMs to be noticed by consumers.

Whole-unit automation offerings, focused around hardware hubs or software packages, are being delivered by systems integrators and installers to minimize complexity and deliver ongoing support and maintenance. These are typically higher-end solutions, but can be integrated into new builds relatively easily. By selling through building owners and operators to deliver value to MDU occupants, technology providers can deliver these solutions at a larger scale to new builds and retrofits.

Figure 4.37 Comfort and Convenience Channels to Market



4.4.6 Conclusions & Implications

Comfort and convenience offerings have the potential to substantively increase the value of rental units, differentiate units and buildings, and create long-term operational expense reductions for property managers.

Access management provides significant convenience for occupants while enabling managers to limit access to a determined set of tenants and reducing time and labor during tenant turnover. In-unit appliance, lighting, and temperature management offerings provide significant value to occupants, allowing them to control and personalize their experiences. These devices and use cases provide little value to owners and operators while units are occupied, but during vacancy, they can remotely check in on the status of many aspects of their buildings and units, while also providing differentiation to attract potential occupants.

While the devices employed and the level of service provided with solutions varies with occupant demographics, successful deployment of comfort and convenience geared use cases is not confined to upscale properties. Property managers serving lowering income occupants prioritize access management use cases, which provide generous returns to managers and staff while enhancing occupant convenience.[8]

Offerings need to focus on flexibility, such that owner installed devices and appliances can work seamlessly with occupant-provided consumer electronic devices and smart home hubs. Successful platform players are developing large, open ecosystems to expand the capabilities of their offerings well beyond that economically feasible alone. In addition, machine learning tools, especially digital assistants in consumer electronic offerings, are enabling users to interact with devices and services in new ways and to benefit from control and automation with minimal added complexity and significant flexibility.

> "You have a bunch of players get started out in smart home because its trendy, but do you want to battle against Apple and Google, well-funded and deep pocketed providers? We've seen multiple firms switch over to targeting MDUs as a niche market, recognizing that there's a unique set of needs here that those consumer-focused firms aren't well positioned to meet."
>
> - Executive, Cytexone

Recommendations

- Property owners and operators have an opportunity to distinguish otherwise commonplace units by incorporating connected devices and services that enhance the ability to remotely manage and personalize the occupant's MDU experience.
- Property owner/operator decision-making depends heavily on the demographics of the occupants they aspire to attract, with higher-income occupants desiring ready-to-use connected offerings that provide a range of service options from the time they move in.
- For occupants not willing to pay a significant premium for connected offerings, owner/operators should prioritize flexibility and provide only the network backbone and potentially an IoT hub or platform offering, to which occupants can add-on the devices and services they desire.
- Electrical equipment manufacturers have a unique opportunity to enable monitoring and control of unconnected legacy equipment in retrofit projects.
- NSPs are well positioned to utilize existing hardware in units to serve as the hubs from which a range of services are delivered, capturing new revenues and locking in customers longer-term with tailored, AI-personalized services.
- Given the ability for "Remote Management" use cases to reduce the likelihood of events that insurance providers might cover with building, asset or renter policies, these firms can differentiate their policies and reduce their exposure by assisting in the adoption of devices that enable these use cases.
- OEMs can capitalize on the increased willingness-to-pay for convenience-enhancing offerings by embedding equipment with sensors and a range of connectivity options to ensure vendor-agnostic platform and service provider compatibility.

Figure 4.38 Comfort and Convenience Recommendations for Service Providers

		Utilities	Telcos	Insurance Providers	IoT Hubs, Platforms and Software
Primary Opportunity		Implement behavioral program that provides granular billing information and custom recommendations for reducing utility bill	Expand capabilities of existing hardware to become hub for managing automation and entertainment services within the unit	Provide incentives (or reduce premiums) for automation devices that increase comfort while reducing the risk of system failure or events that could lead to a payout	Integrated home automation offering integrating in-unit devices and services, including infotainment, lighting, appliances, temperature control, and access
Value Prop		Increase efficiency of resource consumption while saving users money	Leverage existing business model to provide home automation services on top of existing cable or Internet service	Improve relationships with existing customers, differentiate to win new customers by offering lower premiums due to decreased risk of payout resulting from MDU automation	Holistic, ready-to-rent smart apartment offerings create provide increased value to occupant, increase revenue and reduce expenses for operators
Targets	Occupant Persona	Cost driven	Tech focused	Tech focused	Tech focused
	Owner/Operator Persona and Supplier Targets	Large and small property mgmt. firms	All Owner/Operator Personas	All Owner/Operator Personas	All Owner/Operator Personas; Developers of new builds
	Building Type	All Building Types	Any buildings with exclusive network contracts	All Building Types	All Building Types
Partners		IoT Hubs, Platforms and Software; OEMs	IoT Hubs, Platforms and Software; OEMs	IoT Hubs, Platforms and Software; OEMs	IoT Hubs, Platforms and Software; Utilities; Telcos; Insurance providers; OEMs
Secondary/ Long-term Opportunity		Offer incentives to end customers to install smart thermostats, use to implement ToU pricing or DR programs	Expand beyond comfort and convenience and provide energy management and security services	Provide home automation services on top of underwriting	Expand beyond automation to provide adjacent services – utility billing, insurance, etc; Data brokering to enhance value of services delivered

Figure 4.39 Comfort and Convenience Recommendations for OEMs

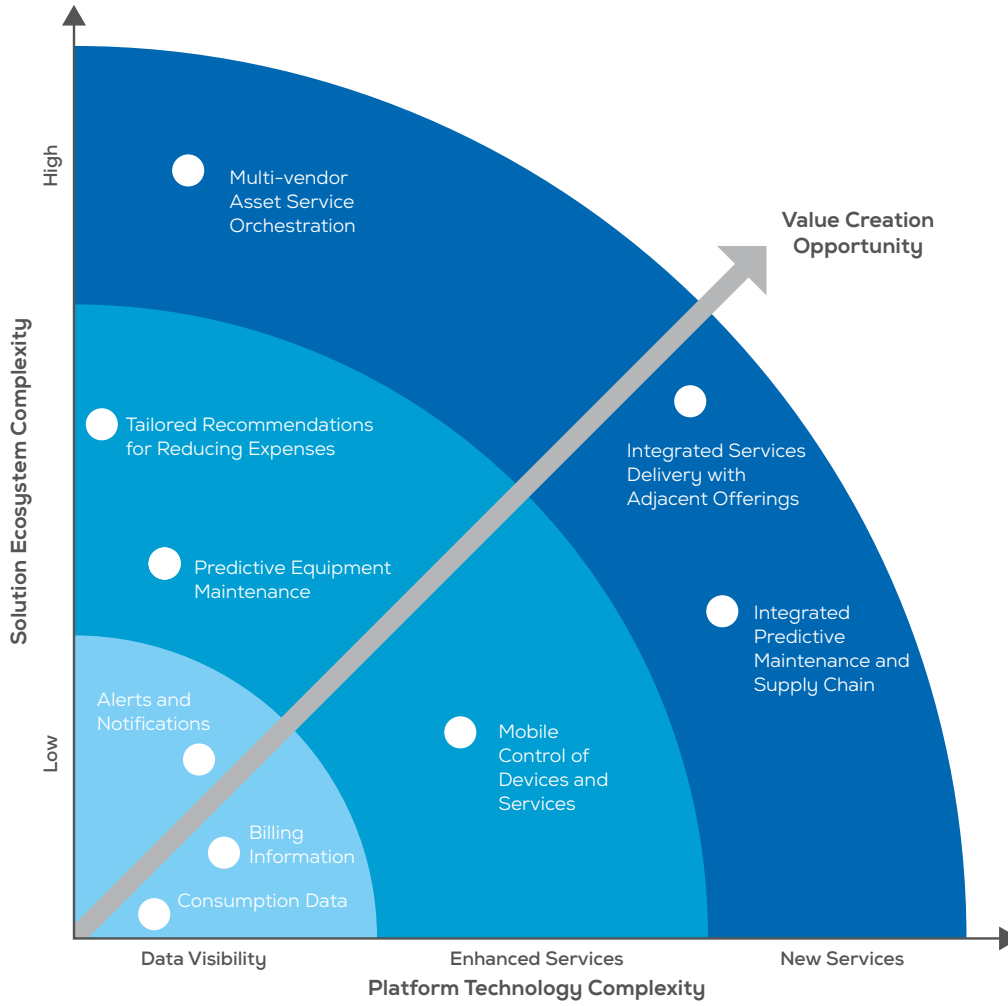
		HVAC-R and Water	Lighting	Appliances	Electrical	Security	Building Products
Primary Opportunity		Embedded connectivity in smart thermostats to integrate with range of platforms for mobile control and automation	Embedded connectivity, sensors for remote lighting control	Embedded connectivity, sensors for remote control and notifications	Smart plugs, sensors, and actuators connect and enable mgmt. of legacy equipment	Connected smart locks and video intercoms for remote access management	Embedded connectivity, sensors for remote control and automation
Value Prop		Allow building owners and occupants to connect climate control systems directly to HVAC to increase comfort and reduce costs	Allow building owners and occupants to control and automate lighting systems from mobile or fixed interfaces and to integrate with whole-unit automation offerings	Allow building owners and occupants to control and automate in-unit and common area appliances from mobile or fixed interfaces	Allow occupants and operators to observe, control and automate existing HVAC-R and water systems, lighting equipment and appliances	Provide occupants remote access management to reduce inconvenience of physical keys, especially for visitor or maintenance access	Provide ability to integrate control over windows and blinds into unit automation systems
Targets	Occupant Persona	Tech focused; Cost driven	Tech focused	Tech focused	Tech focused	Tech focused	Tech focused
	Owner/ Operator Persona and Supplier Targets	All Owner/ Operator Personas	All Owner/ Operator Personas	All Owner/ Operator Personas	All Owner/ Operator Personas	All Owner/ Operator Personas	All Owner/ Operator Personas
	Building Type	All Building Types	All Building Types	All Building Types with in-unit appliances	Retrofits of existing buildings of all sizes and structures	All Building Types	All Building Types
Partners		IoT Hubs, Platforms and Software; Installers	IoT Hubs, Platforms and Software; Installers	IoT Hubs, Platforms and Software; Installers	IoT Hubs, Platforms and Software; Installers	IoT Hubs, Platforms and Software; Installers	IoT Hubs, Platforms and Software; Installers
Secondary/ Long-term Opportunity		Expand thermostat capabilities to leverage energy management as entry point for broad suite of in-unit automation offerings	Leverage connection to end users to enhance product design and service delivery	Leverage connection to end users to enhance product design and service delivery	Current and voltage analytics provide notification of abnormal appliance operation to avoid downtime	Partner with security providers to provide services bundled with hardware offerings	Leverage connection to end users to enhance product design and service delivery

4.5 END-USER ENGAGEMENT

Equipment manufacturers and service providers, including property managers, have traditionally had to rely on indirect means of interacting with end-users of equipment and services. IoT-enabled devices, however, are changing the nature of this relationship, providing the means to connect with users in new ways. Use cases that provide such engagement fall across a spectrum of ecosystem and technology complexity, with more complex use cases creating more value for both customers and suppliers. At the low-end of this spectrum reside solutions that make usage data visible to end-users via intuitive and informative interfaces. Suppliers are able to then leverage this foundation of visibility to provide enhanced services around offerings, enhancing the efficiency or convenience of equipment and service usage. Finally, suppliers use their enhanced relationship with end-users and other ecosystem participants to identify opportunities to provide new value-adding services while optimizing design, delivery and usage of existing offerings over their life cycles.

> "Most of our HVAC systems have some sort of connectivity today, but its relatively simple. We are looking into ways to increase the value of the data we are collecting from these and our water systems, as a way to enhance the services we can provide to building managers."
> - Senior Product Manager, Johnson Controls

Figure 4.40 Spectrum of End-User Engagement Solutions



These use cases can be provided to owners and operators as well as occupants. Equipment manufacturers are developing new services inside traditionally product-centric businesses, increasing margins by capturing significant new revenues from ongoing monitoring and maintenance of devices while increasing customer retention and differentiating offerings. Service providers, such as utilities, NSPs, insurance and security providers are utilizing consumer electronics offerings, including mobile apps on phones and tablets, as well as smart speakers and virtual assistants to strengthen their relationships with end customers. Property managers are also leveraging these use cases. In-unit technologies enable convenient interactions with occupants and allow managers to offer new services that increase satisfaction and reduce turnover, a major source of operating costs for managers.

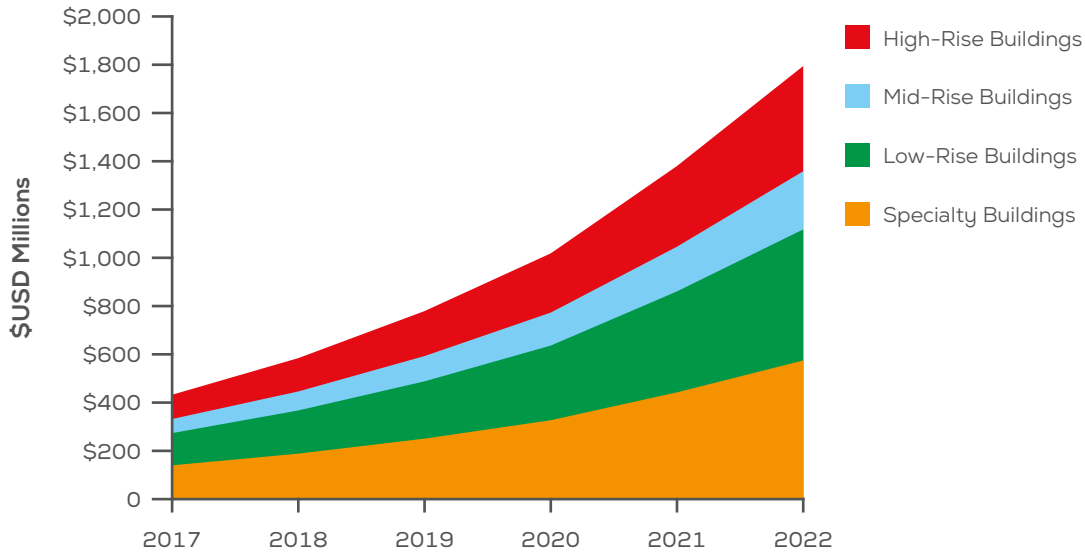
> "We see an advantage from putting keyless locks and lighting with sensors into retrofits. There's a data gathering advantage, using all of the info from electronic locks to provide new services to occupants or maybe use the data with suppliers down the road. It's a huge maintenance time saver, being able to remotely access units, giving access to staff as needed."
>
> - Vice President, EdR

These supplier types all seek deeper connections with users to not only increase customer loyalty, but also to enable new opportunities for user-specific value creation that further increase customer satisfaction and retention. End-users, either operators or occupants, capture greater value from tailored offerings provided by building equipment and service suppliers who have a keener sense of end-user needs and preferences.

4.5.1 Scale of End-User Engagement Opportunity

End-user engagement revenues are projected to grow from $433 million in 2017 to $3,868 million in 2017, representing a CAGR of 31.5 percent. Opportunities within high-rise buildings are forecast to grow most rapidly, due to higher expectations of services by occupants in urban environments where these buildings are predominately located.

Figure 4.41 End-User Engagement Revenue by Building Type, 2017-2022



4.5.2 Trends & Forces Affecting End-User Engagement Opportunities

Competitive markets are driving operators to adopt new offerings to differentiate their units and attract tech-native, millennial renters. Rising expectations for service level and personalization from renters, operators and owners is driving demand for closer relationships with all providers. While many suppliers are leveraging existing devices and technologies, new in-unit connected devices increase interactions with users to create new shared value.

Technology Trends & Impacts

- Increasing processing capabilities with consumer devices is allowing more information about end-users' devices and services to be gathered and presented to them meaningful ways to increase their satisfaction.
- Powerful, intuitive user interfaces, coupled with mobile-ready consumers, are expanding the opportunities for device and service providers to connect to end-users.
- Reducing cost of digital interfaces, from smartphones to tablets and wearables, is increasing adoption and thus the opportunities for engagement across income brackets.
- Virtual, digital assistant offerings are increasing both the breadth and depth of ways that device and service providers can interact with end-users.

Competitive Trends & Impacts

- MDU owners, operators and managers are working with specialty platform providers to create new modes of interaction with building occupants, leveraging smartphones as well as dedicated smart home hardware that occupants provide.
- Consumer-focused companies (Google, Samsung, etc.) are entering the market through acquisitions, recognizing the opportunity for consumer data collection and revenue capture from new services delivered in the home.
- OEMs and service providers are recognizing the value they can capture from engaging end-users in new means, including:
    - Increased user satisfaction;
    - Increased user retention;
    - Insight into product use enabling creation of new value adding services; and
    - Product life cycle improvements.
- Commoditization of devices and hardware is making support and services increasingly valuable for differentiating offerings.

Customer Trends & Impacts

- End-users' expectations of mobile access to information about the services that they rely on are driving providers to become increasingly engaged or risk losing customers to service providers who make data visibility and service management possible via intuitive interfaces.
- Ubiquity of smartphones in developed markets have introduced new means of interaction between service providers, including building managers, utilities, insurance and security providers and end-users of services.
- Customer expectations of flexibility and low switching costs on the Internet in the and "X-as-a-service" era has made them wary of long contracts.
- Customers have shown a willingness to exchange permissions over personal data for enhanced services from device and service providers when value of these services is made clear.

Socioeconomic Trends & Impacts

- Millennials, who currently make up the largest portion of MDU renters, overwhelmingly believe that technology makes their lives easier and seek means to enhance the value they

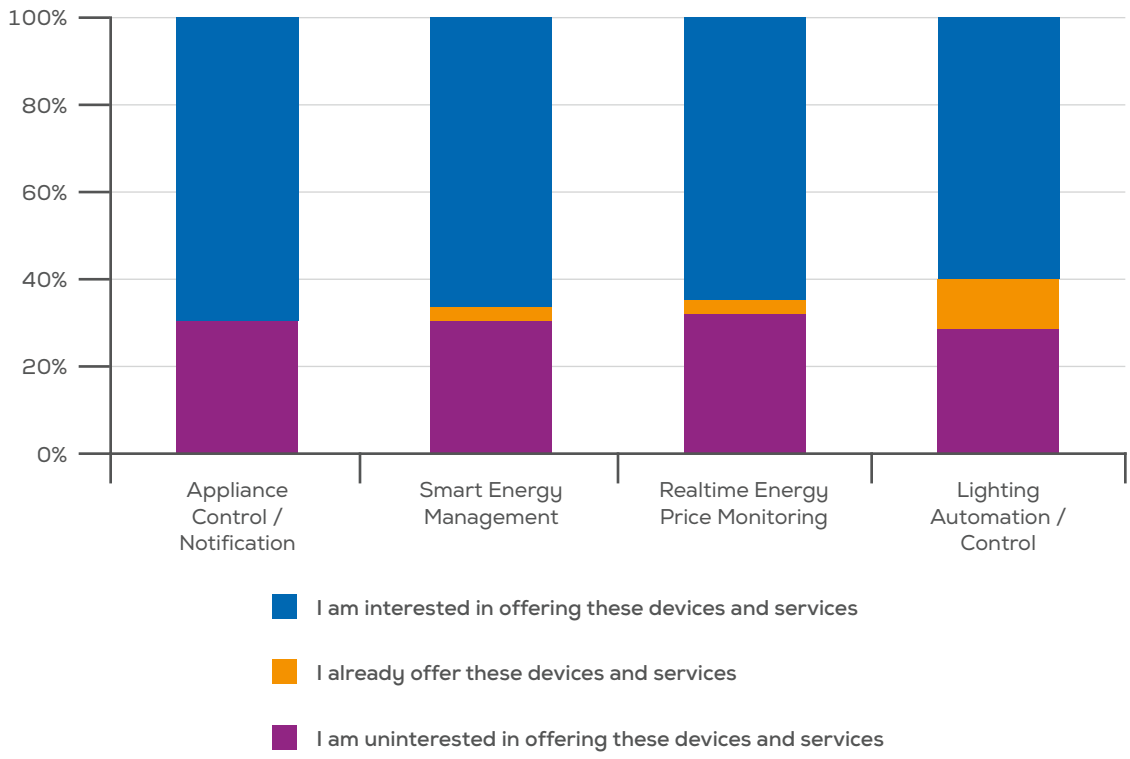
receive from devices and services with digital means of interactions.

- Competitive housing markets in geographically constrained urban areas are incentivizing property managers to pursue innovative means of differentiating their properties, and increased engagement is a low-cost means of increasing occupant satisfaction and reducing turnover.
- Partial or complete deregulation of wholesale generating markets has led to the creation of independent power producers, who must compete for customers based on price as well as quality of service, both of which can be improved with enhanced levels of coordination with end-users.

4.5.3 Customer Interest & Adoption Influencers

Among the top End-User Engagement applications that building operators are interested in, those leveraging Smart Appliances to offer new services to occupants and those enabling energy management are most desired. These devices and services must be designed so as to enable operators to capture either a direct benefit, from more efficient service delivery to occupants, or an indirect benefit from the ability to rent units at higher prices due to enhanced third-party services to occupants.

Figure 4.42 Operators' Top Interests for End-User Engagement Devices & Services, n=36



4.5.4 Case Studies

Several case studies demonstrate the value of these offerings:

- **Hartford Steam Boiler**
  - **What**: The insurer offers customers a holistic IoT solution including hardware, software, analytics tools to develop sensor-based implementations for risk management.
  - **Result**: New monitoring and alerting programs based on IoT implementations have increased dialogue with customers while reducing claims, increasing profits

from existing customers, and enhancing underwriting and risk profiling to increase profitability of future customers.

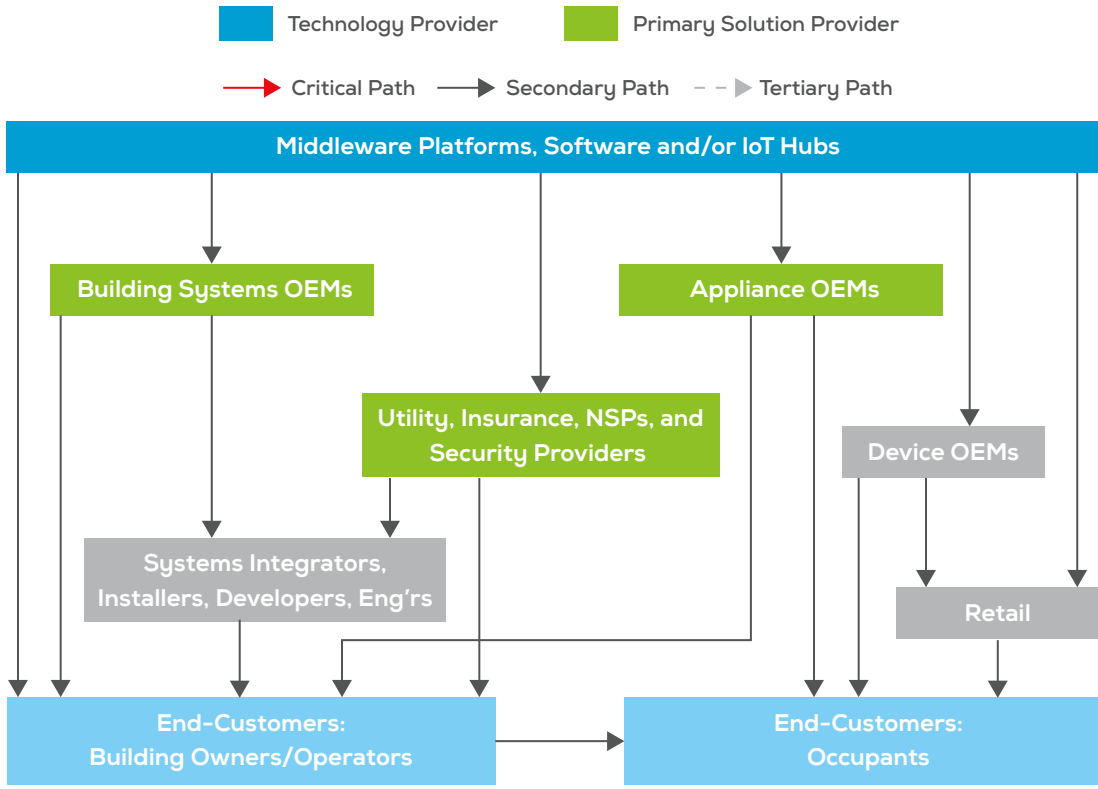
- **ConEdison and C3IoT**
  - **What**: The partnership enables the electric utility to capture and analyze enormous volumes of disparate data from sensors and devices, enterprise information systems, and external data sources such as weather, traffic, and social media to capture business insight and optimize operations in order to serve customers more efficiently.
  - **Result**: Enhanced customer engagement will enable ConEd to improve operations and differentiate products and service.
- **CEIVA and Amazon**
  - **What**: CEIVA's HomeView app allows end-users to access utility billing information, resource consumption patterns, and receive alerts from home sensors via Amazon's Alexa.
  - **Result**: Utilities are able to interact with customers via the voice interface of Alexa to encourage efficient behaviors, while OEMs increase the value of their connected offerings by integrating with the intuitive interface.

4.5.5 Channels to Market

There is no single "critical path" to market for end-user engagement solutions, but rather a range of routes depending on the supplier, the technology and the targeted end-user. Equipment manufacturers and service providers are leveraging IoT technology to engage with end-users via numerous channels, including retail, systems integrators and installers, and directly to customers.

Building systems OEMs can either directly bring technology to building owners and operators or work through integrators and installers who provide additional support of connected offerings. Appliance OEMs, utilities, NSPs, insurance and security providers can leverage IoT technology to engage with owner, operators and MDU occupants. Property managers are either directly offering platforms and hubs to occupants or sourcing these from SIs or service providers to enhance their engagement with occupants.

Figure 4.43 End-User Engagement Channels to Market



4.5.6 Conclusions & Implications

Connected offerings provide a unique means for unit or building owners and managers, OEMs, and service providers to increase their level of interaction with end-users. Increased engagement allows equipment and service providers to reduce customer attrition and occupant turnover and increase pricing for equipment, services, or units, but equipment manufacturers are realizing that they must migrate from being "product" companies to being "service" companies. While some are starting to make the shift, few have developed the business model and processes to move beyond simple data visibility and capture value from enhanced and new services.

> "In the past, we focused on manufacturing everything related to heating and cooling buildings, all the products touching the HVAC system. Then we moved into software to control all of these pieces, manufacturing the software and selling licenses to control all of those elements in all sorts of commercial buildings. Everyone's going this direction, everyone wants to sell software...we're differentiating ourselves with a focus on services, leveraging our knowledge of these systems to provide superior support."
>
> - Account Executive, Siemens

IoT platforms and hubs are enabling OEMs, and service providers the ability to engage with end-customers in more advanced ways than simply providing data visibility without the means of developing advanced tools in-house. Similarly, these platforms are providing new means for building owners and property managers to interact with MDU occupants to increase satisfaction and enhance retention as well as new occupant acquisition.

Property managers are leveraging mobile apps to enable direct communication of maintenance and billing, decreasing the costs of collecting and depositing billing, the lag in cash receipts, and quality

assurance with immediate maintenance responses. These offerings also allow property managers to play to the millennial generation's familiarity with smartphones and technology in general, as well as their desire to be self-sufficient.

> "Customer service and making sure our occupants are happy. That, at the end of the day will drive our consideration and implementation of any solution. At the same time, there are some areas of our operations where I could see technologies helping out. Particularly in security and access management, automating and coordinating unit maintenance, as well as rent payments and other customer interface points."
>
> – Property Manager, Gables Residential

Recommendations

- IoT hubs, platforms, and middleware software partnerships give equipment manufacturers, service providers, and property managers a host of new means to meaningfully engage with MDU occupants.
- NSPs should partner with providers of holistic apartment offerings, or leverage hubs and platforms to organize an integrated ecosystem of offerings and provide the integrator function as an additional service to occupants, capturing new revenue from ecosystem partners as well.
- Electric utilities should partner with specialty service providers to meet the heightened expectations from "always on" consumers who increasingly seek the tools to increase consumption efficiency, reduce individual environmental impacts and pay only for services that they choose.
- Building systems OEMs should leverage installers and systems integrators to increase interactions with building owners and operators, especially in new builds.
- Electrical equipment manufacturers have a unique opportunity in retrofits to provide the circuit monitoring tools to connect legacy equipment owners with manufacturers or third-party service providers.

Figure 4.44 End-User Engagement Recommendations for Service Providers

		Utilities	Telcos	Insurance Providers	IoT Hubs, Platforms and Software
Primary Opportunity		Deliver granular billing info with custom recommendations for reducing utility bill via mobile and fixed home interfaces	Access and control streaming content on TVs and speakers throughout unit via mobile applications	Deliver detailed billing information to end customers and provide recommendations for premium-reducing actions	Provide means for service providers and device OEMs to interact with end users
Value Prop		Increased customer satisfaction and greater utility value from engaged customers	Increased customer retention and development to capture more revenue per customer	Increased customer retention and enhanced customer acquisition with differentiated service, plus reduced likelihood of unexpected payout	Sell SaaS or white label software to service providers looking to increased customer retention and enhanced customer acquisition with differentiated services
Targets	Occupant Persona	Tech focused	Tech focused	Cost driven	Tech focused
	Owner/Operator Persona and Supplier Targets	All Owner/Operator Personas	All Owner/Operator Personas	All Owner/Operator Personas	All Owner/Operator Personas; Utilities; Telcos; Insurance providers; Specialty services; OEMs
	Building Type	All Building Types	All Building Types	All Building Types	All Building Types
Partners		IoT Hubs, Platforms and Software	IoT Hubs, Platforms and Software	IoT Hubs, Platforms and Software	Specialty providers; Utilities; Telcos; Insurance providers; OEMs
Secondary/ Long-term Opportunity		Interactive tools for participating in utility programs to reduce expenses while facilitating utility operations	Offer holistic unit automation platform via existing hardware on top of existing subscription and service contract	Provide asset management and maintenance offerings	Expand beyond user engagement to become platform for resource management, peace-of-mind, or asset management offerings

Figure 4.45 End-User Engagement Recommendations for OEMs

		HVAC-R and Water	Lighting	Appliances	Electrical	Security	Building Products
Primary Opportunity		Embedded connectivity to enable data capture and usage, alerts triggered by events	Embedded connectivity to enable data capture and usage	Embedded connectivity to enable data capture and usage	Alerts and notifications from device in response to abnormal current or voltage detection	Alerts and notifications from device in response to events	Alerts and notifications from device in response to events
Value Prop		Provide customers with enhanced view into system performance	Provide customers with enhanced view into lighting system performance	Provide customers with enhanced view into equipment performance	Differentiating capabilities increase customer satisfaction and retention	Differentiating capabilities increase customer satisfaction and retention	Differentiating capabilities increase customer satisfaction and retention
Targets	Occupant Persona	Service centric	Service centric	Service centric	Service centric	Service centric	Service centric
	Owner/ Operator Persona and Supplier Targets	All Owner/ Operator Personas	All Owner/ Operator Personas	All Owner/ Operator Personas	All Owner/ Operator Personas; Developers	All Owner/ Operator Personas	All Owner/ Operator Personas; Developers
	Building Type	New buildings of all sizes and structures	All Building Types	All Building Types	All Building Types with in-unit appliances	All Building Types	All Building Types
Partners		Installers; IoT Hubs, Platforms and Software	Installers; IoT Hubs, Platforms and Software	IoT Hubs, Platforms and Software	Installers; IoT Hubs, Platforms and Software	IoT Hubs, Platforms and Software	Installers; IoT Hubs, Platforms and Software
Secondary/ Long-term Opportunity		Predictive asset maintenance, remote system optimization and OTA updates	Remote system optimization to reduce energy costs and increase bulb lifetime	Predictive asset maintenance services	Analytics tools to highlight when electrical patterns indicate imminent equipment malfunction	OTA updates	

Notes

1. https://www.law360.com/articles/39000/fcc-bans-exclusive-cable-tv-deals
2. http://www.businesswire.com/news/home/20161011006343/en/HSB-Acquires-Meshify-Tech-Startup
3. http://www.multifamilyexecutive.com/technology/the-lure-of-the-smart-apartment_o
4. Interview with Vice President at Alarm.com
5. Interview with Editor of AutomatedBuildings.com, 05 January 2017
6. Interview with Vice President at NHMC, 31 January 2017
7. Interview with Executive at IOTAS, 12 January 2017
8. Interview with Executive at StratIS, 11 January 2017

5. CONCLUSIONS & RECOMMENDATIONS

Fundamental changes to business models will accompany every organization's decision to utilize and act on the data coming from its connected products and the systems of which they are a part. While looking for and identifying the tools available to product-centric businesses that are shifting to services, it is vitally important that businesses consider whether or not the opportunity is one that can be seized alone or in conjunction with another or even with many others.

5.1 BUSINESS MODELS

Simply put, Smart Systems and services offerings can be developed, deployed, and supported in one of three ways: by a solo company; partner-driven, which will in one way or another be an opportunity that is shared with others; or via an open collaborative opportunity.

Solo: Scenarios in which most of the elements of the opportunity are attached directly to a product's life cycle, designed to be deployed by the product player alone.

Partner-Driven: Situations where opportunities require multiple value-adding partners working in a closely coupled fashion and are designed with partnerships in mind.

Open Collaboration: Smart Systems opportunities forged around a platform model that provides for and enables extensive third-party collaboration and contributions. This model clearly addresses a broader scope of the customer's operations systems than any single equipment manufacturer would address alone.

As suppliers look to move beyond simple applications for connected products, it becomes increasingly challenging and costly to pursue opportunities solo. Increasingly complex applications create greater value by sharing information across previously siloed devices, systems, and people, and require broader collaboration across multi-party ecosystems to drive these interactions.

These models are therefore progressive, with value increasing with the integration of each additional player's equipment and systems and the increase of resulting interactions. These "complex" applications and the significant increase in interaction value they inform inevitably require open information flows and shared data across the ecosystem and participants. Creating an unbroken circle of data and information value based on the integration of people, processes, and relationships across the complex ecosystem of partners is the "holy grail" of Smart Systems.

5.2 MONETIZATION & PRICING MODELS

The combination of data and services through smart systems allows businesses to develop monetization models for products and services that align with the usage and value of the offering in use. Traditional

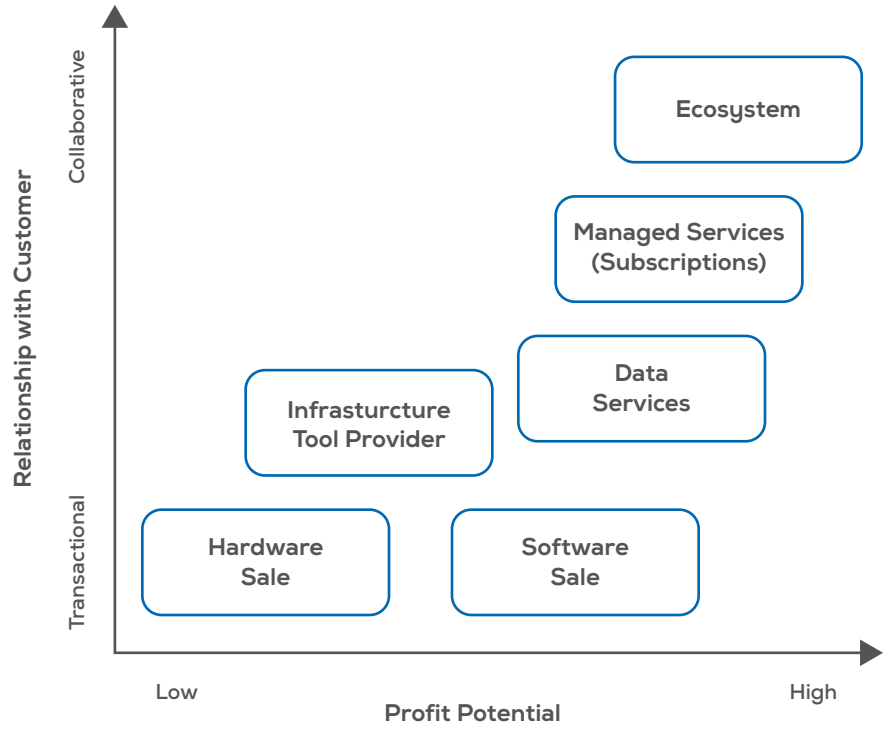
product-based models will increasingly shift toward service-based models as connectivity enhances and extends the relationship with the customer beyond initial sale of the product. Further, services offer an opportunity to achieve higher profit margins.

> "Making these sales requires flexibility on the provider's part in terms of manager financials. They've got very different CAPEX and OPEX availability, depending on size and even timing. Rule of thumb, 10 percent of portfolio of good size is coming up on CAPEX refinance, where they're looking to put more money into the unit to add value with a retrofit or renovation. Everyone wants to go in with the SaaS model with these offerings, but managers haven't had a line item for SaaS in the past. We have to shift how they pay for these offerings to accommodate their needs or the sale is gone."
>
> - Vice President, Embue

The research has identified six monetization models and five pricing models that can be leveraged within the MDU market and across the Buildings Venue. The six types of monetization models are distinguished based on profit potential and the extent of the customer relationship.

- **Hardware Sale**: Selling physical products, such as HVAC equipment, electrical components, processors and connectivity hardware.
  - Success Factors: Providing differentiated products
    Example: Intel selling quark processors ideal for low power and size applications.
- **Software Sale**: Providing software either as a bundled purchase with products or through licensing models.
  - Success Factors: Enabling customers to pay for customizable software applications based on usage over a period of time.
    Example: Streetline providing connected parking management applications along with its parking sensors.
- **IoT Infrastructure**: Offering software tools and capabilities that enable building and deploying IoT solutions.
  - Success Factors: Tools can be configured to meet varying customer requirements (e.g., high-rises have much different requirements than low-rises).
    Example: Microsoft's Azure provides middleware and tools on which partners can develop applications.
- **Data Services**: Leveraging data collection role to generating revenue by gathering, packaging and orchestrating data markets for the benefit of end customers, intermediaries and suppliers.
  - Success Factors: Ensuring data privacy and identity/access management; ability to extract value from data in correct context for each customer
    Example: Tendril, a home energy management platform and analytics provider, organizes end-user data and provides utilities with the information and tools required to enhance service delivery.
- **Managed Services**: Providing a service with recurring revenue instead of selling a traditional product.
  - Success Factors: Flexible pricing and subscriptions; strong domain expertise.
    Example: iControl Networks white labels its iControl One platform to security providers who want to offer a branded home automation and security solution.
- **Ecosystem**: Leveraging a platform that is open to third-party developers and vendors who extend the value of the platform into application-specific contexts.
  - Success Factors: Optimizing platform openness to maximize network effects while ensuring quality of contributions.
    Example: Amazon's Echo products are open to allow for others to create applications and tie their devices and services to the platform.

Figure 5.1 Monetization Models



As more offerings flood the market, innovative pricing and financing models will be increasingly required for differentiation. Every customer likes to purchase products, software and services differently depending on their usage, so customers value flexibility and are usually willing to pay a premium for it. The total price customers pay is not as important as how they are charged. Reducing an upfront cost of a product to a customer in favor of recurring, service-based models can drive initial adoption, improve customer satisfaction and result in increased revenue per customer over time: 62 percent of occupants said they would like to pay for connected services and offerings either on a monthly subscription-based charge or a use-based charge, as opposed to 26 percent who said they would prefer a one-time charge.

> "We provide home automation services free to consumers, but charge for professional uses of these services, including both commercial applications and MDU applications that are delivered by property managers. By offering smart home free to consumers, we hope to drive demand for these solutions. We may eventually charge for managed services, but we mostly see this as a necessary next step to differentiation in an increasingly competitive market."
>
> - Multifamily Specialist, UTC/Carrier

The following pricing model examples indicate the range of ways a vendor can charge a customer for products, software and services. It is important to note that multiple pricing models can be used within and across multiple types of monetization models, and choosing the right models has to be done on a case-by-case basis, with vendors potentially leveraging multiple pricing or monetization models to better serve their customers.

- **One-time charges:** Customer pays an initial, one-time price to purchase the product.
    - Example: Nest provides connected thermostats sold via retail channels with no recurring costs.

- **Subscription**: Customer pays recurring fee based on the features and duration of the service or software.
    - *Example*: Xfinity offers multiple tiers of home services and subsidizes the cost of home automation equipment depending on the duration of service purchased.
- **Freemium**: Customer gets a low-level tier of services for free, has the choice of upgrading to a paid service tier based on needs. In many instances, Freemium is tied to a one-time hardware or software charge.
    - *Example*: Lowe's IRIS hub and platform provides basic alerting and notification functions for free, with rule-based actions and control offered at a premium.
- **Pay-as-you-go**: Customer pays according to their actual use of a product or service.
    - *Example*: SwannOne offers home security system that comes with the option to pay for professional monitoring services for a two-day or weeklong period as opposed to committing to pay monthly. The company also utilizes the Freemium model, by offering the base tier of its service for free.
- **Value-based**: Customer pays based on the results realized from a product or service.
    - *Example*: Enlighted provides lighting energy management solutions and charges customers based on realized energy savings obtained through the use of the solution.

More and more, customers will want the price to match the value derived from the use of offerings. The shift toward subscription and usage-based models are the beginning of this trend, however, these are still not one-to-one with the value created. Value-based pricing models are better enabled by data and connectivity through the ability to collect information about the product or service in use and to measure the value created through that use, whether it be cost savings, satisfaction or, in the case of property managers, new revenue streams.

> "We're partnering with OEMs to develop unique solutions, integrating their equipment into our automation services. They'll purchase our sensors and embed them into products, and purchase our platform as SaaS, reselling to customers to manage assets. The razor blade strategy that these service focused OEMs are taking means they have to limit costs of running service wherever possible, and we want to help them do that with optimal IoT decision-making. These OEMs enhance their service delivery to create greater end customer value but also reduce friction in delivery to increase their margins."
>
> – Executive, PowerhouseDynamics

5.3 Success Factors

Traditional suppliers, including NSPs, consumer electronics players, insurance providers, utilities and equipment manufacturers are seeking to develop connected offerings to serve the MDU market. To find success as they do so, factors related to the key targets and their needs, the technical capabilities of solutions, and the delivery of solutions must be kept in mind.

5.3.1 Key Opportunities and Targets

The exact makeup of offerings, the types of stakeholders to target with those offerings, and the solution delivery path tend to vary by application, but there are guidelines for success that are broadly applicable as suppliers consider offering connected devices and services.

Property Manager Priorities are the Key Variable. The property manager persona has the biggest impact on the type of solutions desired and the delivery of these solutions. Owner/occupant decision-making primarily focuses on device and service investments that increase in-unit comfort, convenience, and peace-of-mind or reduce unit operating expenses. On the other hand, private owners/managers are

seeking connected offerings that either significantly increase the value of units or provide differentiating value to units and create long-term operational expense reductions for themselves. The value to small and large property management firms varies with the MDU structure. In small buildings without onsite staff, remote access and equipment management reduces manager time and labor costs, while these offerings in larger properties with dedicated staff enable managers to reduce staff expenses and increase response quality. Managers of large properties also seek solutions that utilize scalable cloud tools that extend property management capabilities across a large portfolio of properties.

Creating Multi-Stakeholder Value. Suppliers stand to gain a unique, sustainable competitive advantage from offerings that create new end-user value while enhancing their own service delivery. Differentiated solutions enhance customer loyalty and data collected from connected offerings enables enhanced value creation over time to reduce turnover. Meanwhile, reducing friction in service delivery enables suppliers to actually reduce the cost of offerings relative to competitors, further strengthening the value proposition of their offerings.

> "The split incentive means we have to put together packages with tools that work for everyone. You can market it to occupants, but if the owner is the one buying it you better make sure the value to them is clear. I think we're getting away from the marketing focus and entering a period where value is really getting created, and that this is where we'll see things really start moving."
>
> - Executive, PowerSage

Access management provides significant convenience value for occupants while enabling managers to limit access to a defined set of tenants and reducing time and labor expenses during tenant turnover. The device capabilities and overall scope of solutions will vary with targeted occupant personas, with ready-to-control holistic apartment/condo offerings ideal for higher income occupants. Owner/operators of buildings serving lower-income occupants may create the most value by simply providing the network backbone and platform/IoT hub tools, enabling occupants to invest in the devices and services that they can afford.

Opportunity Targets and Timing. Managers of all-inclusive or high turnover properties are most likely to adopt offerings that provide resource consumption and building access management. Targeting large property managers provides suppliers an opportunity to capture significant scale of deployments if they can install offerings across all future new build or retrofit projects in the portfolio. Small property management firms and individual owner/managers may find new connected appliances and building systems prohibitively expensive for their limited capital budgets, while large property managers undergoing retrofits and developers of new builds are capable of making upfront investments that will reduce long-term expenses.

DIY and add-on offerings that provide energy management, equipment and appliance monitoring and control, and security have a significant opportunity to enhance occupant value or reduce operating expenses without requiring major renovations. Retrofitting unit-by-unit during occupant turnover presents the largest opportunity for devices requiring owner/operator installation in MDUs, requiring that firms develop cost structures suited for the small margins and lack of scale which unit retrofits offer.

5.3.2 Technology Success Factors

The ability to create new value in the background of users' lives, enhancing comfort, convenience, peace-of-mind or reducing costs without additional user interactions with a device or service is key to successful adoption of offerings.[1] Offerings that leverage open source conventions have the potential to create the most value by seamlessly interacting with adjacent devices and value-adding services.

Software Enabled Interoperability. Operators are looking for offerings that integrate disparate HVAC-R, water and air distribution, lighting, electrical distribution, and security systems onto a single IP-based platform that enables remote monitoring and control with minimal complexity.[2] The ability for disparate systems to communicate with each other and share data with analytics engines and automation services is critical to enable these tools to create value for MDU stakeholders across the value chain. A focus on open source data models and communications protocols enables this communication to occur innately, though middleware platforms and hubs are being utilized to provide interoperability in the absence of adhered-to standards.

> "One of the biggest challenges is to create a platform upon which all the relevant devices can speak to each other. It's up to the software to makes things interoperable, not the hardware. We're looking to future-proof all of our offerings, building in protocols like Z-Wave and ZigBee but leaving space to add the functionality to work with Thread or Homekit."
>
> - Executive, BuLogics

Benefits in the Background. Operators and occupants alike seek tools that move beyond data visibility and control, which reduce costs and/or increase comfort, convenience, and peace-of-mind with automated actions that occur in the background without direct user interaction. Rising consumer adoption of machine learning services, especially in form of digital assistants offered via smart phones and speakers, give service providers a powerful interface for connecting with users and tailoring services to individual needs.

> "Voice is becoming the leading interface for smart home products and applications… beyond voice interaction, however, is a more important principle - one of the main value mechanisms of the smart home actually doesn't include interaction at all. These systems must make the home function more efficiently without human involvement, at once increasing convenience, driving cost savings and providing suppliers with more information to serve you and others better."
>
> - Manager, Ayla Networks

Flexibility and Extensibility. End-users are eager for solutions that readily adapt and expand as needs change, technology evolves, and regulatory and market factors shift the economic rationale for adoption of connected offerings. Cloud-based platforms for managing IoT offerings within a single MDU can readily be scaled to provide monitoring and control of systems across a portfolio of buildings. As costs of devices and services drop, or demand from a shifting occupant base encourage operators to invest in new offerings, the ability to easily incorporate additional solutions differentiates management tools.

> "Soon as we were seeing savings from the [LED] installations, we had customers looking to expand to new use cases, use the sensors in their lights in new ways. We've rolled out a new platform to meet these demands, moving the software to the cloud for scalability and making mobile control feasible."
>
> - Vice President, Digital Lumens

Distributed Architectures Unlock Smart Systems. Intelligent processing and transactional computing cannot occur on clients with intermittent server connections, proprietary "locked" platforms, and large install footprints. Networking technologies and the standards that support them must evolve to the point where data can flow freely among sensors, computers, and actuators. Software to aggregate and analyze data, with intuitive user/system interaction design techniques, must improve to the point where huge volumes of data can be absorbed by human decision makers or synthesized to guide automated systems more appropriately. Devices that host intelligent software components must communicate to

other devices directly (peer-to-peer) or to logical collections of devices (peer-to-group) in any programming language, and do so autonomously, with or without network connectivity.

> "Open source is necessary to allow all of these devices and systems to natively interact and combine in new ways. Without it, too much user interaction will be required for adoption to spread widely. Interactions have to occur autonomously, creating value based on user defined or learned rules. That's where we see this all going. You can convince operators of the value of these offerings but if somethings complex they won't use it, if they don't use it they don't actually see that value and then your product isn't worth a damn."
>
> - Executive, WhiteSpace Building Technology Advisors

5.3.3 Key Supplier Considerations

Technology, equipment and service suppliers have opportunities to leverage connected devices and services to differentiate their offerings and increase margins. Success depends on their ability to develop business models that enable efficient delivery and support of those offerings.

Collaborate Between Organizations. Industry participants are beginning to realize the importance of having continuous interactions within an ecosystem of partners and allies. As information, automation and equipment systems become more complex, customers are looking to suppliers to provide broader services and address business outcomes. Companies who choose to address the Smart Systems market on their own will undoubtedly fall short of their true potential. Partnerships that encompass all aspects of production and service provisioning are necessary to create and capture value from increasingly complex Smart Systems. OEMs and service providers need to partner with technology and device manufacturers to develop the requisite sensing, connectivity, analytics, control, and autonomy capabilities for new and enhanced services. Providers must keep an eye on the adoption of in-unit connectivity platforms, whether a specialized hub, gateway, smart phone or speaker, as popular offerings present a valuable channel to providing new services to end-users.

> "Our platform is a B2B offering, that's seen a lot of adoption among network and security providers who want to have their own branded home automation services offering. Instead of these guys trying to develop platforms in house, requiring new talent and time, they can get a ready to use, all-in-one monitoring and automation offering by white-labeling ours."
>
> - Vice President, iControl

Establishing a Service-Oriented Business Model. Simple, product-oriented business models ignore significant opportunities for revenue throughout a product's life cycle. Equipment manufacturers must recognize the opportunity to leverage sensing and connectivity in their offerings to provide new monitoring and management services. Traditional service providers can utilize connected devices to capture new revenues with enhanced or new adjacent services, increase customer satisfaction and acquisition, and even increase margins by reducing the friction of service delivery and value creation. As connected devices proliferate, suppliers will be able to establish an ongoing relationship with customers based on post-sale services that provide greater value to end-users. Senior executives must recognize that realizing this opportunity requires shifting from a product-centric to a solution-centric business model.

> "We're the "white glove" provider in the rental space. Managers want solutions, not headaches, and tech can bring a lot of headaches, especially the first, second, third go around. Some of the biggest managers could conceivably develop these solutions in house, but its not their competency and there's scale and value to be wrung from going with a provider like us that nails it, does it all the way through, and doesn't lean on maintenance staff to deploy and support the solution."
>
> - Executive, Dwelo

Process Differentiation. Successful suppliers are shifting from a focus on product differentiation to focus on process differentiation, including customer service, supply chain, delivery, and support. Initial and ongoing support of connected offerings is one of the most significant criteria for success, creating a major opportunity for installers and SIs as equipment and tech suppliers are often poorly organized to provide these services. Suppliers must therefore develop business models that incorporate installer and integrator margins to ensure that these parties are adequately incentivized to assist in solution delivery.

> "Our value is in providing a holistic offering, from consulting, to scoping, to procurement, install and support. These guys come to us, not knowing what they want or need, and we provide recommendations in a package that we will service. By becoming the single channel to a holistic solution, we provide a seamless route for them. The single platform gives them automatic device pairing, provisioning, and managing for a monthly software fee."
>
> - Vice President, IOTAS

Address the Reality of Customers' Environments. As customers continue to invest in new network and communications technologies, a significant premium will be placed on leveraging legacy equipment due to the large investments required to replace them. Since legacy equipment will continue to be part of building systems for years to come, solutions that integrate and share legacy system data with new systems will be highly valued.

> "The issue is that we have all these suppliers trying to be the providers of everything to everyone, and this isn't a one size fits all environment. Open-source platforms that are IP or Niagara-framework compatible have been successful in commercial buildings because they allow users to stitch together solutions that meet their specific needs. That needs to happen in the MDU space too. We need platforms and gateways that enable users to easily and cheaply connect any type of device from any type of supplier. Flexibility and agility are what operators are looking for, that's what suppliers need to figure out how to deliver."
>
> - Executive, WhiteSpace Building Technology Advisors

Security Cannot Be Overlooked. The importance of securing systems to prevent theft of data and IP, and to ensure the safety of operations and building occupants, requires players to ensure they prioritize security in offering design and provide support throughout the product's life. Adopters, often possessing little background or interest in IT systems, must be provided with the appropriate tools and support to effectively and securely deploy and use connected offerings.

> "With the incumbents, the Johnsons, Siemens, and Schneiders of the world struggling to get into this market, you're seeing a lot of new players, startups who aren't prepared for some of the challenges of long-term support. Over the air (OTA) updates and security concerns are especially challenging this group, and when their offerings get adopted, their customers are at risk. We're getting to a point where their models are foolhardy at best, and really dangerous at worst."
>
> - Executive, StratIS

5.3.4 Owner/Operator Success Factors

Owners and operators are critical organizers of IoT solutions in MDUs. Their needs define the makeup and delivery of solutions and they alone are positioned to develop the ecosystem of suppliers required to successfully implement and support connected offerings.

Relationships are Key. Owner/operators must develop and maintain positive relationships with stakeholders across the value chain, including: technology, equipment and service providers, as well as local and federal governments. Suppliers partnerships are critical to developing solutions that fit an operator's unique needs, considering portfolio size, building structure and occupant personas. Further, working with installers and systems integrators to efficiently implement those solutions is critical to successfully deploying and maintaining offerings. Operators are key to organizing these relationships, with installers/integrators serving as valuable resources for informing their decision-making.

> "[Residents] love smart thermostats--but getting the software in place so we can have our residents properly operate this technology is a challenge. It also puts additional training requirements and stress on our maintenance staff and engineers. The servicing of these solutions is really complicated; it's a whole new set of training for onsite staff. They already have lots on their plates with BAS systems and this would overload them. We've wondered about outsourcing this maintenance: the big question I have is are they available when they are needed - 24/7? The tech equipment and then third-party contracts on top of that are just another big expense--at what point does it just become too much money?"
>
> - Vice President, WC Smith

Collaborate within organizations. Today, knowledge and expertise largely resides in functional silos and systems dispersed across organizations. Legacy processes and habits inhibit any natural ability to communicate and work together to solve big problems or create new solutions. In many companies, lean practices have been applied so aggressively that people are simply consumed by "running the business." This restricts their ability to harness collective intelligence to inform creative decision-making and problem solving. Building systems affect the entire organization, and the most effective solutions will direct information and provide support to all users, rather than being limited to building management owners and their departments.

5.4 RECOMMENDATIONS BY STAKEHOLDER TYPE

Outside of the supplier-agnostic success factors outlined above, we observe certain opportunities and factors that differ between various types of service providers and OEMs involved in serving the MDU market. While full opportunity matrices of supplier-specific recommendations can be found in Appendix A, below are outlined key recommendations and success factors for each involved party.

5.4.1 Utilities

Smart submetering infrastructure in MDUs lays the foundation for a host of programs that can enhance the provider's relationship with end-users while encouraging efficient resource consumption and increasing the efficiency of the overall resource delivery system. Working with specialty service and/or hub and platform providers, as well as manufacturers of major resource consuming building systems, utilities can target property managers with holistic offerings that provide them an attractive ROI. Without submetering, utilities are unable to identify unit-specific resource consumption and therefore unable to highlight inefficiencies. For retrofits without submetering in place, and for new builds, utilities should look to partner with electrical OEMs to install smart submeters to subsidize the upfront cost

of the hardware for building owner/operators such that utilities can capture value from consumption visibility.

The primary short-term opportunity is for utilities to provide consumption visibility and customized recommendations for how end-users, both occupants and operators, can reduce expenses with behavioral changes. The same foundational hardware provides the capabilities for utilities to incorporate buildings into demand response, voltage and current regulation, distributed energy resource management, and other programs that provide grid operators greater control over the distribution system. Utilities should take the opportunity to lay the groundwork for these programs which provide greater internal value, putting in place the analytics, control mechanisms, and contractual frameworks that enable expansion of services at a later date.

5.4.2 Net Service Providers (NSPs)

NSPs, including telcos, cable and Internet service providers, are best positioned among service providers to organize an ecosystem of interoperable devices and services that creates value to occupants and operators. These firms benefit from existing relationships and trust with end-users, positioning them to deliver services that occupants might not trust new firms to provide. Further, these providers can leverage existing hardware in units, including set-top cable boxes and Internet gateways, to serve as the hubs from which a range of services are delivered, capturing new revenues and locking in customers. While buildings with which NSPs can develop exclusive network contracts are a significant, clear opportunity to offer a suite of holistic tools at scale, NSPs are unique among suppliers as expected to offer tools and services that can travel with occupants as they move. This relationship with end-users is an important differentiator in supplier ability to offer solutions that work for the high-turnover MDU market.

Short-term opportunities focus on direct extensions of current services, including expanding management of infotainment services for value creation via enhanced occupant comfort and convenience and supplier end-user engagement. Net hardware is fully capable of serving as a central hub around which services related to resource management, peace-of-mind and equipment management use cases can be delivered, which should be NSPs' long-term goal.

The predominant traditional business model in this industry involves subsidizing the cost of network hardware in exchange for multi-year contracts for service, over which time the NSPs capture their ROI. This model is a great fit for accelerating deployment of the connected devices required in units to enable enhanced and new services, as upfront cost of equipment has slowed adoption.

5.4.3 Insurance Providers

Building or asset insurance providers can expand from current offerings to provide monitoring and management services of connected devices that reduce the likelihood or magnitude of payouts. By decreasing the likelihood or magnitude of payouts, insurance providers are able to offer policies with lower premiums, providing a competitive advantage in the market. The tools that enable system management create value to building operators, enhancing their visibility of and ability to remotely control systems, as well as occupants, enhancing peace-of-mind and convenience, further differentiating insurance firms with these offerings.

Short-term focus should continue to be on reducing risk, however providers should consider that the same equipment positions them to deliver new services rather than simply creating ancillary convenience or peace-of-mind. Firms can expand to provide asset management services that proactively maintain building systems rather than paying out in the event of failure. Insurance players should be cognizant of these long-term opportunities when developing contracts with building owner/operators, as brokering data to third-party analytics and automation players will be a requirement to enable these future use cases.

5.4.4 Specialty Service Providers

Specialty service providers play a unique bridging role between technology providers, existing service providers and OEMs, and end-users. With the technical expertise to make informed decisions surrounding enabling hardware and software, and processes and cost structures designed for MDU-scaled opportunities, these players offer unique value to both suppliers and adopters. Holistic MDU offerings providing apartment or condo automation are targeting managers of mid and high-rise buildings in larger portfolios of managed properties, seeking opportunities to outfit every unit in a building or across the portfolio with connected devices and services. These players often leverage white-labeled platform offerings to provide end-users with a unified control interface, and both the platform provider or the service provider make attractive channel partners for OEMs and conventional service providers seeking routes to end-users for new connected offerings.

While end-user engagement and comfort and convenience offerings do not have specialized service providers beyond these holistic automation providers and standard platform offerings, the remaining application segments are served by specialty players. Key opportunities for each of specialists are called out below.

Resource Management

Energy service companies (ESCOs) have been a primary driver of commercial building management systems, due to the significant portion of building operational expense from energy bills. As has been mentioned, the major BMS players and ESCOs serving the commercial market have failed to successfully migrate into the MDU market, leaving a niche which specialists have emerged to fill. Specialists are providing granular monitoring of building systems with subscription as well as "pay-for-results" business models, which are preferred by owner/operators uncertain of offering benefits.

Specialists are also serving utilities with offerings, especially in the electric sector. The players are providing the analytics and visualization tools that enable utilities to deliver customized behavioral suggestions to end users via intuitive interfaces on mobile devices. Additionally, specialists are helping forward-looking utilities manage grid operations more efficiently with centralized distributed energy resource management systems that enable granular control over variable grid assets. Finally, specialists are creating the programs that connect grid operators to users in demand response programs, and aggregating DR loads to provide operators with a significant flexible load to "turn down" net demands and avoid turning on new generators.

Peace-of-Mind

Security offerings have been a key driver of automation technology in single-family residential, but have struggled to achieve wide adoption in MDUs. Apartment-focused security providers are working with property operators to provide occupant peace-of-mind, organizing the installation, maintenance, and responses to building and unit monitoring systems. Video surveillance-as-a-service is becoming increasingly viable due to improving processing and connectivity capabilities, and specialty service providers are well positioned to provide this in higher-income or high-risk buildings where physical guard expenses can be drastically reduced. Specialists have also driven the development of occupant well-being monitoring solutions, providing family members and caretakers convenient health monitoring and alerting solutions.

Building and Equipment Management

Specialty equipment and building system management players provide a valuable offering to both owner/operators and equipment providers. Though OEMs are increasingly developing connected services to generate new revenues over the course of the equipment lifetime, the shift from product to service-centric is a challenging one which can require significant restructuring. These manufacturers have an opportunity to instead partner with specialists, who utilize captive or third-party sensors, devices and software to capture data from equipment and deliver management services that reduce downtime.

While certain owner/operators desire the ability to remotely monitor equipment, most prefer that offerings reduce operational expenses without direct interactions, creating an opportunity for automated or specialist provided monitoring and predictive maintenance.

Long-term, specialist performance management providers have an opportunity to leverage their relationship with end-users and an extensive database of equipment operations to extend into insurance services. By working with a range of building equipment that they have records of historical performance on, specialists can predict failures to a high-level of accuracy, enabling them to offer policies with little overhead, and even manage the warranties for equipment manufacturers if they so desired.

5.4.5 Hubs, Platforms, Software Providers

As an integral element of every MDU use case, hub and platform providers' primary considerations are whether they will provide services atop their interface for connecting offerings and the best channel by which to deliver their offerings. As consumer electronics players expand the capabilities of hub offerings and make integrating partner services simple for end-users, platforms are increasingly pressured to provide differentiating capabilities beyond connectivity. This is particularly true as artificially intelligent digital assistants pervade consumer electronics offerings, enabling personalized services to be delivered to end-users. Ultimately, the platforms that provide access to the broadest suite of customized services, with the least added cost and complexity, will experience the greatest near-term adoption, which they will translate into long-term customer lock-in.

Many platform and device providers are successfully utilizing B2B channels, white labeling offerings for service providers looking to provide new connected offerings under their brand. This channel has proven valuable as service providers leverage existing relationships with end-users to drive adoption of connected offerings without having to reorganize to develop the technical capabilities and ongoing support structure internally.

5.4.6 HVAC-R and Water OEMs

As the manufacturers of some of the most expensive and building-critical systems within an MDU building, these OEMs have a valuable opportunity to expand from a one-time revenue opportunity to recurring services revenues. Embedding sensing and connectivity capabilities are the bare minimum steps that these players must take to participate in these opportunities, allowing equipment customers to capture data and utilize as they wish. By partnering with specialty services providers, or joining ecosystems of interoperable services centered around a platform offering, these OEMs can differentiate their offerings with ready to use value-adding applications. Of particular focus should be analytics offerings which reduce the likelihood of downtime by identifying faults before they occur, and shifting equipment operations autonomously to avoid equipment failure.

Given the high capital expense and long lifespan of these pieces of equipment, the opportunity for HVAC-R and air and water distribution OEMs is greatest in new builds, such that the extra cost of connected offerings can be built into building financing. Low, mid and high-rise buildings are likely adopters of these offerings, especially those managed by larger property management firms.

5.4.7 Lighting OEMs

Lighting manufacturers have the opportunity to be involved in a value creation across all of the identified business cases, beginning with embedding fixtures and/or bulbs with sensing and a range of connectivity options. Given the range of use cases in which lighting control is valuable, flexibility and versatility are key to gaining a competitive advantage in the smart lighting market. Manufacturers should focus on open connectivity standards, while also developing partnerships and joining ecosystems around platform and hub offerings experiencing adoption growth to maximize routes to end-users.

While remote lighting alone creates significant multi-stakeholder value, lighting manufacturers stand to differentiate offerings by providing sensing and analytics tools that enable optimization of energy consumption, elderly occupant activity monitoring, and building space utilization monitoring.

By enabling a wide range of potential use cases and developing solutions for both common areas and within units, lighting manufacturers can capture a large-scale opportunity within and across MDUs in manager portfolios.

5.4.8 Appliance OEMs

Appliance manufacturers have the potential in new buildings to deploy connected appliances that enable a range of use cases that create value for multiple MDU stakeholders. Reducing maintenance costs for owner/operators while enhancing the convenience of appliance use for occupants, OEMs can also utilize equipment usage data to improve product design and better serve existing and future customers. Such manufacturers should look to join existing platform ecosystems and work with specialty service providers, as end-users are increasingly considering the breadth of interoperable services when making purchasing decisions.

While new builds provide suppliers the chance to deploy offerings at scale, unit-by-unit retrofits represent the majority of total opportunities, and sales channels must enable these to be pursued. Electrical OEMs have already developed tools for monitoring legacy equipment, saving operators the cost of installing new appliances to gain data visibility. Appliance OEMs must now embed these tools natively and offer enhanced service capabilities with the equipment to differentiate in an increasingly competitive market.

Notes

1. Interview with Editor of AutomatedBuildings.com, 05 January 2017
2. Interview with Executive at PowerhouseDynamics, 16 January 2017

APPENDIX A: PRIMARY RESEARCH METHODS

The research for this study included 1,500 surveys and over 60 interviews of market stakeholders in an attempt to uncover important insights that would otherwise be missed through secondary research. The survey and interviews were especially important due to the lack of coverage of the adoption of technology in the MDU space. With this in mind, the survey was designed to provide a snapshot of the current state of the market across a wide range of topics regarding connected devices and services in MDUs. The interviews, on the other hand, were designed to dive deeper into certain subjects and provide more forward-looking insights that could help market stakeholders make decisions about how to target the market and where adoption and other trends may take the market in the future.

A.1 INTERVIEW METHODS

This research conducted in-person and over the phone interviews with market participants, representing each of the key stakeholder groups. These interviews were designed, based on a set of questions developed in coordination with the Steering Committee, to gather information on topics that were too nuanced for survey responses to adequately cover. These topics included market segmentation and opportunity framing, relative positioning and competitive advantages of market participants, and trends and forces affecting the opportunity for connected devices and services in MDUs.

Following the completion of surveying and this initial round of interviews, Harbor Research compiled a set of findings and presented these to 12 industry thought leaders to gather their feedback in a Delphi-style round of interviews. These thought leaders provided feedback on the findings, indicating their level of agreement and, in cases of disagreement, their reasoning. An iterative series of these interactions led to a set of agreed upon organizing principles, trends, forces, competitive advantages and future implications that have been incorporated throughout the report.

A.1.1 Key Interview Quotes

- **Senior Vice President at Dude Solutions**: Integrator/installer of cloud-based work order management for buildings
    - "Buildings have been telling us stuff for a while now, we are either not listening or don't have enough money to address the problems. Building managers are always looking for ways to improve their building, they just need the right tools at the right price."
    - "Suppliers are good at making products speak to their own systems, but it's hard for others to integrate and work them. Interoperability remains a huge barrier."
- **Manager at Optergy**: Platform provider of building automation and management systems, specifically targeting MDUs, that connect everything from the backend systems down to the user interface.
    - "The toughest part for apartment property managers is meeting the individual needs of each occupant while making sure that the building's systems are in top shape. Not many platforms integrate the delivery of enhanced customer experience while also dealing with operational issues on the back-end."

    - "We saw a big, unmet need with regards to occupant-focused building automation solutions in apartment buildings. Everyone is concerned with either commercial OR residential, and don't look at the intersection of these two markets. Even companies that serve both commercial and homes tend to shy away from MDUs."
    - "One of the best features of our solution is the ability to use the back-end platform with other user interfaces or applications. We offer the user interface as well, but we don't want to box OEMs and service providers into using our applications if they have their own."
- **Corporate Manager at Cielo**: Smart plug, lighting and thermostat OEM
    - "Apartments are an interesting market. We see it as an opportunity to expand outside the 'home' and potentially connect the more centralized building systems. We aren't targeting this market now, but our partnerships will be key to addressing this market because of the variability between buildings and sizes, types of units."
    - "We partner with in-unit HVAC and appliance OEMs to integrate our cloud platform with their equipment and to make sure their products will work with our plugs. We get greater reach from an interoperability stand point and they get to sell a better product to their customers."
    - "Sharing data is a main value proposition of our offering, and it is why we've had significant interest from utilities from a partnership standpoint as well."
    - "We make consumer products that you could potentially buy online or at a hardware store to put the power in consumers hands to make any electronic device smart and remote controllable. This flexibility should help demonstrate the value of smart home to these people and work to educate and develop the market."
- **Director at Distech Controls (Acuity Brands)**: OEM of building automation and control systems for HVAC and lighting.
    - "HVAC and lighting systems in a typical building make up 60 percent of energy usage. The potential for cost savings by reducing energy usage is a lever for offering additional services to building owners and operators." They don't have much money to spend, so you kind of have to create the budget in a way."
    - "At this point, most property managers have likely been approached about these types of solutions. There is a hesitation on the part of customers to integrate disparate systems--they are afraid of the potential complexity involved in interacting with these systems. We've been able to gain traction by improving the user experience through these solutions. Not many suppliers in the market today can say that."
- **Director at Delta Controls**: OEM of building automation and control systems for HVAC and lighting.
    - "Delta provides smart building automation systems to both residential and commercial buildings, and see multi-dwelling units as the intersection of these two building types. We have an eye towards MDUs, but to my knowledge don't target them directly with any special sales, marketing or products."
    - "Our global energy management platform is great for national or international enterprises or management groups that want to track building energy consumption across many properties."
    - "Canadian customers tend to be more 'green'-oriented than those in the US. For the most part, both commercial and residential customers are willing to share energy data, if anything to understand how they compare to their neighbors or similar businesses, but also to see where they could save on this energy usage. Partnerships with utilities become key to creating these values for customers."

- **Senior Product Manager at Johnson Controls**: OEM of building automation and control systems for HVAC and lighting.
    - "Indoor air quality monitoring and control has gotten a lot of attention lately, especially in big cities with relatively high levels of pollution, and as a driver of increased productivity and occupant satisfaction."
    - "Most of our HVAC systems have some sort of connectivity today, but its relatively simple. We are looking into ways to increase the value of the data we are collecting from these and our water systems, as a way to enhance the services we can provide to building managers."
    - "We have a relatively extensive support network throughout North America and elsewhere that may be able to help deliver and support what you're calling 'smart services,' but to be honest I doubt that is on our radar."
- **General Manager at Navien**: OEM of HVAC equipment
    - "We integrate Wi-Fi connectivity into all of our products to enable remote monitoring and emergency control. All of our products are Title 24 (California) compliant, and we see this type of regulation spreading to similarly liberal states even under the new administration."
    - "Distributors help us go to market with our products, but we market to engineers and contractors, and see them as key decision-makers in the process of choosing HVAC equipment. For single-family, we market to homeowners."
- **Director at EBM Papst**: Fans, blowers, pumps and motors manufacturer
    - "Virtual machine technologies allow us to test and analyze the performance of our products, both before they are in the customer's environment, but also when this equipment is installed and we need to check out how it is functioning. We incorporate this information into the design of the products and to decrease response times for maintenance."
    - "This is all with regards to commercial and industrial customers. The value in these areas is easily communicable. MDUs are an interesting case, but there is likely less upfront capital on the part of owners and operators in that market to justify targeting the market."
- **Director at Pentair**: OEM of flow control, water equipment, filtration equipment
    - "While we don't have a specific segment for MDUs, we serve those types of customers. Depending on the type of solution and products involved, a sale to MDUs could be covered by residential or commercial business segments."
    - "Connected equipment and solutions are the next frontier for us and we've already started experimenting with these technologies to figure out how to create value, but also how to communicate this value to commercial and residential customers."
    - "One of my main jobs is to figure out the best way to educate current accounts and potential customers of the value of smart solutions. This is not an easy thing to do, but more and more we are seeing folks that at least have some sort of idea about these types of solutions."
- **Manager at LG Electronics**: Appliances and HVAC OEM
    - "On the home appliance side of the house, we don't have smart appliances besides for TVs - Smart TVs are standard issue these days, and represent a good opportunity to organize some smart home services. In the studies we've done, however, the value proposition and price of other smart appliances doesn't line up with consumer needs yet. We see this changing as incomes increase and people want more convenience in interactions with home devices."
    - "On the HVAC side of the house, I am sure we cover MDUs but I am not sure how they are handled, I don't believe we target them specifically. Smart and connected

solutions are a lot easier to communicate to commercial customers and building managers who value the operational efficiencies they enable. These solutions also allow us to better to support our customers from a maintenance standpoint."
    - "All of our HVAC systems are based on the Niagara framework so we integrate with other devices based on that framework. We don't get much push from customers to guarantee this type of integration, however, we think interoperability, especially amongst our own products, will be a key adoption driver as we begin to make more smart home appliances."
- **Multifamily Specialist at Carrier/UTC**: OEM of appliances, consumer electronics for home automation
    - "We market our smart home solutions based on increased comfort and convenience. We've had the most traction from this angle--needs and wants of consumers are a lot different than those of commercial customers."
    - "Integration is a primary focus for us, both across UTC brands but also across already installed commercial and residential systems. This interoperability is required to generate the most value."
    - "Once we realized that we have many of the different components of smart home solutions, we decided to focus on making sure all of our products worked together."
    - "We provide home automation services free to consumers, but charge for professional uses of these services, including both commercial applications and MDU applications that are delivered by property managers. By offering smart home free to consumers, we hope to drive demand for these solutions. We may eventually charge for managed services, but we mostly see this as a necessary next step to differentiation in an increasingly competitive market."
- **Vice President at Alarm.com**: Security and home alarm monitoring solutions, including hardware and software platform.
    - "One of the biggest factors in determining whether an offering will be successful, even more so than whether a building owner is going to save money, is whether installer is going to make a margin."
    - "These days, we've got way too many companies focusing on product differentiation. From a customer point of view, a dealer's ability to differentiate their processes, like customer service, supply chain, delivery and support, are far more valuable."
    - "What we see driving supplier success is offering affordable, accessible, turnkey products and selling them through thoughtless process that makes it easier for customers to decide to purchase than to decide not to."
- **Manager at Alarm.com**: Security and home alarm monitoring solutions, including hardware and software platform.
    - "Property managers in different classes of buildings have different needs, and we have to work to make solutions and financing that works for their situation."
    - "The rental market is challenging traditional home supplier models. We think there's an opportunity here for long-term customer lock-in. You're our customer once, we have data that we can use to enhance what we offer you."
    - "Our dealer structure is well suited to go after buildings with 25 units or less, beyond that it gets challenged. The complexity of larger buildings, especially old large buildings, means we need to enlist new partners before targeting them. We haven't seen enough demand from these buildings to go through that hassle just yet."
- **Executive at SafePlug**: OEM of plug-load and wired-load controllers and energy monitors.
    - "Installing these tools themselves doesn't create any value, you have to get end-users to actually use them. Unless energy costs can really hit people in their wallets, say with time-of-use pricing, people won't change their behavior."

    - "We're seeing a big opportunity as various players seek to gain greater understanding of how energy is used by consumers. Solar producers need to work with consumers to match production and consumption, and utilities looking at DR need to control user loads. Ultimately, it's on them to get the hardware into end-user environments so they can take advantage of it, which is why we're seeing them subsidize."
    - "One of the biggest challenges is that user needs aren't defined by their age or income or community type, but actually very dependent on individual experiences and characteristics. Safety is huge to someone who's experienced an electrical fire, while being able to turn off outlets is big for parents of young children. Ultimately, we try to develop the broadest set of capabilities that appeal to end-users from all walks of life."
- **Editor at AutomatedBuildings.com**: Buildings automation and control system blog
    - "The focus from automation players has long been on energy and comfort, and now we're seeing a push towards satisfaction and productivity. Millennials' expectations around their phones and mobility and changing what's occurring in buildings as they have to develop new interfaces, new means of interacting with occupants. If building managers can provide this segment with IoT tools, regardless of whatever else they get out of it, they can attract a higher tier of renters."
    - "Security and privacy aren't top of anyone's mind until they are, and we should expect major hits to important targets to set back the industry at some point. Building guys won't be the ones to solve these problems. The consumer focused electronics and personal assistant suppliers will be most affected and driven to solve issues. We'll follow their direction and adopt solutions promoted by them."
    - "BACnet has been big for driving interoperability between major building systems, but it wasn't designed for pushing info from the edge to the cloud. These systems are a logical extension of the IoT movements in buildings, and we'll have to follow the lead of the Googles and Amazons in developing communications. Getting all of the elements to speak to one another, that's where we have to head with this, where the real value lies."
- **Executive at WhiteSpace Building Technology Advisors**: Integrator and advisor to developers and property managers.
    - "Building owners need help navigating what is going on in this space, steering the ship towards options that will provide long-term benefits that justify the costs. Owners get a lot of bad advice from a lot of self-interested parties. If you can provide results-focused solutions, if your model doesn't incentivize high costs but rather long term savings, owners will show up at your doorstep."
    - "The issue is that we have all these suppliers trying to be the providers of everything to everyone, and this isn't a one size fits all environment. Open-source platforms that are IP or Niagara-framework compatible have been successful in commercial buildings because they allow users to stitch together solutions that meet their specific needs. That needs to happen in the MDU space too. We need platforms and gateways that enable users to easily and cheaply connect any type of device from any type of supplier. Flexibility and agility are what operators are looking for, that's what suppliers need to figure out how to deliver"
    - "Open source is necessary to allow all of these devices and systems to natively interact and combine in new ways. Without it, too much user interaction will be required for adoption to spread widely. Interactions have to occur autonomously, creating value based on user defined or learned rules. That's where we see this all going. You can convince operators of the value of these offerings, but if something's complex they won't use it. If they don't use it they don't actually see that value and then your product isn't worth a damn."

    - "Traditional players have really struggled with this space. Telcos have struggled, we saw Verizon and AT&T both flop because they failed to create value for property managers. ISPs are pushing building-wide Wi-Fi, Google looking to bring fiber to buildings and help managers control them. The traditional BAS guys just don't have the cost structure required to sell unit by unit offerings. Even if the system is set up for an entire building, those guys will quote $10k to monitor within an apartment. Even the smart apartment guys are focusing only on residents, missing opportunities to reduce building OPEX. Huge opportunities to create value across the chain are being overlooked or missed."
- **Executive at PowerSage**: OEM and platform provider for circuit monitoring and energy management
    - "The split incentive means we have to put together packages with tools that work for everyone. You can market it to occupants, but if the owner is the one buying it you better make sure the value to them is clear. I think we're getting away from the marketing focus and entering a period where value is really getting created, and that this is where we'll see things really start moving."
    - "We're able to capture all this info about how people are using energy, which tells us all about their patterns. There's a big opportunity here, if you think about all the big players. It's not clear how we monetize this yet, but it is clear that the push by the big guys into the home means that they've ID'ed it as the next big data opportunity."
    - "In terms of opportunities, scale is the biggest thing. Large MDU holders, think the top 50 managers in the country, we start there looking for retrofits. The efficiency demanded by these guys to manage big portfolios makes our sales pitch much easier. Even better are managers of master metered buildings. With a straightforward incentive to reduce inefficiencies, it's really our best chance to prove ourselves in this market."
- **Project Manager at GSA**: Design and oversight of government building projects
    - "Higher upfront costs are tough to justify even with lower long-term maintenance costs and higher comfort. Government mandates that promote efficiency investments with financing incentives can go a long way towards speeding adoption."
    - "Architects play an important role in coordinating decision-making, balancing occupant needs with developer priorities. Developers often don't have sense of user needs and generally don't have a close eye on tech options to meet them. We have to stay up to date on tech to be able to recommend the best means to those ends."
    - "It's important that we develop a relationship with providers so we understand offerings available for projects. We don't want to recommend that our customer use unproven tech, put our name on an offering that we can't stand behind. We're looking for proven history, solutions that have managed complexity of multiple interrelated building systems with a successful track record. We aren't looking to be guinea pigs."
- **Editor at BuildingContext**: Building supplier research and marketing services
    - "Efficiency investments are heading towards NZE, and serious players are looking at both passive and active systems. Even passive systems require IoT to enable feedback loops, based on sensing, to trigger building responses to environment. Dynamic control of these buildings requires adoption of automation and control tech, which is often outside the expertise of the ACE firms undertaking these projects. Specialized SIs have an opportunity to educate decision-makers as they evaluate alternative offerings."
    - "Commissioning is a big opportunity for cost savings with tech adoption. It's a huge added expense for high performance buildings. Ensuring that building systems are operating up to spec can go on for years after construction, but with connected

systems we're able to remotely monitor and ensure that everything is achieving guaranteed performance metrics. We can simulate how systems will interact before the building is even completed, and select equipment based on total efficiency gains across disparate systems and vendors."
    - "The tech players might get into the home, but their data expertise doesn't prepare them for dealing with complexity of physical systems. That's where the OT, control guys will continue to have the upper hand. But they're still trying to make everything from the factory, banking on users not being IT-savvy, and its making costs go way up, which doesn't work for the MDU market."
    - "We're seeing eyes really opening to the value of open data models and semantic tagging. Johnson Controls and some of the others are looking to absorb the [Project] Haystack model. The open [communications] protocol movement has changed everything, making clear the benefits of standardized languages. Open data models is next, especially as operators demand more advanced analytics and machine learning tools that integrate all types of building systems."
- **Executive at Powerhouse Dynamics**: Energy and asset management software/platform provider
    - "We leverage IoT tech to connect, monitor, analyze and control building equipment. We're managing thousands of end points from one screen, with no disparate systems, everything interconnected. Consumers are demanding interoperability. If they are going to buy a building management system, they want to buy one that does everything, not need three to manage the HVAC, lighting and security systems."
    - "It's a complex market, but we're seeing adoption across it. Condos are completely different than rentals, and co-ops are different from everything. We've got low-income and senior complexes where operators pay bills and want to be able to increase efficiency to reduce expenses. You have developers who want to offer tools to renters to allow them to reduce their bills. And then there's big master metered buildings that need us to come in and monitor circuits to allocate bills accordingly. Extensible offerings enable us to scale to fit the needs of each."
    - "We're partnering with OEMs to develop unique solutions, integrating their equipment into our automation services. They'll purchase our sensors and embed them into products, and purchase our platform as SaaS, reselling to customers to manage assets. The razor blade strategy that these service focused OEMs are taking means they have to limit costs of running service wherever possible, and we want to help them do that with optimal IoT decision-making. These OEMs enhance their service delivery to create greater end customer value but also reduce friction in delivery to increase their margins."
    - "Our strategy is to design a system in such a way that keeps users from having to interact with it. Control systems should sense the environment and react autonomously based on programmed and learned cues. Machine learning is getting to the point that we can utilize these tools in many applications create value without creating complexity."
    - "Down the road, there likely is a brokering play to be made. We're thinking about the value of data we're capturing to OEMs and electric utilities. If data can be responsibly aggregated and anonymized then, with the users agreement and likely compensation, we think there's a real opportunity to resell equipment and energy usage data, to OEMs or third-parties and create new value across the chain."
- **Executive at StratIS**: Energy and asset management software/platform provider
    - "Big [building automation system] companies have gigantic infrastructures that require really big price tags…that doesn't work in MDUs…because big price tags aren't

a part of this. Even the best situated property managers aren't going to throw out half a million for a building."

- "Energy is more complex because you have conflicting interests participating. Depending on the circumstances, maybe your resident doesn't care about building operator energy costs, or only receives benefits themselves. In low vacancy buildings, return really comes from revenue lift from property differentiation rather than from operating expense savings, which mostly accrue during vacancies. Property operators of all-inclusive buildings, we've set up systems to allow them to set up limitations... we saved so much money, increased portfolio valuation by 40 million. Same thing in student housing, another huge opportunity for savings depending on the type of property and business model."
- "MDUs have been neglected in part because there are so many players crucial to successful offerings in the space. We work with 150 distributors to respond to issues that can't be solved remotely. Property managers and staff are critical boots on the ground. Supportability has been the biggest challenge for sure - managers aren't technologists so we've developed training programs to give support to vendors, maintenance, managers and residents. Relationships with distributors has proven really important, as has close ties with OEMs - particularly HVAC manufacturers. We'll work with architects as well, but they have to be pretty upstream in order for us to spec into the design stage."
- "With the incumbents, the Johnsons, Siemens, and Schneiders of the world struggling to get into this market, you're seeing a lot of new players, startups who aren't prepared for some of the challenges of long-term support. Over the air (OTA) updates and security concerns are especially challenging this group, and when their offerings get adopted, their customers are at risk. We're getting to a point where their models are foolhardy at best, and really dangerous at worst."

- **Executive at BuLogics**: Wireless IoT solution designer and builder
  - "We're in MDUs because we recognized an opportunity that was being overlooked. By starting on the hardware side, designing, engineering and testing wireless IoT devices, we're able to provide clients a rich context on the tools that they need for a given need."
  - "One of the biggest challenges is to create a platform upon which all the relevant devices can speak to each other. It's up to the software to make things interoperable, not the hardware. We're looking to future-proof all of our offerings, building in protocols like Z-Wave and ZigBee but leaving space to add the functionality to work with Thread or Homekit."
  - "Unit automation play is great...you have the potential for revenue lift, ability to differentiate property. I don't think that's where the actual ROI for owners and managers is. They're the ones paying for the actual hardware. It has to get installed by someone. You need to target solutions that will add value to the unit while also creating direct value to the operators. With increasingly interoperable systems, this is becoming much easier. When we focused only on energy solutions, adoption was slowed by the relatively small benefits seen by operators. Since we added access management in the summer of 2015, we've installed the joint offering in 150,000 apartments. It's a win-win for managers."
  - "The story here is about designing the technology in such a way as to make it invisible...as with other industries, we're in one where AI will need to be embraced for long-term success."

- **Global Strategist at Microsoft**: Hardware and software provider for consumer and commercial computing applications.
    - "We think we know what people want, but there's probably a whole lot more that want that we don't know about. Creating a solution that is flexible enough to meet varied individual needs is the holy grail of the smart home."
    - "For now, our smart home strategy focuses on the consumer, and therefore we see MDUs as an opportunity, but not really different from the smart home. As we expand partnerships with OEMs and service providers around the use of Azure, we may try to target the more centralized building systems, but that isn't on my radar."
    - "Microsoft benefits from being known by consumers worldwide, mostly thanks to the Windows OS and Office products, but also the XBOX. Because of this familiarity and the installed base of products and systems, Microsoft has a very interesting play in smart homes. These traditional Microsoft devices and software are now complemented by an Azure back-end that can help integrate other suppliers' devices into a unified smart home."
    - "The XBOX is a trojan horse for Microsoft in the smart home. There are about 20 million of these high-power computing devices in peoples' homes today, and we've seen success expanding services to provide more entertainment-focused capabilities to increase the value of the device as a 'hub'. We've even already integrated voice capabilities into the newer versions."
- **Executive at BuildingBrains**: OEM of behind the switch/outlet sensors and comms to facilitate smart home devices and services
    - "We want to design the smart home, not smart things for the home. The market will never take off if people have to buy a bunch of new, extra devices they are not familiar with. Everything should just work in the background, without any added complexity or puzzle pieces."
    - "Our initial focus has been on age-in-place applications and on improving care, monitoring and services for people with disabilities. No one wants to live in an assisted living facility, due to the foreign nature of the living space, the lack of privacy and the cost. We see the applications of the smart home that allow you to live in your own home longer as having a more tangible ROI than some of the other applications out there today."
    - "MDUs present an interesting opportunity. There is a lot of new construction of MDUs occurring, and this is the best time to get our behind-the-outlet and switch products into these areas. They also have the manager-tenant dynamic where the property manager is already providing services to the tenant, services that can be extended and improved by internet of things devices and software."
    - "One potential service area is granular understanding of energy use by outlet, informing tenants of their energy use and comparing to neighbors, and offering recommendations for how tenants can reduce energy use. A prime partnership for this application is obviously the electric utility, but I could see insurance players getting involved in dual-purpose risk management applications in the future."
- **Vice President at IOTAS**: Smart home platform, device connectivity hub and sensors designed for apartments
    - "As far as regions, we thought it would be coastal but its really not. A big chunk is Midwest…Texas, up to Chicago, Indy, Omaha, Kansas City, St. Louis. A lot of coastal cities, where land prices are extremely high, rental prices are extremely high, and monetarily it doesn't make sense for managers to retrofit in those markets till they need to. NY, SF, tech isn't a differentiator - managers aren't fighting over potential renters, who are just hoping there are no rats in their place… A lot of companies are

moving regional HQs into secondary and tertiary markets where land prices are lower and trying to recruit the right people by giving the standard of living they expect. That's why we're seeing this Midwest boon."

- "About 90 percent of our customers are inbound, owners and manager groups know this is coming, but don't know how to think about opportunities and challenges. We've found that these stakeholders are best convinced of the value by running pilots in a few units at a site, showing how people will interact with systems over a decent time frame. They can really appreciate the benefits when they see the savings from managing energy usage in vacant units. We're selling them on holistic systems that connect unit usage and building systems with these pilots."
- "Our value is in providing a holistic offering, from consulting, to scoping, to procurement, install and support. These guys come to us, not knowing what they want or need, and we provide recommendations in a package that we will service. By becoming the the single channel to a holistic solution, we provide a seamless route for them. The single platform gives them automatic device pairing, provisioning, and managing for a monthly software fee."
- "The data that's being generated in these units is hugely valuable to companies. We've been approached by numerous tech firms who see the opportunity. Developers too. Everyone knows their data is already being used. Google, Facebook, Amazon, we know they're using our information, but we like what they offer in exchange. Why wouldn't we?"
- "Tech giants and ad companies are already tracking people's movements, both online and physically. No one has really done that within the four walls of people's houses. With multiple sensors and plug load monitoring, we know if you're watching HD TV and how many hours you watch, how often the toilet is flushed and how often you'll need to order toilet paper, how many times you run the dishwasher...we're working with Target, Amazon, Facebook, Uber, from a strategic partner side of things, trying to figure out how you might repurpose the physical environment where users live. Google, Facebook track where you're purchasing stuff online, and everyone gets a fraction of a penny per transaction - no one's done that in the house. We aren't looking to exploit people obviously. But down the road, if you want to automatically have detergent delivered when you're about to run out, we'll be positioned to be that intermediary of accurate data literally by the second of what people are doing. A lot of things that you're already seeing with every other app - aggregate data and repurpose it. We're looking to do the same thing but in physical housing. With integration into the units, we create a living profile for users that they'll take with them. We end up with a long-term play where real estate is essentially a deployment mechanism to get residents using our services, giving us data to analyze over the next few years to determine how we position ourselves."
- "I don't think apps will be in existence in five years. We're heading towards voice and automation. Services running in the background without direct interaction. You won't be Google searching per se, you'll just speak to your Amazon, Google, Apple device or whoever and it'll tell you the answer. We're working with these firms to ensure that our offerings are enabled for this future state, and setting up our contracts with residents to provide the level of data sharing required to get those sort of services to them."

- **Vice President at Embue**: Cloud-based smart apartment platform, connectivity hub and sensors
  - "We're seeing more residents looking for certain devices, certain brands, and that's driving property managers to look into these things. We're always working with the

owners, making sure they're getting real value and figuring out what sort of payment plan makes the most sense for their situation. From our end, a slightly smaller margin with less favorable monetization is better than no sale."

- "It's critical we make this about more than the sale. We have managers who bought smart thermostats from someone, installed them, and have a building full of unprogrammed devices that don't talk to central HVAC systems. That's an expensive marketing move. We want to make sure these guys see real value, that's our value proposition. We work with local installers, specialists in getting these systems up and running and maintaining them to make sure managers get real, long-term value with little headache."
- "We're offering a coordinated suite of packaged products, enabling remote management of building systems as a collection of entities rather than separate systems. Value is in the info created from gathering data, running analytics, creating alerts, and storing info in big data sets. Our analytics and machine learning tools are automating consistent M2M tasks, augmenting qualitative decision-making with new info. "
- "Making these sales requires flexibility on the provider's part in terms of manager financials. They've got very different CAPEX and OPEX availability, depending on size and even timing. Rule of thumb, 10 percent of portfolio of good size is coming up on CAPEX refinance, where they're looking to put more money into the unit to add value with a retrofit or renovation. Everyone wants to go in with the SaaS model with these offerings, but managers haven't had a line item for SaaS in the past. We have to shift how they pay for these offerings to accommodate their needs or the sale is gone."

- **Manager at Ayla Networks**: Enterprise application enablement platform targeting OEMs
  - "Voice is becoming the leading interface for smart home products and applications, and we've developed an API to integrate OEM smart home products with Amazon's Alexa."
  - "Beyond voice interaction, however, is a more important principle - one of the main value mechanisms of the smart home actually doesn't include interaction at all--these systems must make the home function more efficiently without human involvement, at once increasing convenience, driving cost savings and providing suppliers with more information to serve you and others better."
  - "We don't target MDUs specifically, however, some of our customers are focused on the space and we are hearing more and more about it from customers looking to serve the space better. Interoperability is a key adoption driver, and rule-based access control, both for physical security and for data access is an important enabler of compound value in these buildings."
  - "Insurance providers have shown some interest in providing smart home services as a way to identify potential equipment failures, leaks, and other payout-driving factors early so that they can be fixed before they become an expensive problem. This allows insurers to charge less for premiums and more than make up for it by paying out less, increasing margins while providing better services to their customers."
- **Director at Friendly Tech**: Device management platform, built for telcos
  - "The Friendly platform can be used off the shelf, but its also easy to tweak the functionality to specific customer needs. This is very important when dealing with the smart home and consumers in general--flexibility is a requirement."
  - "Most telcos are not interested in collecting user data right now. Some want to offer additional services and would benefit from collecting this data, but the privacy stigma cannot be ignored...the dynamics around user data haven't been effectively dealt with yet. Someone is going to have to push the envelope here."

    - "Voice interfaces are an interesting development, but Word '95 had voice recognition capabilities. It's a nice concept, but the technology is not quite to the point yet where it can add value beyond convenience."
- **Executive at Cytexone**: Device management platform for high-end apartments and hospitality
    - "Few players are really looking at multi-family as a distinct product offering - most building automation systems players are looking to put square peg in round hole. They have control systems that they're trying to put everywhere, they have common protocols throw on thermostats, contact sensors, and think that they start to chip away at it. In reality, they are far from actually hitting the needs of the operators and the occupants. It's a space they aren't set up for, and its expensive to change."
    - "There's two different conversations -- first its about energy efficiency, cost reduction opportunities through technology. Then there's the "well what's my value add?" If tech is going to be put into my MDU, is there a feature benefit that's outside of energy consumption that makes sense to pursue a project? You have to pull all the data back, determine what is happening in the building based on trends and analysis, but what's the action item? Is technology actually solving that? Human behavior is one of the biggest variables in all of this. If residents are leaving windows open and the HVAC on, what is a smart thermostat going to do to improve building efficiency?"
    - "You have a bunch of players get started out in smart home, cause yeah, its trendy, but do you want to battle against Apple and Google, well-funded and deep pocketed providers? We've seen multiple firms switch over to targeting MDUs as a niche market, recognizing that there's a unique set of needs here that those consumer-focused firms aren't well positioned to meet."
    - "Utilities and government could play a much bigger role in making this come around. Housing and urban development is the biggest owner of multi-family buildings in the country, there has to be an ROI for them to get involved. They don't have the money to give features to tenants, you can do boiler retrofits, maybe install solar, CHP is of interest, but I'd say the success in MDUs comes from looking at it in the aggregated form. Solutions that make a small impact in a single building, applied across a huge market of those building types can end up having an incredible impact."
    - "HUD owned properties can't use PACE financing, which allows investment in new lighting, controls systems to be put onto the property and costs passed through to tenants. Great way for privately owned MDUs to move the needle on efficiency investments. Government incentives could be huge for increasing adoption of these solutions in low income housing. But right now it's mostly seeing uptake in mid and high income buildings."
- **Account Executive at Siemens**: Building automation and control systems for energy distribution and HVAC
    - "In the past, we focused on manufacturing everything related to heating and cooling buildings, all the products touching the HVAC system. Then we moved into software to control all of these pieces, manufacturing the software and selling licenses to control all of those elements in all sorts of commercial buildings. Everyone's going this direction, everyone wants to sell software...we're differentiating ourselves with a focus on services, leveraging our knowledge of these systems to provide superior support."
    - "We've been heading towards the Internet of Things for a long time, just a logical next step really. Taking our systems and becoming the master integrator of all the systems in the building that are getting connected, use our software to control lighting, shades, windows, all those systems through our front end. If we've got the HVAC,

power, lighting systems, those are the primary energy consumers and what people primarily want to control and optimize, that's our in. That's the control point for the building."

- "BACnet provides the direction between two different systems, which used to be proprietary, now have to be open protocol. Everything on BACnet means they can communicate, but doesn't mean we can use all the data right away. On a small project where we're connecting lights from a different vendor into our front end, we still have to do about 1,200 man hours of programming to get all of the systems sharing information in a meaningful way. When you plug in two systems from different vendors, yes, they're compatible with BACnet, but the system pulls all of this info over, we have to unbundle it, figure out what to do with it, and how to code it. Doesn't send it over as a perfect sequence, every sequence and every building is completely different."

- **Vice President at Digital Lumens**: LED lighting and controls company
  - "Our initial focus was on energy savings - with LEDs alone you're getting 40 to 50 percent savings relative to your traditional bulbs for commercial spaces, you add in sensors for daylight and occupancy and we're reaching 90 to 95 percent savings. We were focused on industrial from the start, designing and manufacturing large bulbs and fixtures with integrated occupancy, daylight and power monitoring sensors. We realized before long that commercial buildings had similar needs and use cases, opening up a big new market. Have yet to see apartments demand solutions of our magnitude, but we'd be open to pursuing it if we can make the costs work."
  - "Soon as we were seeing savings from the installations, we had customers looking to expand to new use cases, use the sensors in their lights in new ways. We've rolled out a new platform to meet these demands, moving the software to the cloud for scalability and making mobile control feasible. Occupancy sensors are linked to heat mapping applications to optimize personnel routing and inventory management. Environmental sensors are tracking temp and humidity across the facility and lights are linked to security sensors to signal emergencies. At the end of the day, lighting is everywhere, and it's our entry point to provide all sorts of services. Like many others, we're moving from a core focus on hardware to one on software."
  - "We're extending the platform capabilities, but we don't see ourselves moving forward alone in this. Doing a lot to make the lighting platform open to other providers, leveraging BACnet and providing an open API into any BMS [building management system] out there. So, any of the big automation guys can, say, link into our platform, extract data from Lumens equipment and use occupancy data to enhance the efficiency of the HVAC system. We've got some big partnerships underway to further increase the value, working with Schneider right now to integrate into their BMS systems in exciting new ways. Partnering with Phillips to link control of their fixtures into the new platform. Lighting is critical, but the offering doesn't become necessary unless we have enough value wrapped around it, and partnerships are an efficient way to capture that."
- **Demand Response Specialist at ConEdison**: Electric utility
  - "Within MDUs, there's potential to get the common area loads enrolled in our DR programs, get operators receiving performance payments for cranking down common area HVAC or precooling at certain times. Ultimately, the opportunities in commercial are just far larger, way simpler. If we could get all the units in an apartment building and common areas, then it'd be worth our while. Best we can do today in residential is provide incentives for consumer to buy them, but its only upfront, not a performance payment, they're on one-way meters. They can opt out,

and will still keep the incentive. We're looking to move towards two-way meters in the future, but residential is a drop in the bucket compared to commercial."

- "We've got a pretty unique window AC program, some 3M window units in a DR program. It's a long-running pilot programs that is an interface between the dumb window unit and the socket. Interface plugs into the socket, window unit plugs into interface, window unit is WiFi enabled. User gets the interface for free, we pay them if they connect it and pay them for not overriding the DR call when it goes out."
- "We're pretty hamstrung by the regulatory structure in terms of developing any innovative approaches, unfortunately. Our mandate is to reduce costs with minimal investment risk. Traditionally, we're passing on all of the costs of building and maintaining the grid, but efficiency upgrades and investments that cut demands just aren't incentivized in the current structure. Who ends up paying? Managers are concerned with customer value and rent, and don't want to disrupt tenants. They aren't interested in an ROI > 3 years, and have a tough time justifying benefits that don't accrue on income statements."
- "Ideally, we're providing finance and regulatory structure, ESCOs provide all the equipment, control systems, and strategy. We're looking to software platforms, DR aggregators and analytics players, as key components in getting DR programs underway. We've seen cases of operators doing this manually, literally running around and shutting things down when we give the call, but its all heading towards advanced BEMS systems integrated in the platform. It has to for the system to run efficiently. To keep all these guys involved, we really need the incentives as high as possible, so we get customers and third party guys selling services to their customers, making money themselves to fund reinvestment."

- **Vice President at Greenwave Systems**: Application enablement and network management platform
  - "Telcos have been organizing to offer creative and application-specific solutions to enterprises, but expect to serve consumers and the residential market with off-the-shelf IoT offerings, as they have been with traditional data services. I'm sure you can use off-the-shelf as the base of an IoT solution, but there isn't a one-size-fits-all solution for consumers."
  - "We provide the building blocks for managed services and networks. Both are very applicable to MDUs, but we haven't targeted this space and haven't seen much specific interest there. I would assume that property managers stand to gain a lot by leveraging such services to provide better experiences to tenants, either adopting these technologies directly or partnering with traditional service providers to do so."
- **Manager at Stok**: Sustainability consulting for new and existing buildings
  - "Our biggest challenge is translating sustainability into business metrics to measure ROI. Internet of Things technologies could help this problem by increasing the ability to actually measure things like savings, avoided costs, productivity and more."
  - "For every $1 spent on design, $10 are likely to be spent on construction, $100 on operations, and $1,000 on employees for the life of the building. Designing and building these types of technologies costs relatively little compared to the potential value they create. Any way to decrease operations and employee costs should be considered in the design and development of buildings. This goes for MDUs too-employees may be less of an issue, but operational costs are still very important."
  - "We are working with one building owner in Denver who wants his new MDU building to be as high tech as possible, and plans to charge a rent premium to recoup costs. Part of what we are doing is bringing the necessary parties together in the design to make sure we are incorporating what occupants will actually pay for. This

includes sales folks who may not traditionally be included in this process. If it doesn't increase comfort, convenience, safety or security, people will not pay more for it."
    - "Even in California, you can't get people to adopt energy efficiency measures without communicating cost savings over time. Some regulations help make this case, but in the end, it's about having proof that this works."
- **Executive at Dwelo**: Holistic smart apartment software platform
    - "The value of remotely managing the building and systems in it goes way up if you are not on site to begin with…smaller PMs, rather than having to drive around to a dozen small properties around town to rekey doors or check out an HVAC issue can manage these from a central office or mobile phone. Bigger PMs, they might be able to drop the number of on-site staff at major properties by centralizing systems, huge savings for them too, just different. The middle-sized guys certainly boost staff efficiency but might see less significant benefits."
    - "Demand bubbles up from residents, whoever the residents that the manager is trying to serve will impact whether or not they are going to adopt offerings. There are quirks to dealing with different types of ownership groups, whether its REITs, or buy and flip type model, that complicate selling subscription models, but we've had success across the board. If you're trying to serve lower income communities, you have to learn more on the management tools in the value proposition. If you're selling into Class A, B+ properties, its an easier sell in terms of what residents would want."
    - "Resident value creation is more substantial because they are living with offerings every day. How do you put a price on comfort and convenience? People with money are really willing to shell out for this. The variables change obviously depending on demographics and type of building. Look at student housing. You're not likely to pay for offerings that increase convenience, but you're footing the bill for utilities, so you'll want the ability to set a range on thermostats or things like that."
    - "We use Z-Wave devices, not based on any exclusive partnerships, just buying in bulk from a range of vendors to offer owners a set of choices. Part of the model is being hands on, walking them through the process to boil the ocean of Z-Wave options down to a set of recommendations and installing the devices they choose. We're the "white glove" provider in the rental space. Managers want solutions, not headaches, and tech can bring a lot of headaches, especially the first, second, third go around. Some of the biggest managers could conceivably develop these solutions in house, but its not their competency and there's scale and value to be wrung from going with a provider like us that nails it, does it all the way through, and doesn't lean on maintenance staff to deploy and support the solution."
- **Vice President at the National Multifamily Housing Council (NMHC)**: Research and lobbying industry organization
    - "Segmenting the multi-family market has always been difficult as there are so many dimensions you have to take into account, including the building type and size, occupant demographics and ownership model, among others. NMHC segments the market by rent level, as it takes into account the demographics of the occupants and the class of building. This works because we have a broad, nation-wide focus, however, you might want to get into more dimensions if you are looking at specific regions."
    - "[Property managers and building owners] are looking for differentiators. They want what their competitors have, driving an amenities war. This is mostly for marketing to potential occupants, but we are seeing a slow movement towards a more holistic building management model that leads to efficient and optimized systems."
    - "We've been on a run for several years where multi-family housing has been on

fire. During the recession, construction ceased by demand for MDUs increased as millennials started coming of age and entering the workforce, particularly in urban areas where the job market took them. Due to the recession and cultural changes, millennials are marrying and having kids later, and are instead opting to rent for longer instead of buying a house to raise a family. This will begin to change, but the condo market will continue to benefit from urbanization."

- "Nest thermostats and keyless entry is about where this technology is at from a tenant standpoint as provided by property management groups. The biggest issues so far have been around privacy and cybersecurity, and interoperability of these systems, especially with back-end property management software and systems. This hasn't been well-addressed yet, and offers an opportunity for some innovators to come in and change the game."
- "Property managers don't want to violate trust of residents. If property managers can't guarantee the security of data or that others will not use the data to discriminate or target particular tenants with particular services, they will stay away from such applications. This dynamic is driven mostly by the Fair Housing Act in the US, but I am sure there are similar laws in Canada and elsewhere."
- "'Take it with them' technologies present a problem for property managers because of turnover, and the problem of integrating new devices with building or unit systems that stay in place when there is turnover. Part of this could be solved if there is a central hub that is left in the unit or that a tenant brings with them, but this hasn't really been figured out yet. Turnover is a key differentiator between MDUs and single-family homes that hasn't been well addressed by suppliers yet."

- **Vice President at Duraline**: Provider of air-blown fiber optic cable microduct solutions for buildings
  - "The Internet of Things is driving unpredictability in amount and location of bandwidth needed to support connected devices. MDUs in particular provide a unique case, as the increase in streaming and other Internet services are likely going to be used during similar hours in the evening, not to mention other potential device and equipment connections. Access to high-speed Internet is #2 on list of top amenities by today's renters and 33 percent of all Internet traffic today is Netflix. Fiber networks are really the only way to support all of these bandwidth needs."
  - "AT&T and Verizon have been putting fiber into MDUs for a while, but they and folks like Comcast have had to step up their game as new entrants like Google are coming in, trying to disrupt these traditional suppliers. In most new builds, particularly in fast growing cities, all three of these companies and others will put fiber infrastructure into a given building so that occupants have a choice of the network they can use. These include regions such as the south east (Atlanta, GA; Raleigh, NC), south west (Austin, TX; Phoeniz, AZ), central-mountains (Denver, CO; Salt Lake City, UT) and others. In these cases, each supplier will have fiber in its own dedicated pathway so they can provide separate service to their customers."
  - "Network infrastructure in new builds is currently paid for by the owners or builders, however, as the market becomes more competitive for network service providers, the opportunity could arise for MDU owners and managers to sell space for this network, or charge NSPs a percent of their revenues from the building as a service fee for allowing their network to be provided to occupants."
  - "Fiber networks have to first be installed connecting network base stations to the buildings themselves before fiber can be put into the building. For instance, Verizon is building up its fiber network in the northeast so as the building stock turns over it can extend that network into the new buildings."

- **Vice President at iControl**: Smart home technology connectivity platform and monitoring device provider
    - "Today, we're mostly seeing success from companies that have been able to generate awareness of their offerings with brand recognition, not with proven benefits. Cable and security providers, guys like Nest. It's mostly people buying point, retail solutions though we're beginning to see traditional service providers educate existing customers on whole home automation benefits."
    - "Our platform is a B2B offering, that's seen a lot of adoption among network and security providers who want to have their own branded home automation services offering. Instead of these guys trying to develop platforms in house, requiring new talent and time, they can get a ready to use, all in one monitoring and automation offering by white-labeling ours."
    - "Peace-of-mind is driving the smart home market today. There's a range of needs among consumers in terms of what's needed to achieve this…younger demographic has a very different lifestyle and needs than older ones. Coming out of college, you don't have much to protect, and don't have the money for a professionally monitored system. Millennials are looking for DIY tools that they order online, shows up at their door, auto-integrates and provisions into the network and begins working out of the box. Aged 34 years and up, they're the market for monitored solutions. You have to come to the market with a range of tools to serve different occupant demos if you want to capture a large chunk of it."
    - "Apartments are challenging the traditional security guys with models that rely on multi-year contracts to recoup device costs. You can't install a system and sign a three-year contract in an apartment. It's never been a good fit for MDUs. If occupants can take devices with them, think the cable box routine, then maybe you can set up a contract based model. We're getting into the DIY, "bring it with you" device space to make our entry into MDUs for this exact reason."
- **Senior Associate at Rocky Mountain Institute**: Research and consulting firm that focuses on energy efficiency
    - "We're definitely seeing more architects learning about and looking into active control systems to reach efficiency goals, but even the passive systems that have seen a huge uptick in the past decade, especially with LEED and all, there's lots of control needed. These systems are using predictive control algorithms to manage thermal mass with the building, know when to precool slab based on upcoming weather forecast."
    - "Instead of centralized air handlers with standard rules-based control, we're seeing a shift towards numerous subsystem control systems, which coordinate to control a system that would otherwise have a significant lag. The coordination and prediction required to make this work efficiently is super complex, definitely an area where we'll see machine learning pick up the slack from human controllers."
    - "The integration issue…we've integrated seven systems to control the thermal load in our building. When you start integrating these systems, each of which has a unique warranty, you have a tough time identifying the responsible manufacturer when a system goes down because it's hard to identify the boundaries between them. This comes back to the need to get away from such a fragmented system, the need for better integration. I don't know if its just better BMS, getting away from the big players who are fighting hard against open protocols."
    - "The biggest barrier, for the Johnsons the Siemens, their models have worked great since pneumatics. They don't necessarily feel the same demand to move towards open standards because things have been working so well for them. These guys will

begin to quickly realize that they don't have the same hold on the market that they once did, and will begin to see their margins decrease at an accelerating rate. Most of their profit is coming from services today, and you've got innovative tech players who are more effectively accessing and servicing these markets that the product companies will have to change or will go under. Buildings are on the edge of catching up to every other market out there with open models."
    - "In multi-family, we're struggling to determine which systems need to connect. PV batteries aren't necessarily something that tenants would care about, unless there's a unique PPA structure that allows tenants to share in building renewables. Integration of systems that actually need to be are not that different from single family. Depends on the HVAC system, but they'll probably have their own internal HVAC, lighting is internal, all the consumer stuff will be within the unit."
- **Vice President at EdR**: Collegiate MDU developer
    - "We aren't necessarily looking at ROI, its really more about meeting occupant preferences. Our actions are consistently driven by what our occupants are seeking."
    - "We see an advantage from putting keyless locks and lighting with sensors into retrofits. There's a data gathering advantage, using all of the info from electronic locks to provide new services to occupants or maybe use the data with suppliers down the road. It's a huge maintenance time saver, being able to remotely access units, give access to staff as needed."
    - "We're using our own equity for these upgrades."
- **Executive Property Manager at WinnResidential**: National MDU owner and third-party manager
    - "New buildings have much more comprehensive technologies; rehabs have just limited technology upgrades--usually new lights with sensors. Our energy department in corporate division makes decisions across portfolio on this."
    - "If there are regulations helping out with investments, I imagine that there are loans and incentives available, but I haven't seen them or taken advantage of them for any of my properties."
    - "Evaluating offerings, our primary requirements are simplicity and clear benefit to occupants. Internal cost reductions are certainly appreciated, but not what we're aiming for in pursuing these options."
- **Manager at Greystar**: Multi-family building manager
    - "We have key fob access control, but that really isn't considered anything new at this point. Haven't really explored access management systems beyond this point, and are focused on external building access rather than unit access."
    - "We have an interior renovation coming up soon on the building, and have spoken with an Xfinity home rep looking to sell them on additional services for the building. These decisions are all made at the regional manager level, and I don't know what sort of tech offerings will be included in the upgrades for my specific buildings."
    - "We advertise as a green community, which have been an important selling point for the millennial crowd we're fighting hard to attract currently. One of the major green feature is solar panels on our garages and other parking areas which feed building energy demands."
- **Vice President at WC Smith**: Developer and property management firm
    - "Keyless entry is becoming a standard offering in our luxury buildings for sure, but we haven't gotten much further--we love the idea of adding technology but just haven't gotten much further. The high turnover in apartments has been a challenge, and the very personalized nature of these solutions creates challenges--we don't have an easy way to reset all technologies to 'zero' and make them ready to connect to

the new resident's phone or Echo or whatever else they bring with them. Due to the issues I detailed with personalization in individual units, we're more looking at these technologies within common areas for now."

- "Everyone love smart thermostats--but getting the software in place so we can have our residents properly operate this technology is a challenge. It also puts additional training requirements and stress on our maintenance staff and engineers. The servicing of these solutions is really complicated; it's a whole new set of training for onsite staff. They already have lots on their plates with BAS systems and this would overload them. We've wondered about outsourcing this maintenance: the big question I have is are they available when they are needed - 24/7? The tech equipment and then third-party contracts on top of that are just another big expense--at what point does it just become too much money? The margins are small for luxury buildings already."
- "From what I've seen, residents are not expecting these technologies yet as standard offerings--they are not coming up as priorities in search criteria that people are listing when looking for an apartment. People appreciate these technologies, but they're ultimately not a priority. It's just one more technology for residents to learn, and that isnt always convenient--people just don't have the time to do it. We'll see this in apartment common areas even; people just don't want to put the time in to learn about the tech; they see it as a massive learning curve. At what point are we inconveniencing residents by overloading them with technology?"
- "Beyond lighting replacements (LEDs), we don't do a ton of retrofit work related to technology. Older buildings we own are a big challenge--even things like new dishwashers put too much strain on the old wiring/electrical infrastructure. In addition, cable companies aren't interested in retrofitting old buildings at their own expense in order to improve bandwidth capabilities for these new technologies."

- **Multi-family Operations Manager at Alliance Residential**: Fully-integrated MDU real-estate operating company
  - "We use the Dwelo smart home app, it allows residents to unlock doors, turn off their lights, and adjust their thermostat all through their phones. It's really easy for residents to manage: all they have to do is download the app and make a profile. We also use it in the leasing office to see what's going on in unoccupied units; it'll alert us if an apartment is getting too cold or anything like that. The biggest benefits are energy savings and monitoring/safety features. Currently, the app doesn't provide any sort of predictive maintenance alerts to us, but that would be really helpful."
  - "This is a new building, but we have also integrated similar solutions into retrofitted buildings with no real issues."
  - "Occupant preference is huge for us, as we're catering to the younger, tech saavy crowd."
- **Executive at Gables Residential**: Developer and property management firm
  - "Customer service and making sure our occupants are happy. That, at the end of the day will drive our consideration and implementation of any solution."
  - "At the same time, there are some areas of our operations where I could see technologies helping out. Particularly in security and access management, automating and coordinating unit maintenance, as well as rent payments and other customer interface points."
- **Executive of Broadband Operations at AT&T**: Network service provider
  - "We are directly targeting MDUs and we want to win this market. We see fiber as a key aspect of this strategy, but 5G and utilizing existing copper and coax infrastructure

will be critical as well. In places where our wired networks don't reach yet, we are leveraging DirecTV offerings as a way to get to MDU occupants."
    - "There is a lot of demand coming from millennials for better Internet service. Further, this generation is staying in apartments longer than previous generations. MDU networks need to be able to serve these occupants as best as possible."
    - "If I remember correctly, we have about 450,000 units covered with our fiber to the home offering. This has been a key focus of ours over the past two years, and should continue to be a focus for the near future. Part of the problem is just getting the fiber infrastructure installed, so its easy to hook up new buildings."
    - "Outside of the building's network infrastructure, we have the AT&T Digital Life offering for smart homes and consumer products. There is some interaction between that unit and ours, but we could probably benefit from increased interaction and aligned efforts. They are mostly targeting single-family applications though."
- **Manager at Verizon**: Network service provider
    - "Verizon doesn't do much in the intelligent buildings arena outside of fiber to the home. We do, however, have a strategy around what we call smart communities--providing the infrastructure that will support sustainability, livability and public safety in cities around the world. I could see this extending to MDUs, and come to think of it, MDUs could be a good test bed for these types of technologies, particularly on properties with multiple buildings and many residents."
- **Manager at Lockstate**: Smart lock OEM
    - "In MDUs, access management is an issue of convenience. Managers want to be able to let people into vacant units for showings, occupants want to be able to grant access to visiting friends and family in addition to making easier for themselves to access the building, their unit, and particular building services like laundry or the pool."
    - "We have targeted the MDU market with our platform and locks as these represent large, relatively untapped markets for these types of services. Locks in these buildings are the ultimate access managers, and we allow many different codes to be programmed so you can track who is entering or leaving, including occupants, maintenance, janitors, guests and more. Our products leverage Wi-Fi connectivity as opposed to ZigBee or Z-Wave because everyone has Wi-Fi these days and it provides the best UX. We also have programmable memory in the lock itself, so if the Wi-Fi goes down, the lock still remembers the codes you set."
    - "We don't do anything with user data right now, and are leaving it encrypted for privacy's sake. We are taking a 'wait and see' approach here as the market is still figuring out what to do with this type of data in aggregate. We don't want to know the granular habits of any individual person, but could see value in understanding the average number of weekly enters and exits, when those usually occur and what turnover looks like, but we would only look at these metrics in aggregate."
    - "The biggest problem right now is that the industry is so fragmented. UX for home automation isn't great. Even within a single platform, you are usually stuck with the devices in that platform, and we see this as a big barrier to widespread adoption, especially in the face of DIY installers. There is such a frustration with the lack of interoperability that people have taken it upon themselves to create makeshift interoperability in some cases."
- **Vice President at ADT**: Home security systems and services
    - "ADT involvement in this space was primarily a response to Alarm.com offerings, security focused remote arming and disarming abilities. No one had a smart phone back in 2005, mostly targeting the remote business traveler with a laptop who can log in and check on their home. Beauty of what security players did was that people

were buying a security system to satisfy a need, to secure their homes and families, and adding cameras, locks, etc., added value that people didn't need to pay for on a monthly basis, which people don't seem to want to do."

- "We're seeing an expansion from security providers into other areas, especially energy. Vivint and Vivint Solar are worth looking at. Will they be able to scale and maintain the customer service necessary to drive adoption of offerings? Support is critical for any home service, for any connected device-based service, but especially for connected device services in the home."
- "Of course we're watching the movements of the Googles and Amazons. Our focus has been on our services, delivering the highest quality of service and utilizing our guys in trucks, which those players don't have. You need someone that will provide ongoing support and service."
- "There's a handful of players doing high-end, holistic automation - Control4, Savant, Crestron - and then all the DIY offerings from retail. All the major tech players are leveraging brand recognition and trust and pushing voice interfaces into the home, and we're looking to ride that train. They're extending offering touch points and we want to ensure that our offerings benefit, which is why we're integrated with Alexa. Amazon's Home Services, where they're ranking device installers, is a fascinating shift. Can they virtualize what ADT spends tons of money on, all the operating costs in having fleets and people, can they put that in the cloud and gain the trust of consumers to the needed level that ADT or Comcast have?"

- **Manager at Ironshore**: Insurance provider - property, casualty, cybersecurity, environmental, professional, etc.
  - "Multi-family buildings are much different than commercial and single family. There is a lot greater risk involved, as there is more of an opportunity for fires and other issues, but owners and operators of these buildings also typically need lower deductibles, which makes it hard for us to insure a lot of these buildings. We work in the market for sure, but its a difficult one to properly serve."
  - "The most important piece is data- the more information we have, the better rates we can provide. Predictive analytics is transforming the industry. This will definitely disrupt traditional models as premiums fall, but risks and incidents will decrease as well. I think those that can provide additional services on top of insurance will be the best positioned."
  - "With more technology comes more risk of hacking, and there are some companies, including Ironshore and Hiscox, that are already offering cyber insurance."

A.2 SURVEY METHODS

The surveys targeted occupants, owners, operators, designers, engineers and developers as adopters of these technologies and OEMs, service providers and technology vendors as suppliers. These stakeholders comprised four main stakeholder groups, each having its own survey.

The goal of outreach was to target respondents already involved in multi-dwelling units. For occupants, this meant anyone currently living in a household that is connected to at least one other household.

For owners, operators, developers, designers and engineers, this meant companies or individuals who own, manage or work on multi-dwelling unit buildings.

For OEMs, service providers and technology vendors, this meant companies who supply products, services and technology to multi-dwelling units and buildings.

Across all four surveys, there were a total of 1,500 respondents, including 1,375 completes. The

following survey characteristics affected the completion rate:

- **Survey Length**. Because of the number of topics being covered by this report, each survey contained over 25 questions and took about 15 minutes to complete.
- **Narrow Target Groups**. The MDU market is not well served today by dedicated companies or people within companies. This made it difficult to only target these people with outreach, resulting in some non-MDU companies and individuals trying to participate in the survey.

Responses by survey group were as follows:

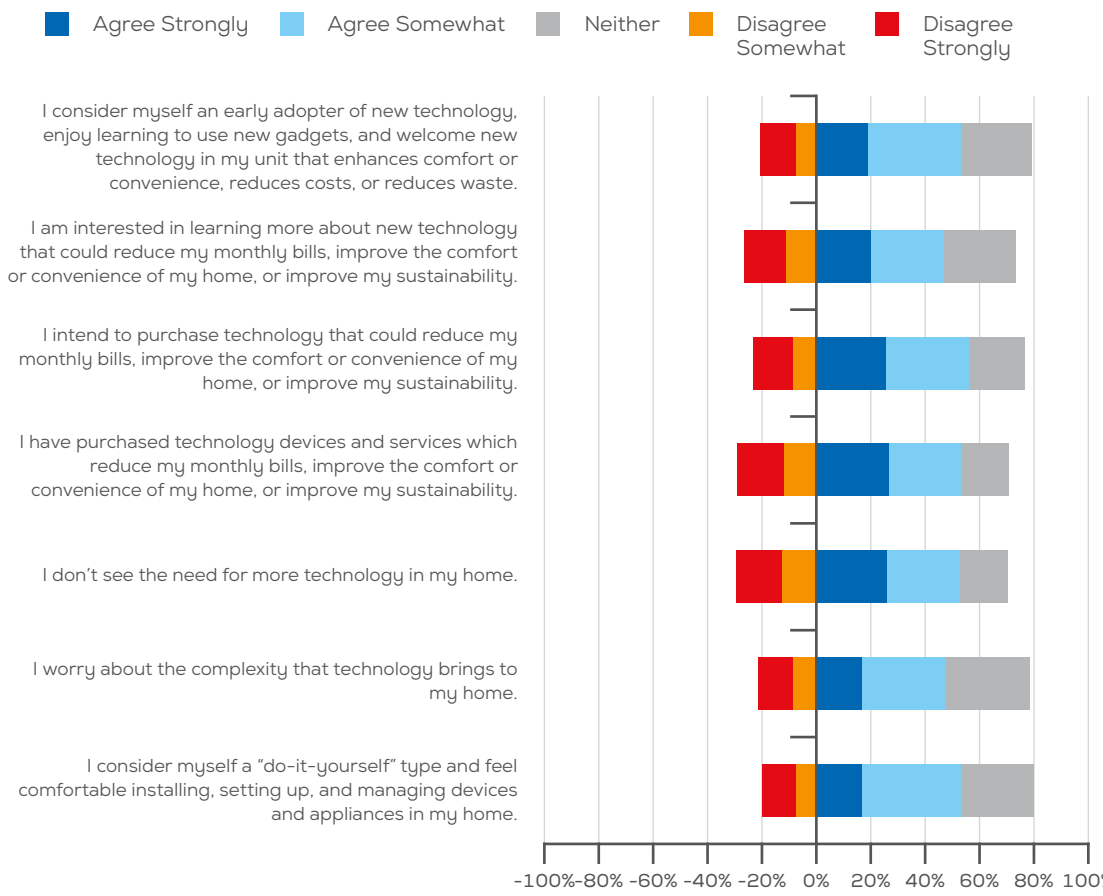
Adopters:
Occupants: 1,222 respondents, 1,140 completes
Designers, engineers, developers, owners and operators: 149 respondents, 111 completes

Suppliers:
Technology suppliers: 51 respondents, 48 completes
OEMs and service providers: 79 respondents, 76 completes

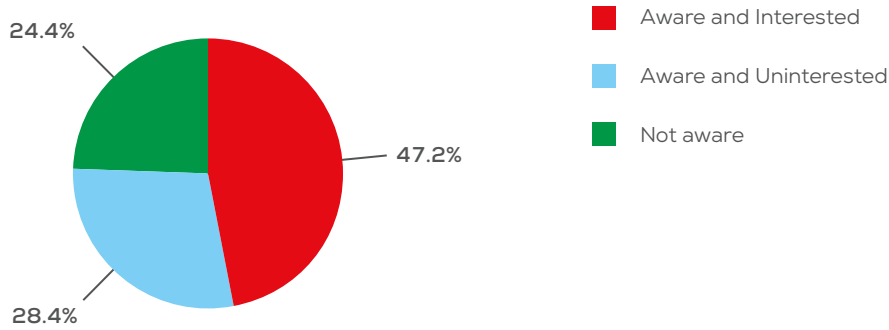
The results of each survey are laid out below:

Occupant Survey Questions

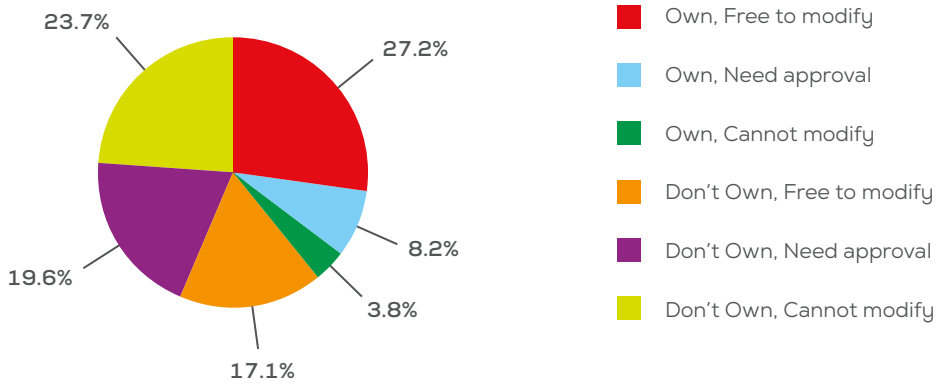
1. How much do you agree or disagree with the following statements:



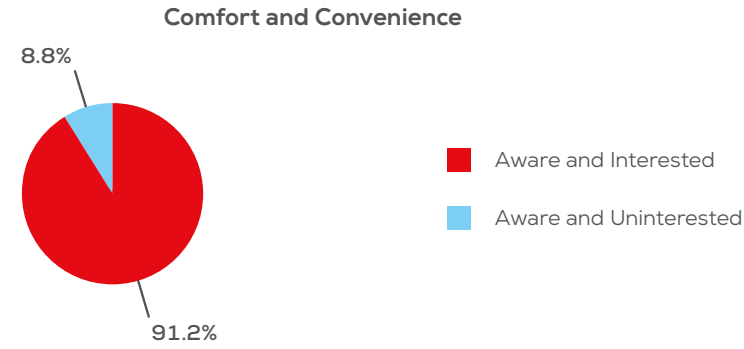
2. Please select the option that best describes your awareness of connected devices and services (drop down list)

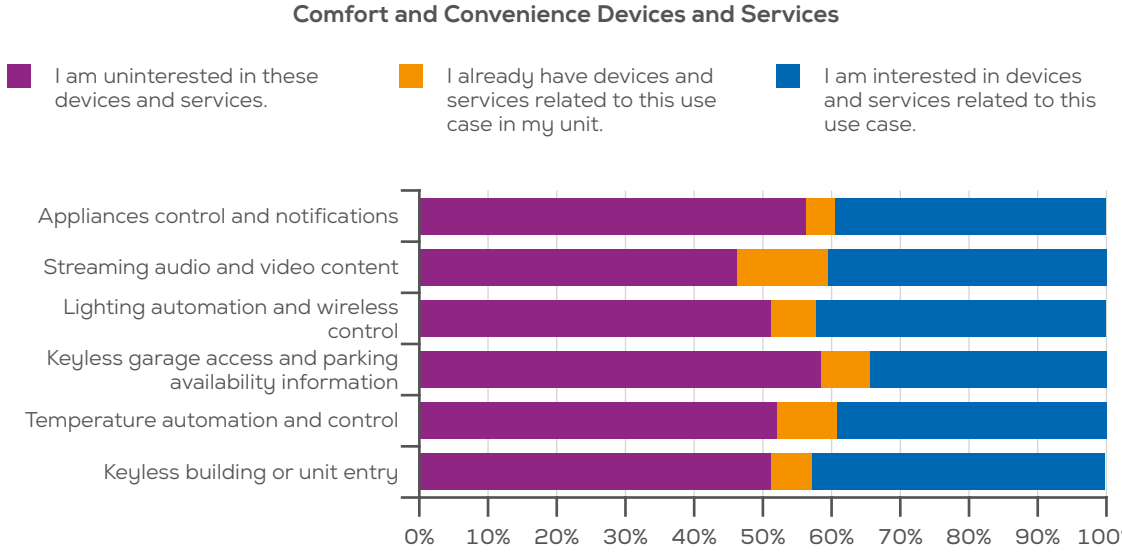


3. Please select the statement that best describes your ability to make decisions regarding new devices and services from your unit:

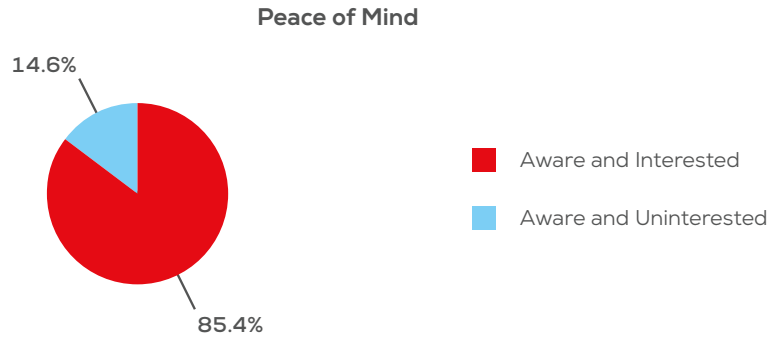


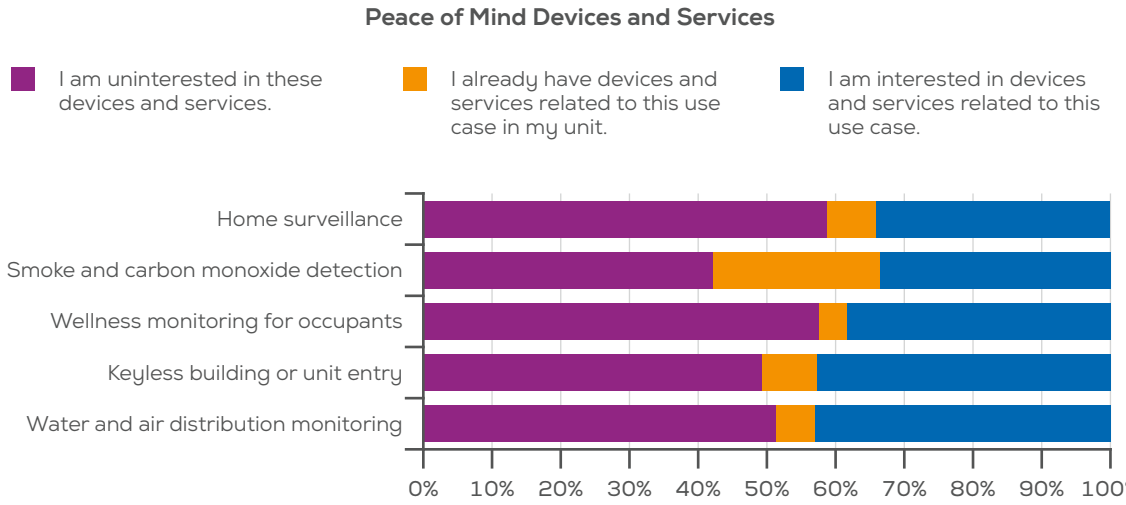
4. Please indicate your awareness of, interest in, and adoption of Comfort and Convenience use cases enabled by connected devices:



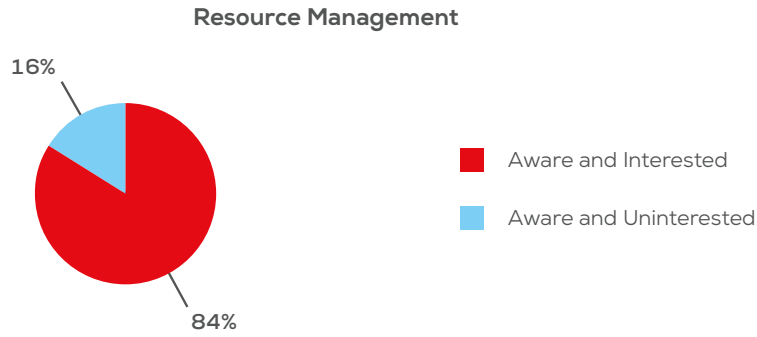


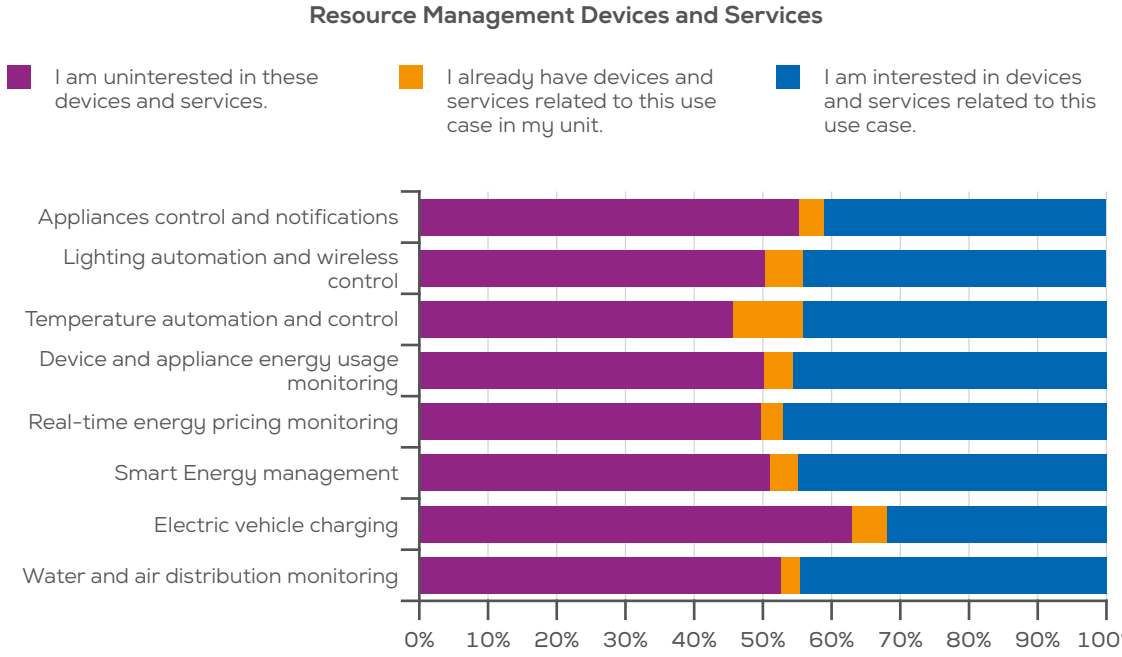
5. Please indicate your awareness of, interest in, and adoption of Peace-of-Mind use cases enabled by connected devices:



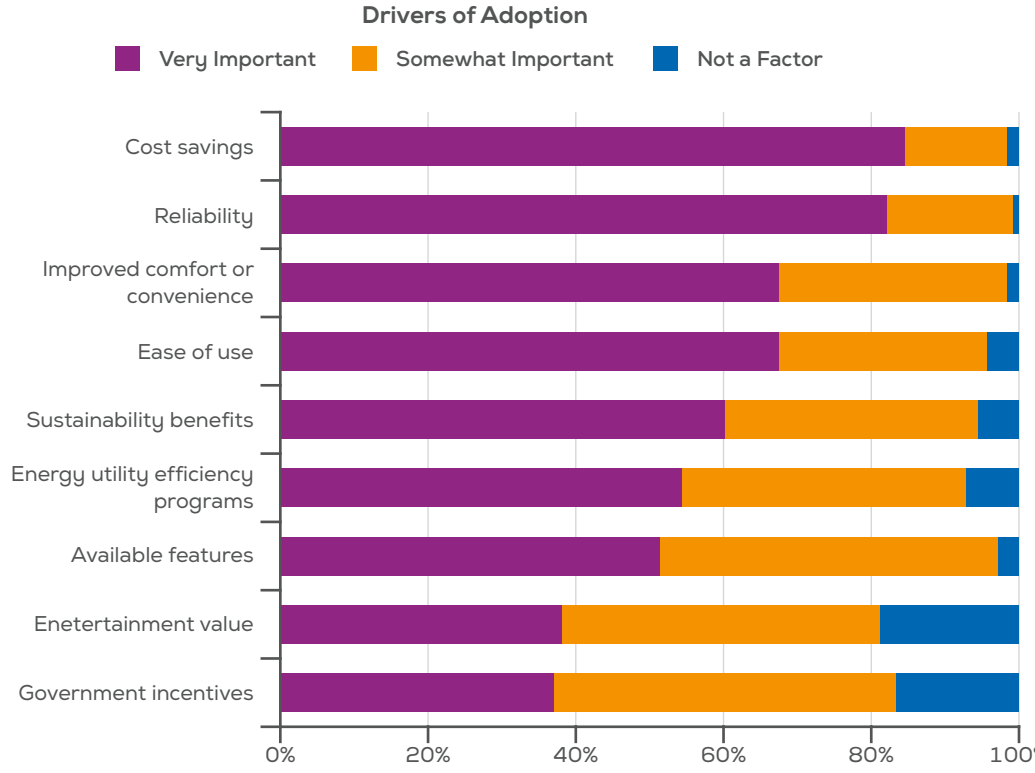


6. Please indicate your awareness of, interest in, and adoption of Resource Management use cases enabled by connected devices:

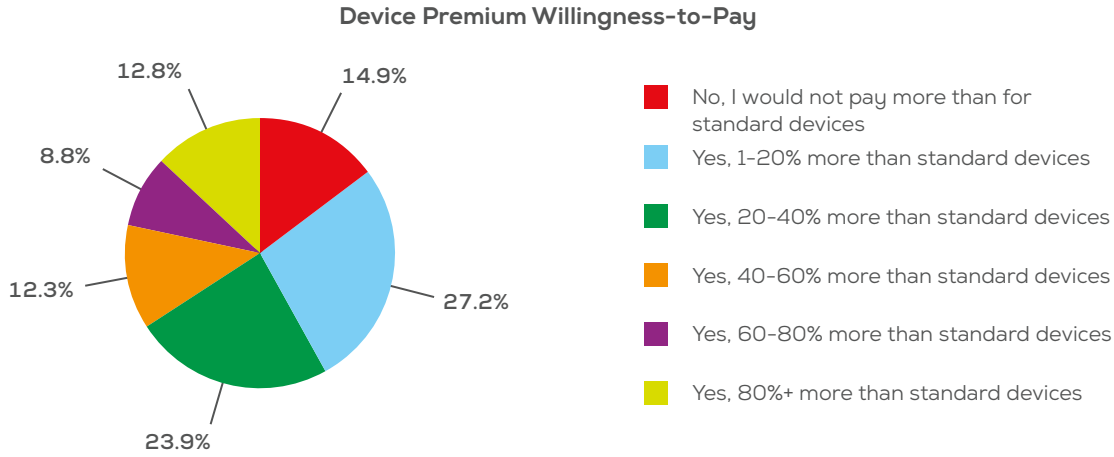




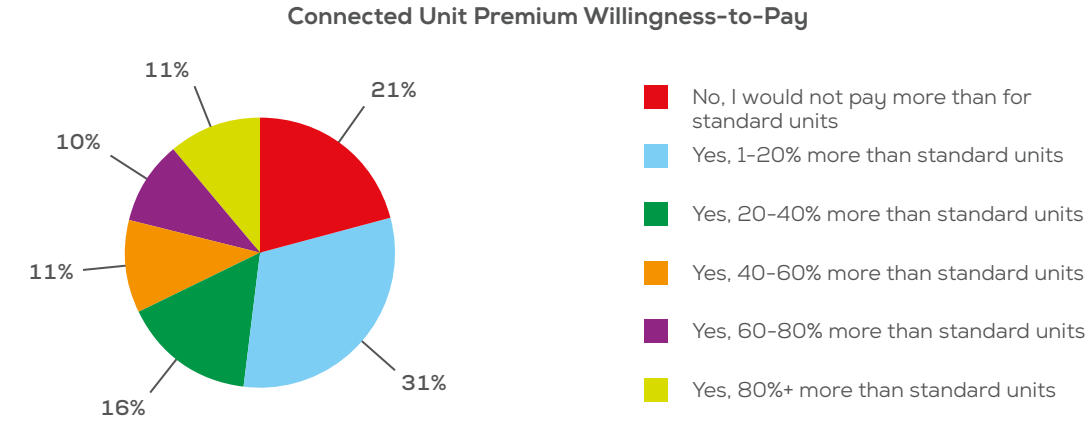
7. How influential were the following criteria in driving your interest in connected offerings or multi-dwelling unit buildings with connected offerings? (5 = very important, 3 = somewhat important, 1 = not a factor)



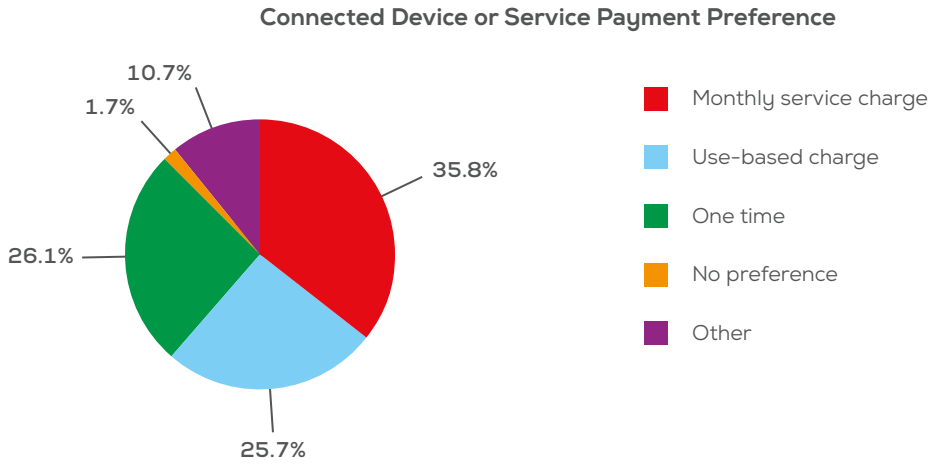
8. Are you/would you be willing to pay more for devices that enable this service? (drop down)



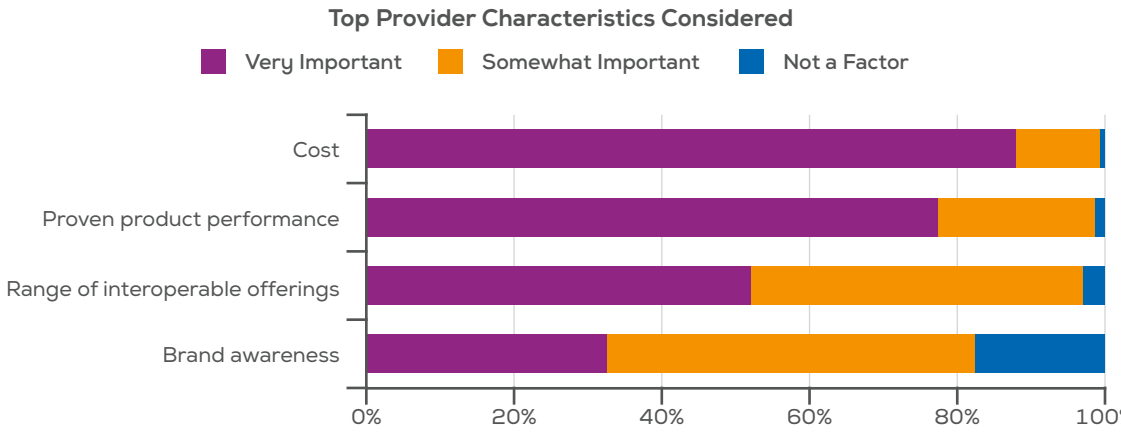
9. Are you/would you be willing to pay more an apartment/condominium with this offering? (drop down)



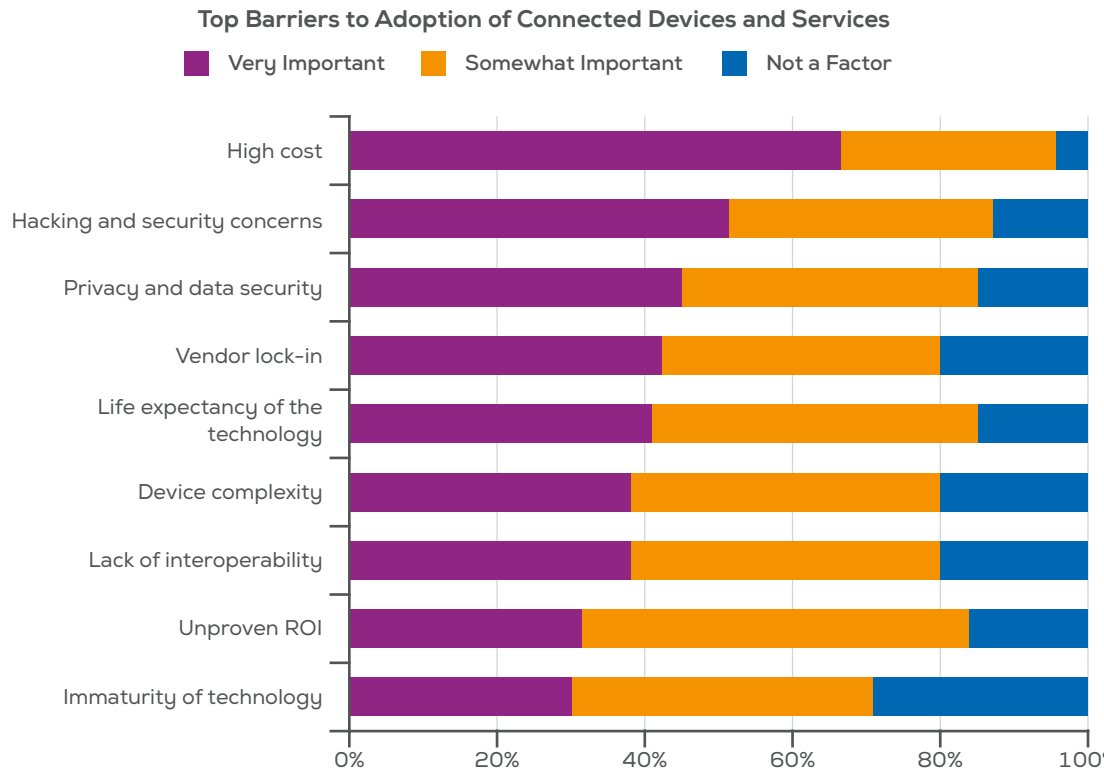
10. How would you prefer paying for this connected device and/or service? (drop down)



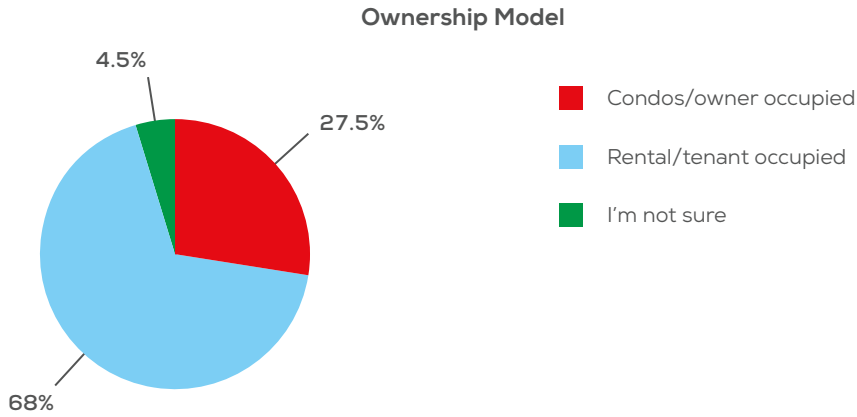
11. How important are the following criteria in selecting the provider of connected devices or services? (5 = very important, 3 = somewhat important, 1 = not a factor)



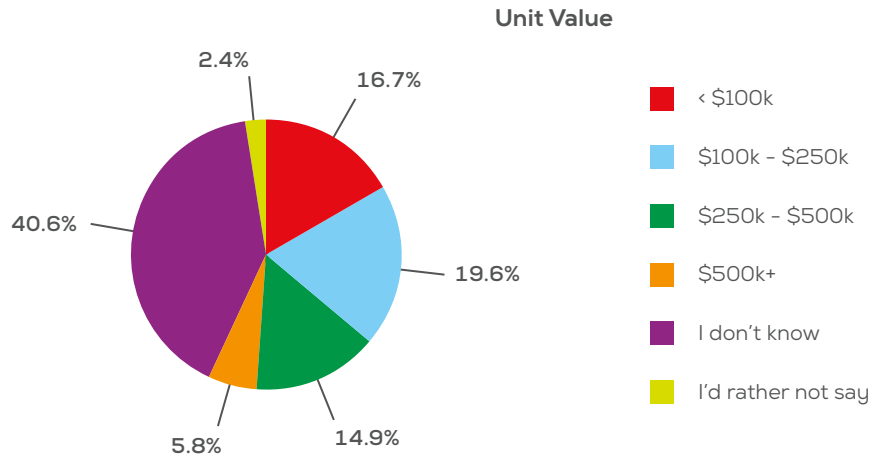
12. How important are the following criteria in your decision to not adopt certain connected offerings? (5 = very important, 3 = somewhat important, 1 = not a factor)



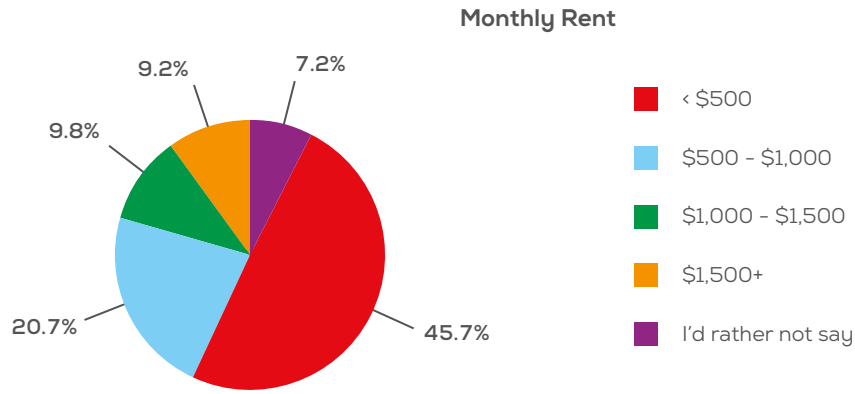
13. What is the ownership model of your building? (drop down list)



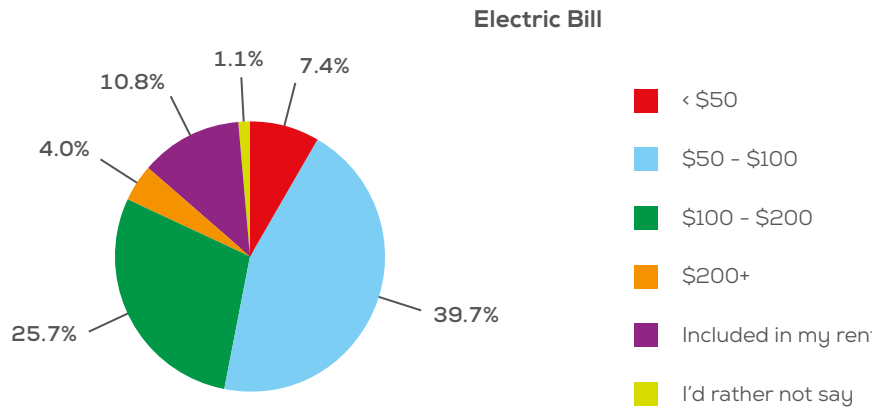
14. What is the value of your unit? (drop down list)



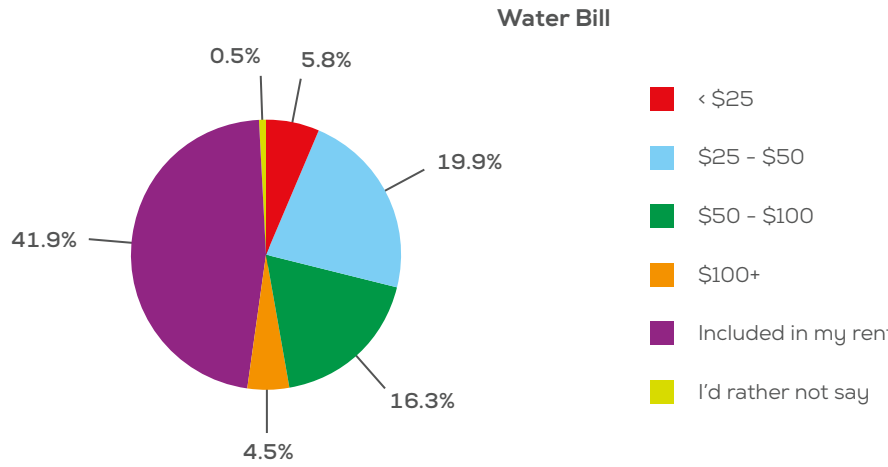
15. [If respondent answers (ii) above] What is your average monthly rent (including building fees)? (drop down list)



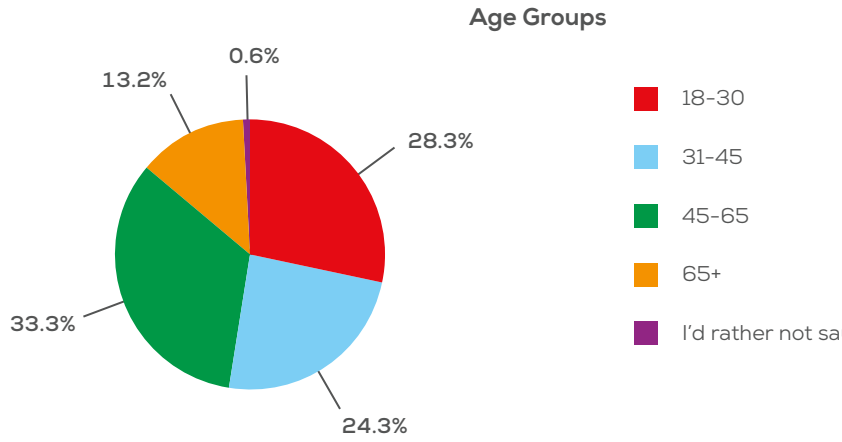
16. What is your average monthly electric utility bill? (drop down list)



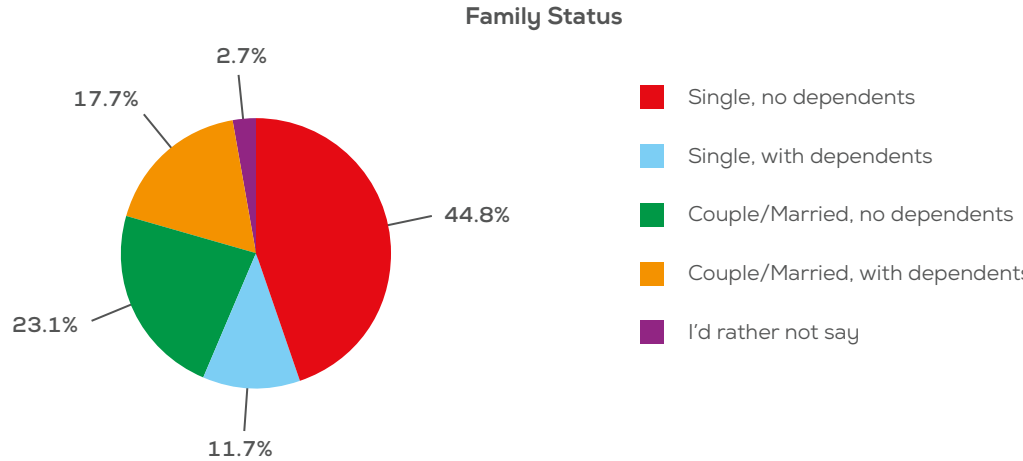
17. What is your average monthly water utility bill? (drop down list)



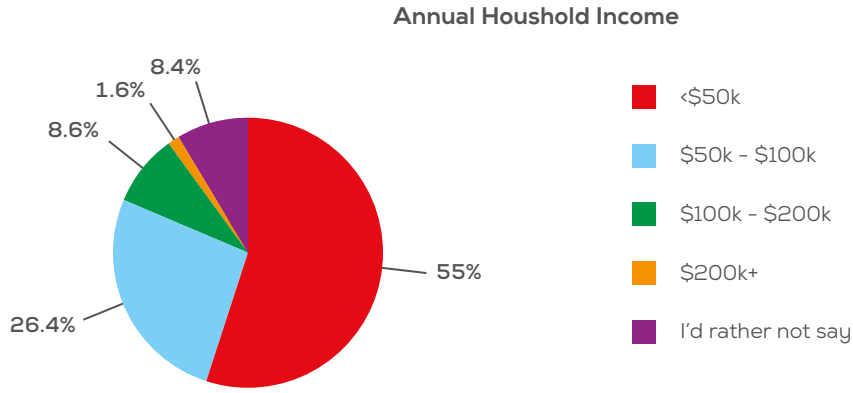
18. What is your age? (drop down list)



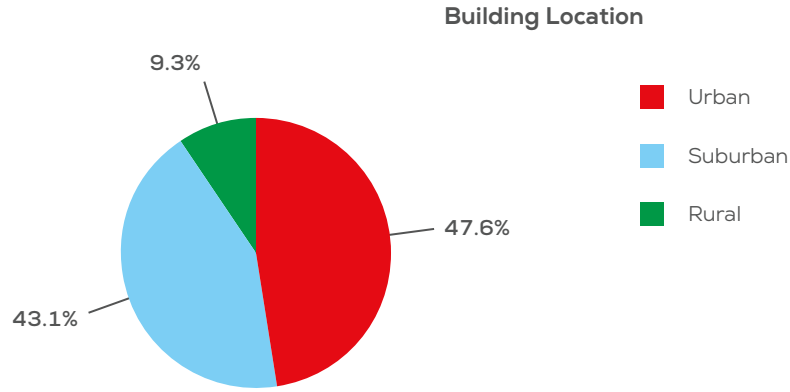
19. What is your family status? (drop down list)



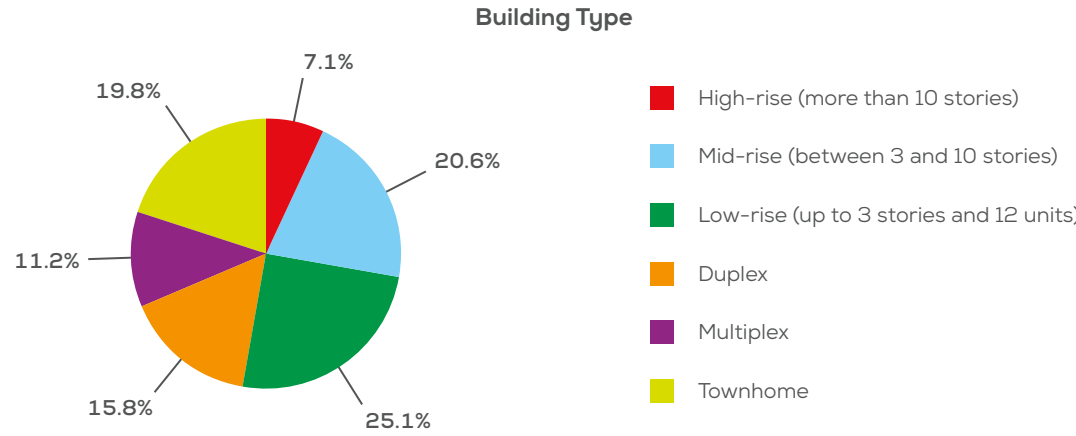
20. What is your annual disposable household income? (drop down list)



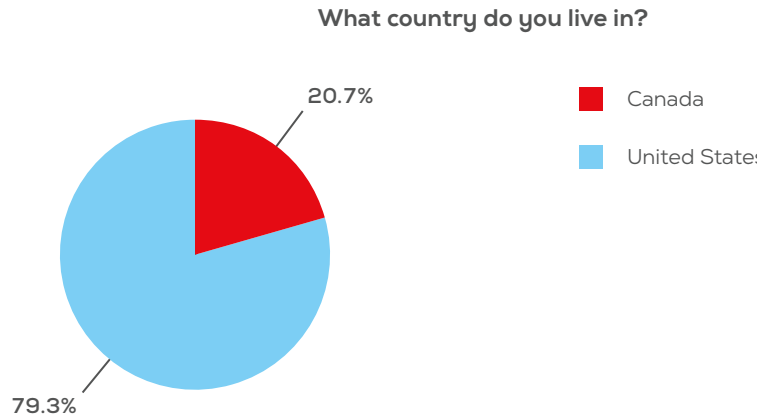
21. What type of community do you live in? (drop down list)



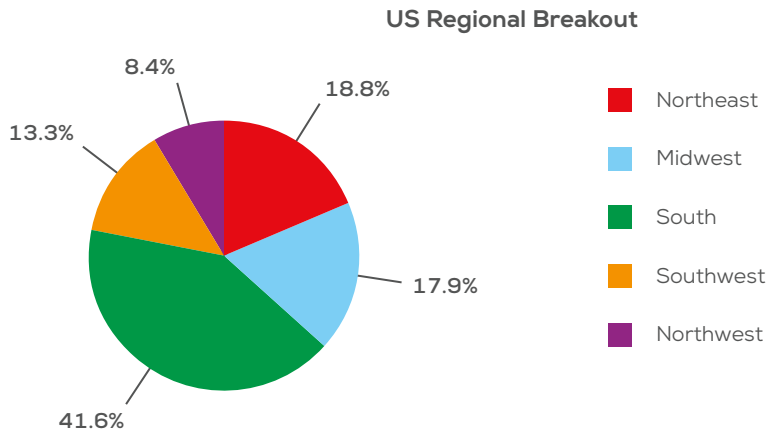
22. What is the building type of the MDU that you live in? (drop down list)



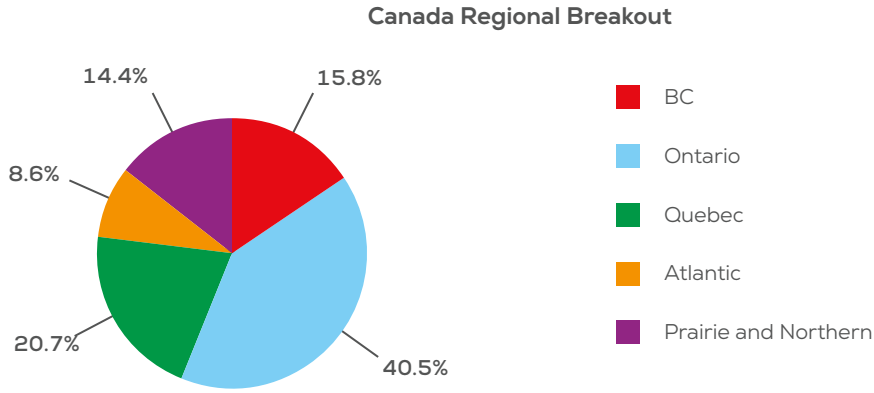
23. Which country are you located in?



24. If American, which US region are you located in?

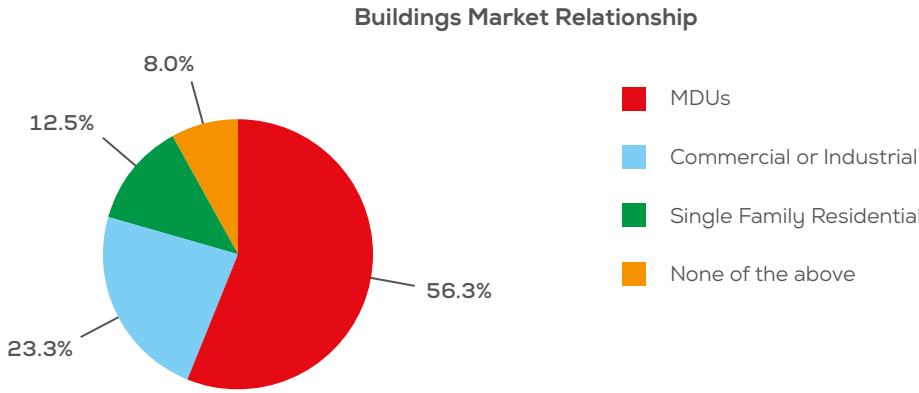


25. If Canadian, which Canadian province are you located in?

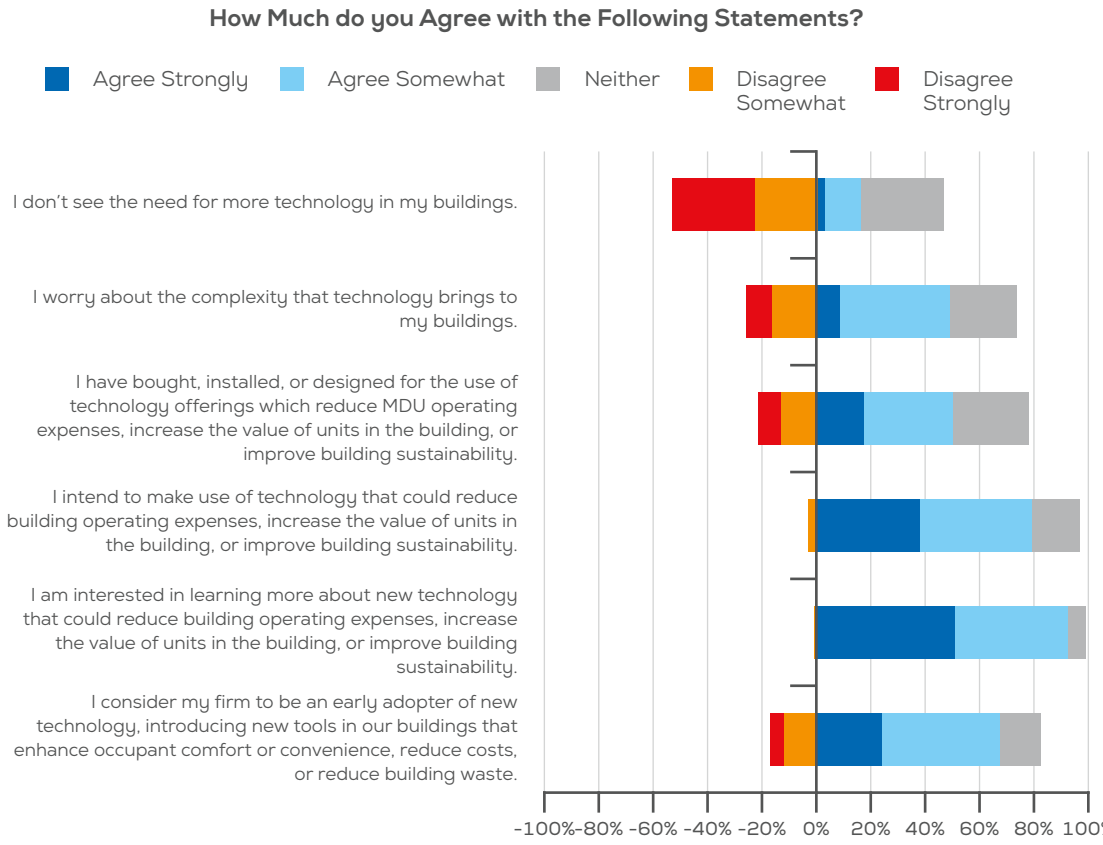


Multi-Dwelling Unit Owner, Manager, Developer, Builder, Engineer or Architect Survey Results

1. Which of the following best describes your relationship with the buildings market? (If respondent chooses at least (b), they qualify for study)

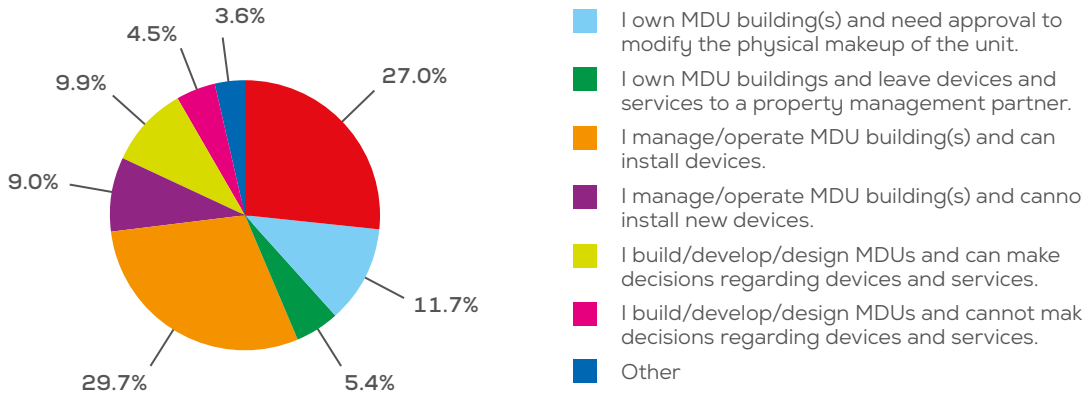


2. How much do you agree with the following statements?



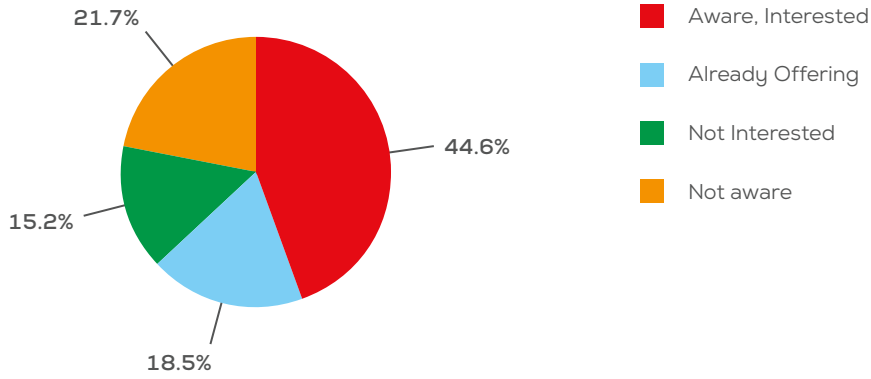
3. Please select the statement that best describes your ability to make decisions regarding new devices and services in multi-dwelling units (MDUs)

New Devices and Decision Making



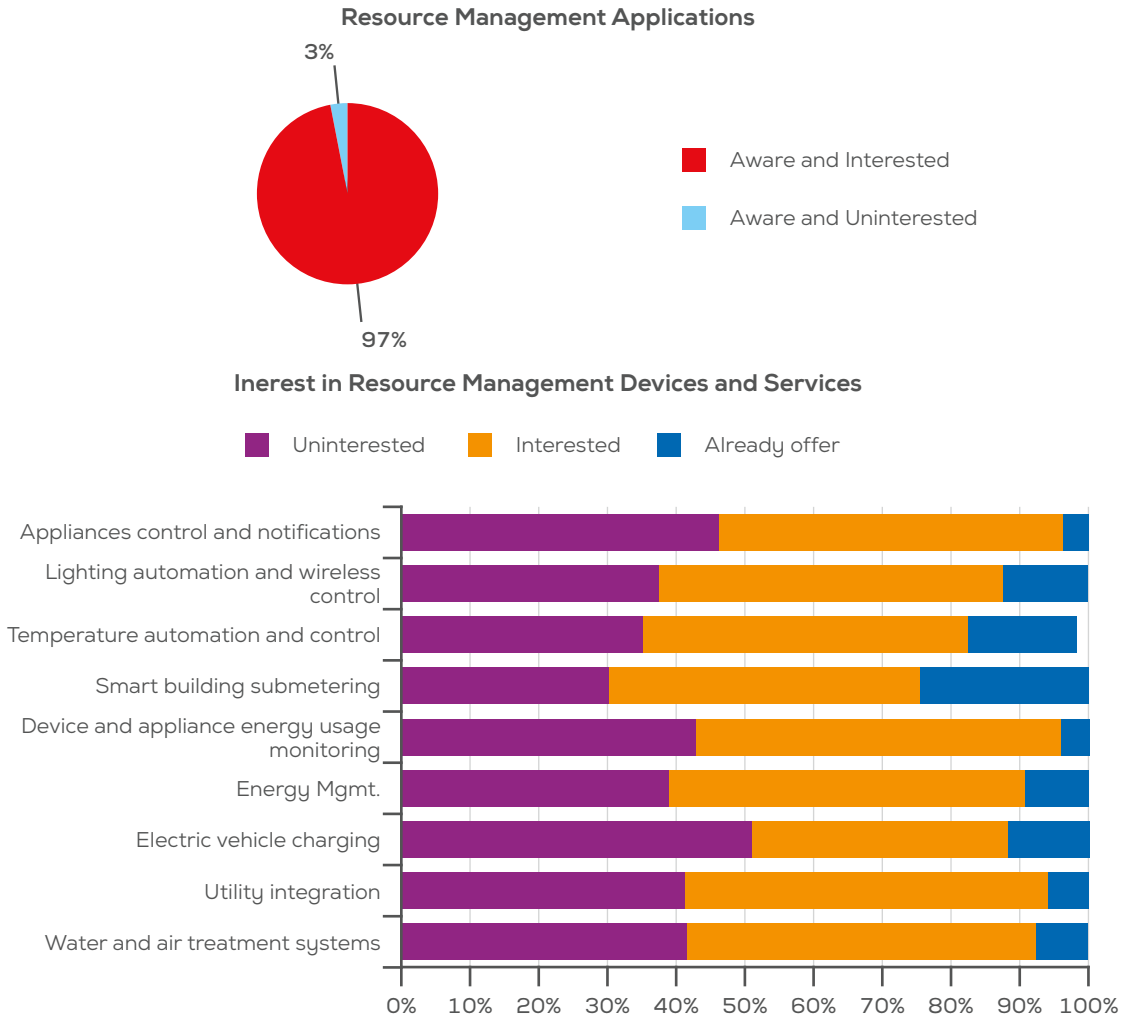
4. Please select the option that best describes your awareness of connected devices and services

Connected Devices and Services in MDUs you Develop, Own or Operate

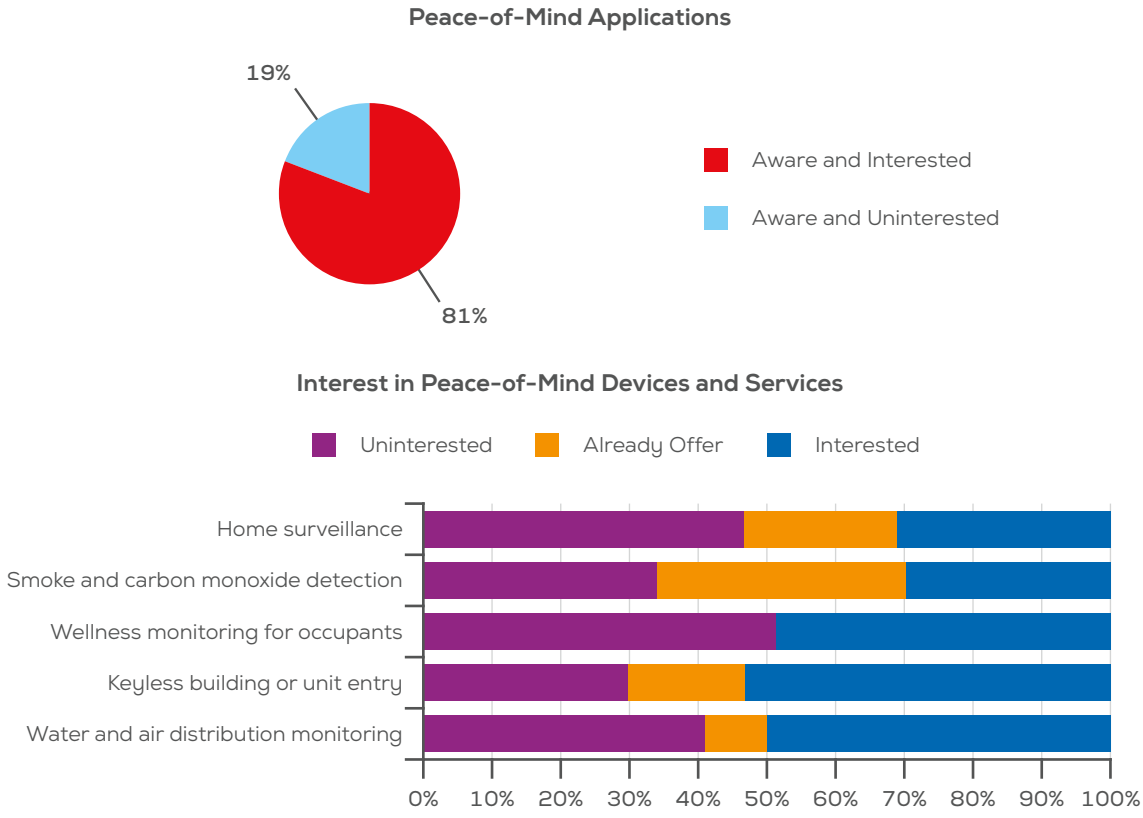


5. **NOTE: This question is broken into 5 different "yes" or "no" questions** -
Please indicate if you are interested in or already are using or offering the following applications in MDUs: (check list of applications)
   a) Energy and Water Waste Reduction
   b) Safety and Security
   c) Building and Equipment Visibility and Management
   d) Occupant Engagement
   e) Data Brokering and Contract Management

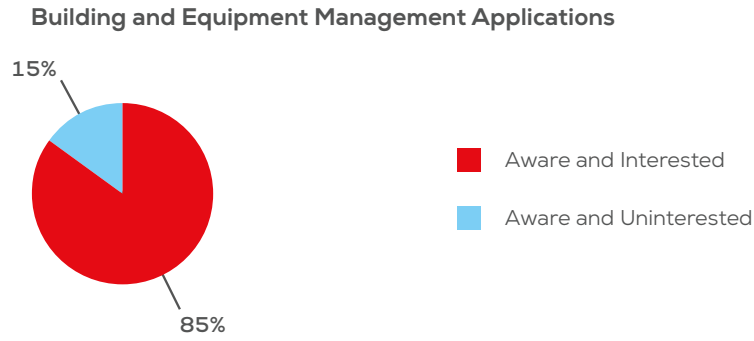
6. [for those who select (a) to 2] Please indicate your awareness of, interest in, and adoption of Energy and Water Waste Reduction use cases enabled by connected devices:

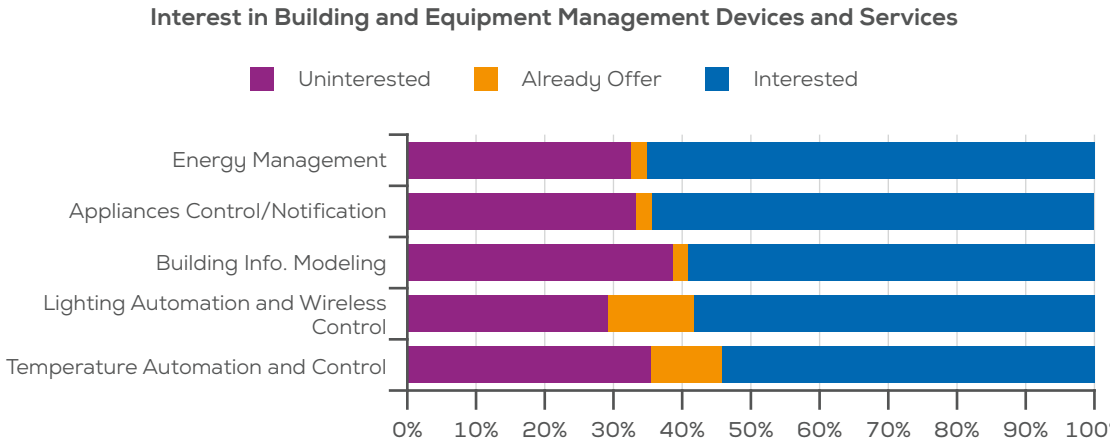


7. [for those who select (d) to 2] Please indicate your awareness of, interest in, and adoption of "Peace-of-Mind" use cases enabled by connected devices:

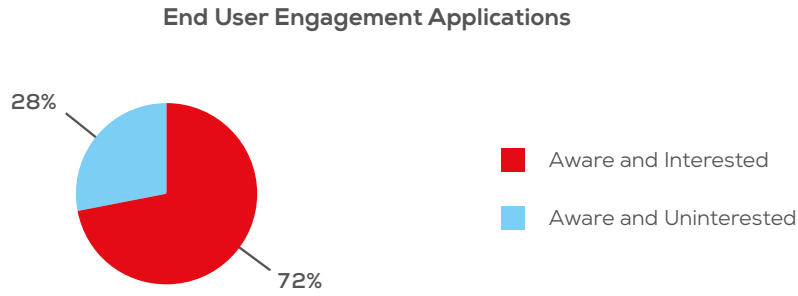


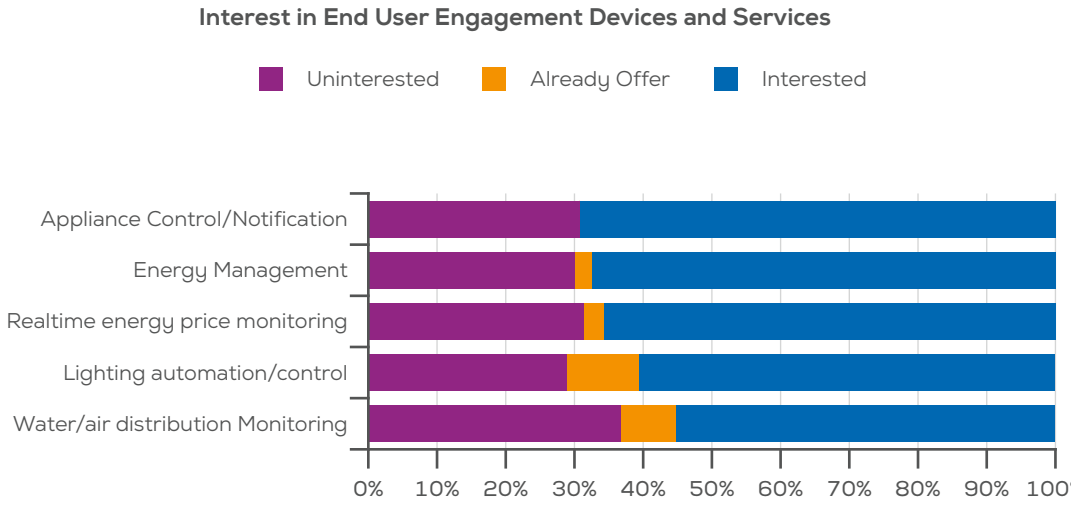
8. [for those who select (e) to 2] Please indicate your awareness of, interest in, and adoption of "Building and Equipment Visibility and Management" use cases enabled by connected devices:





9. [for those who select (c) to 2] Please indicate your awareness of, interest in, and adoption of "Occupant Engagement" use cases enabled by connected devices:

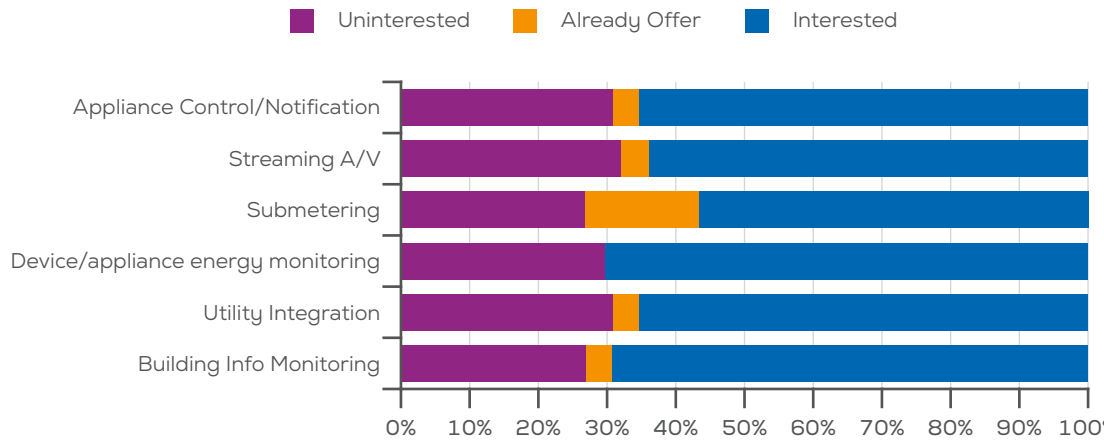




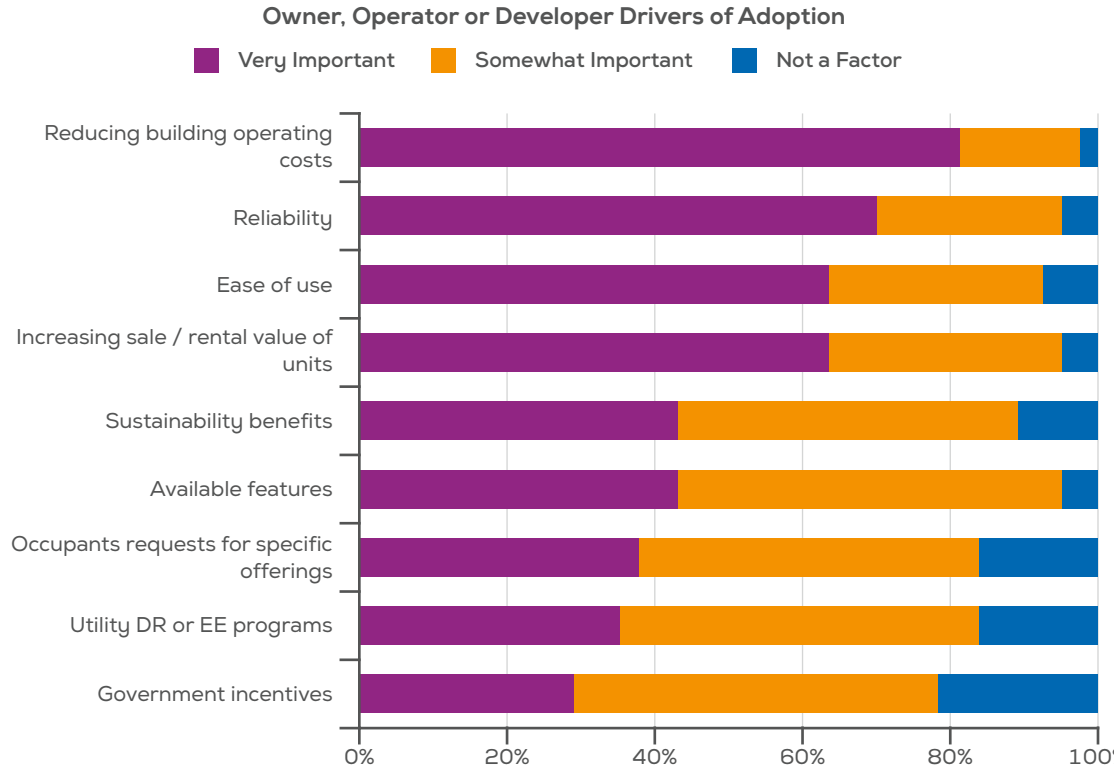
10. [for those who select (b) to 2] Please indicate your awareness of, interest in, and adoption of Data Brokering and Contract Mgmt. use cases enabled by connected devices:

Operator Interest in Data Brokering Applications

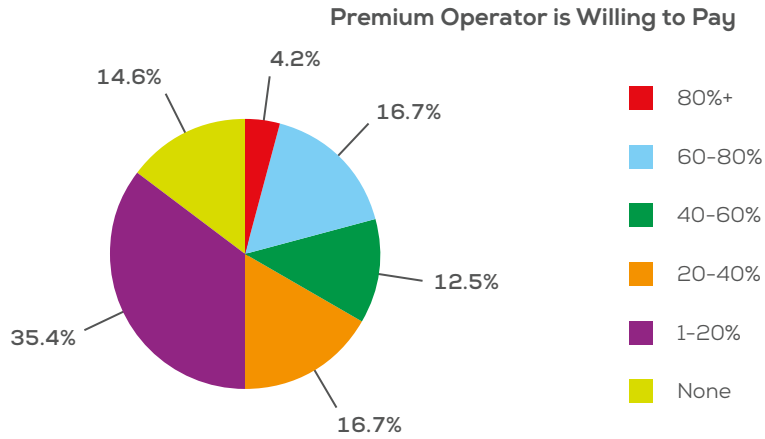
Interest in Data Brokering Devices and Services



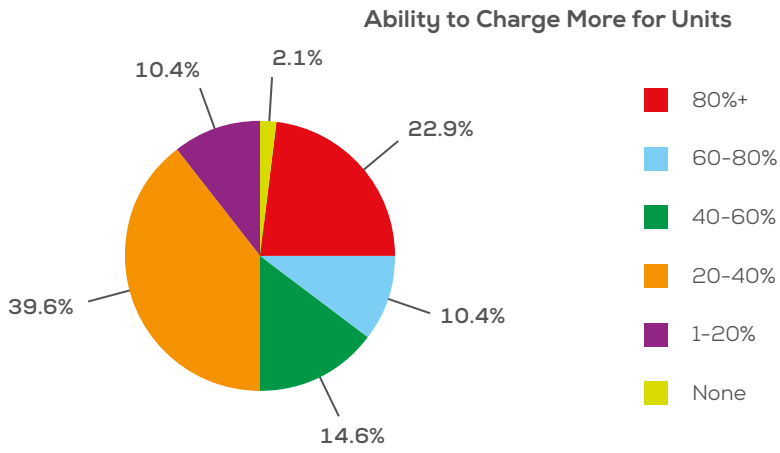
11. How influential were the following criteria in convincing you to select these applications for your MDU(s)? (5 = very important, 3 = somewhat important, 1 = not a factor)



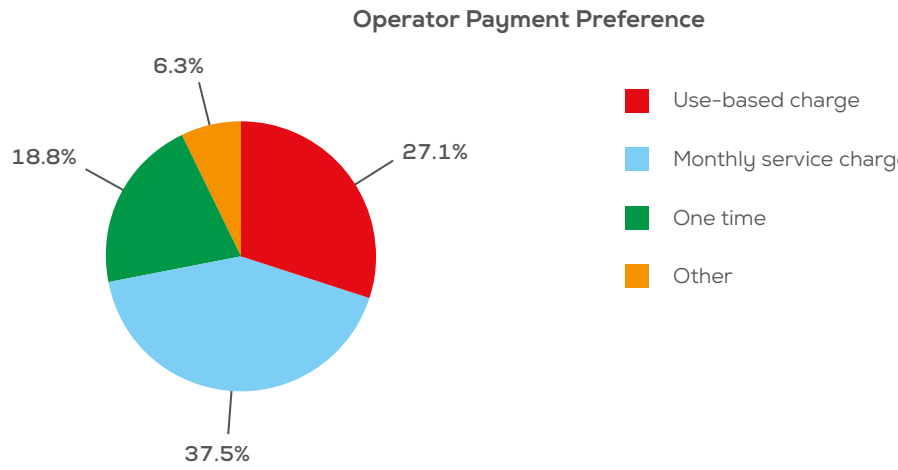
12. Are you/would you be willing to pay more for devices that enable these offerings? (drop down)



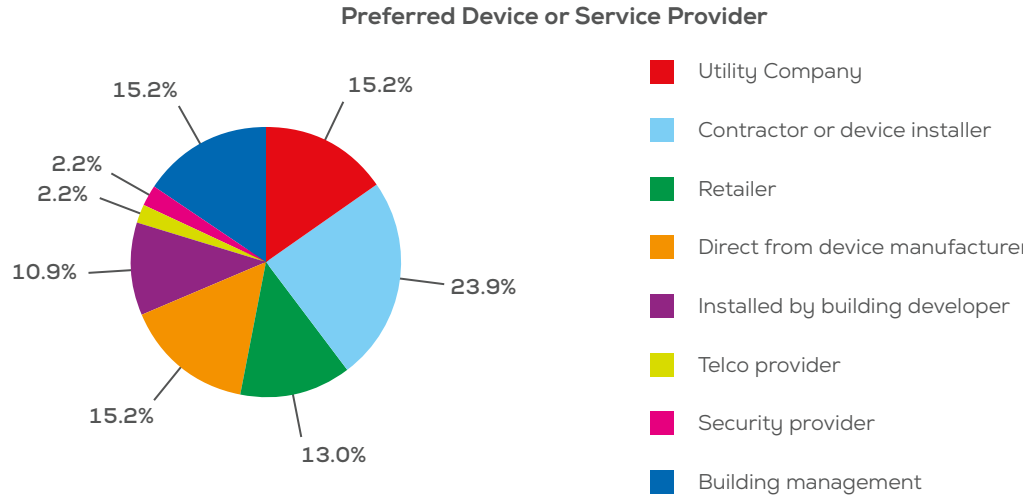
13. Are you/would you be able to charge more for units that feature these offerings? (drop down)



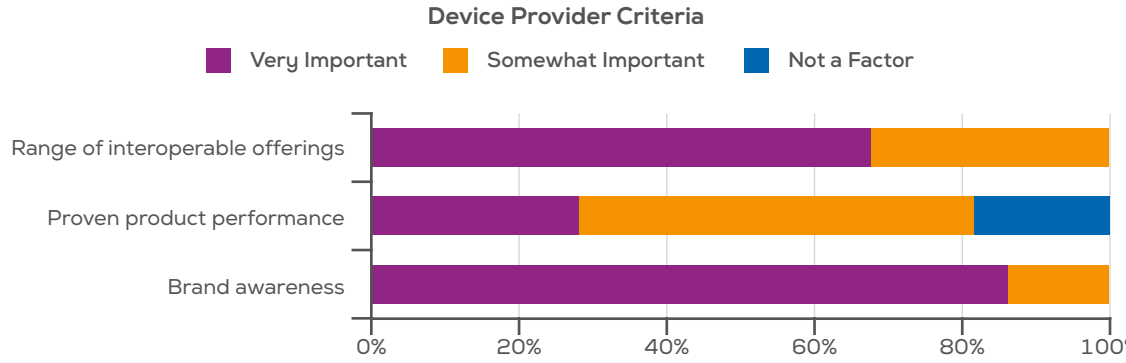
14. If a third-party does/were to provide these offering to your building, how would you prefer paying for them? (drop down)



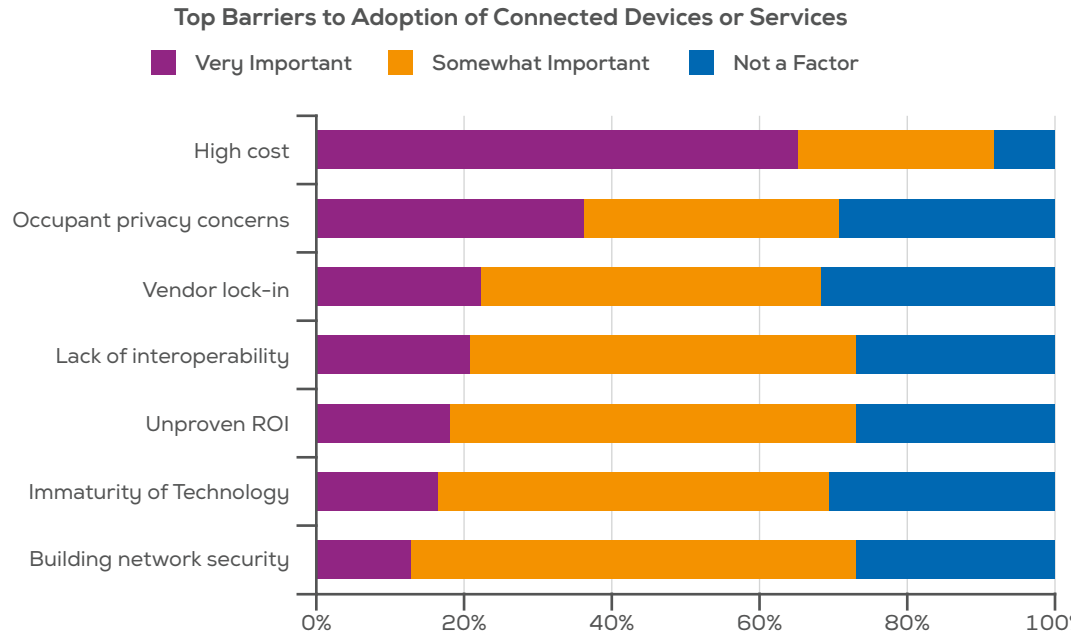
15. How did you come to adopt this device/service? (drop down)



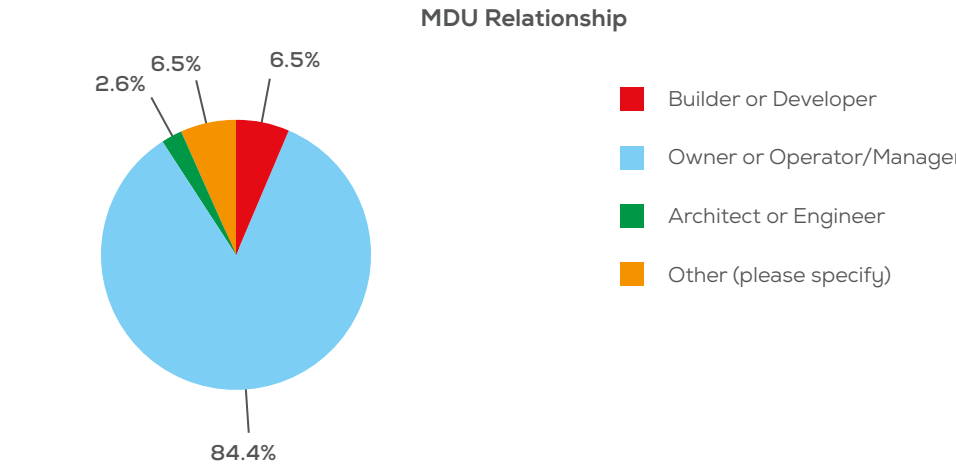
16. How important are the following criteria in selecting the provider of connected devices or services? (5 = very important, 3 = somewhat important, 1 = not a factor)



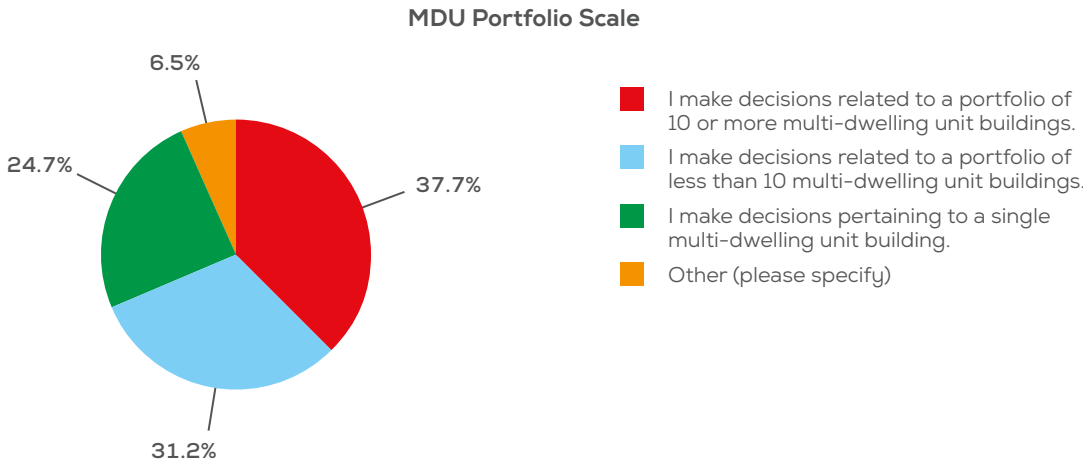
17. How much of a barrier are the following criteria to you utilizing connected offerings in MDUs you are associated with? (5 = very important, 3 = somewhat important, 1 = not a factor)



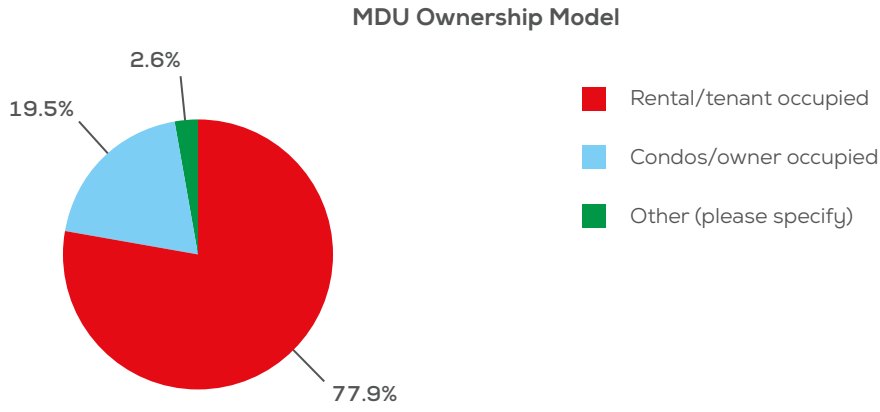
18. Which of the following best describes your role in MDUs?



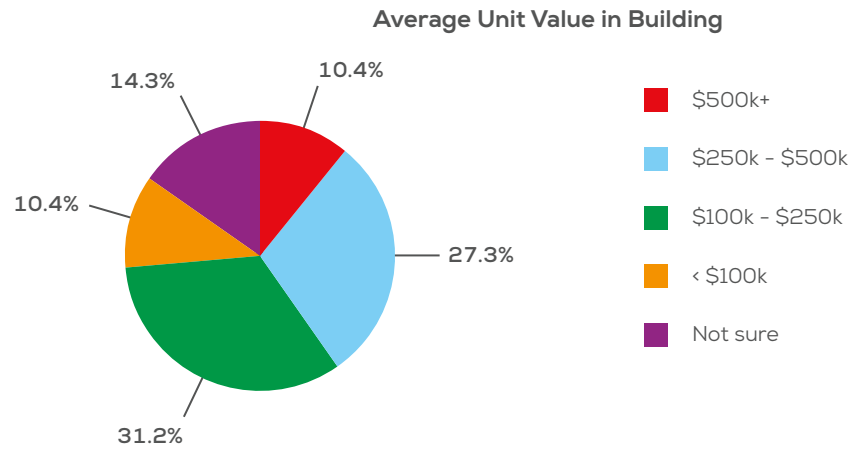
19. Which best describes your relationship with these MDU buildings?



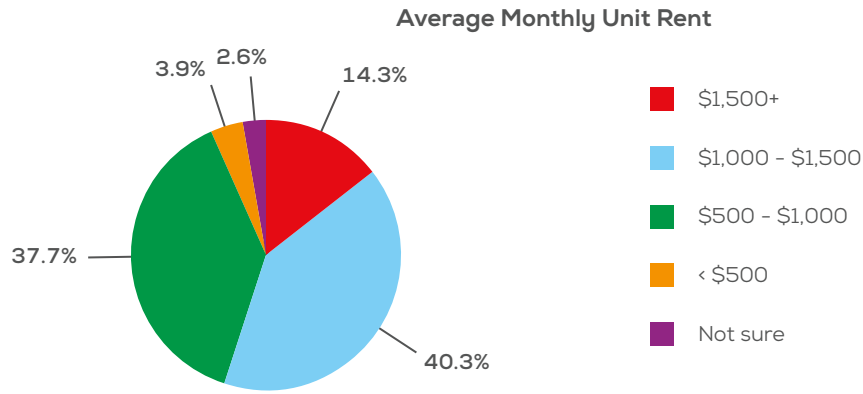
20. What is the ownership model in these MDU buildings? (drop down list)



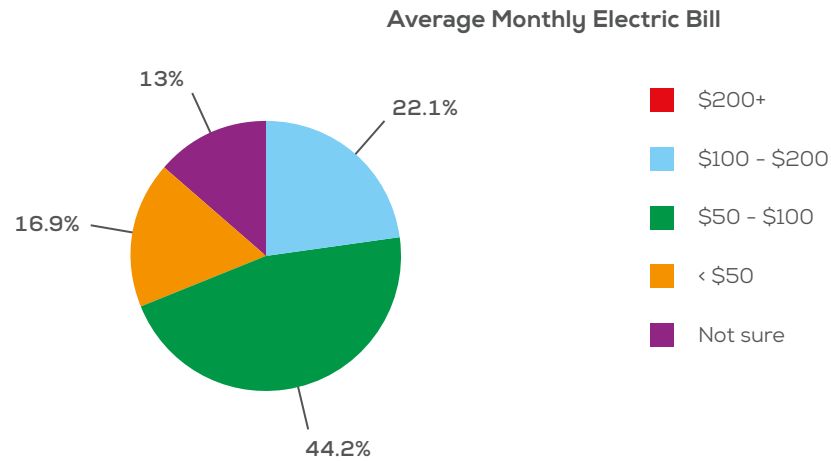
21. What is the average value of individual units in these MDUs buildings? (drop down list)



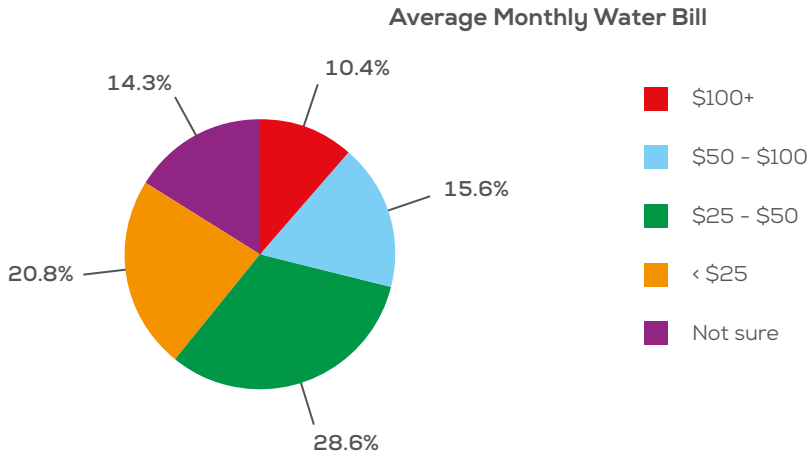
22. What is the average monthly rent (including building fees) in these MDU buildings? (drop down list)



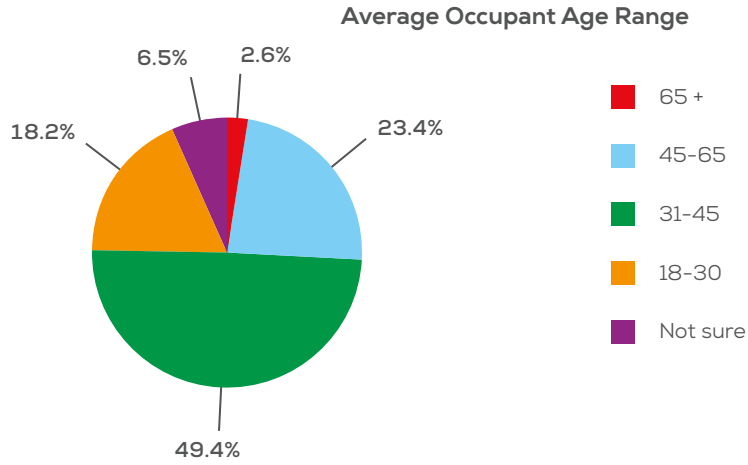
23. What is the average monthly electric utility bill for units in these MDU buildings? (drop down list)



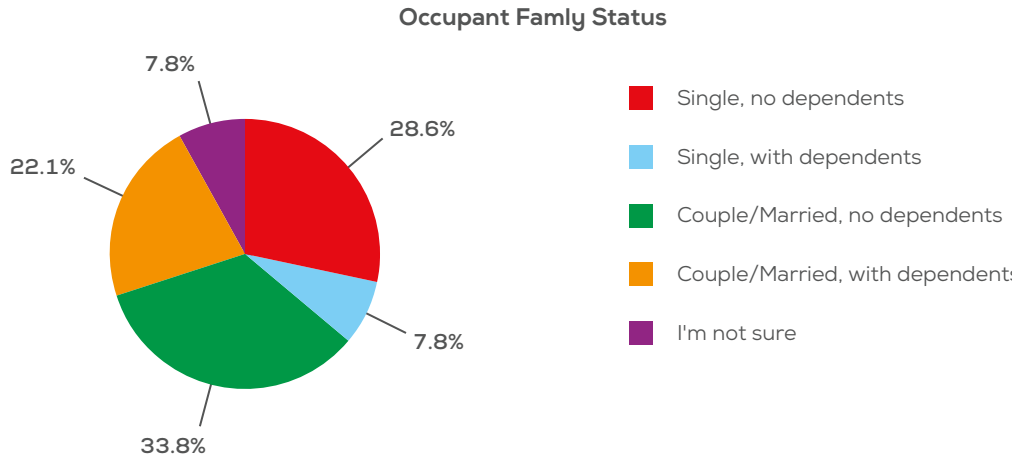
24. What is your average monthly water utility bill for units in these MDU buildings? (drop down list)



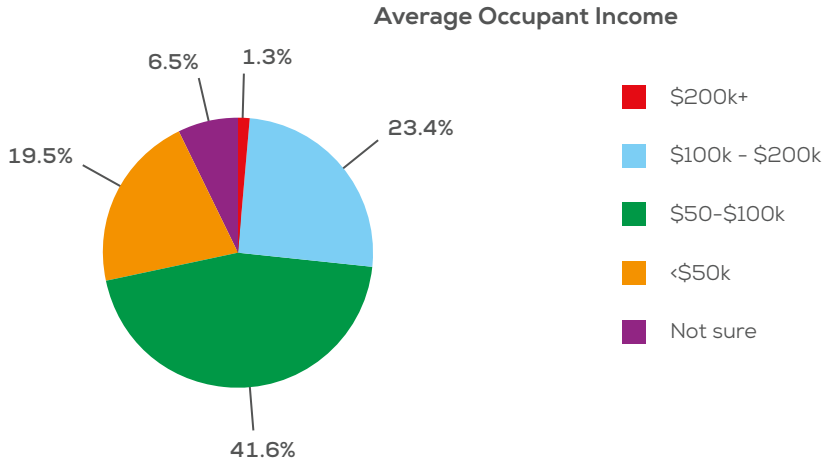
25. What is the average age of target MDU occupants? (drop down list)



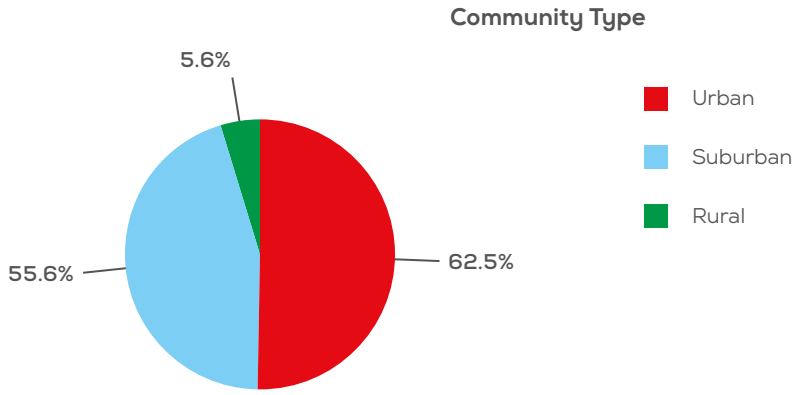
26. What is the typical family status of target MDU occupants? (drop down list)



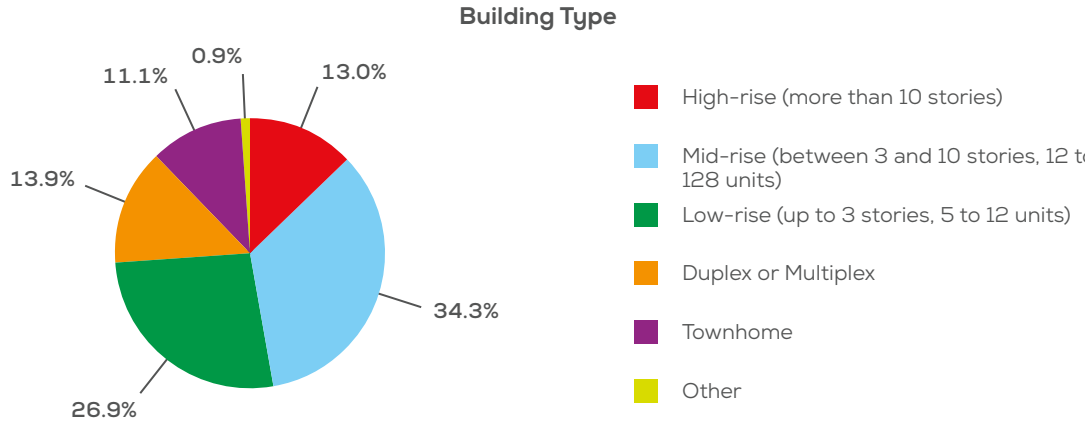
27. What is the typical household income of target MDU occupants? (drop down list)



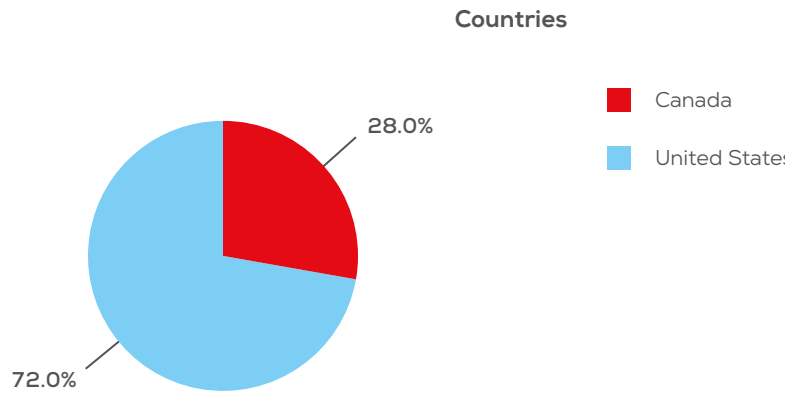
28. What type of community are these MDU buildings in? (check list)



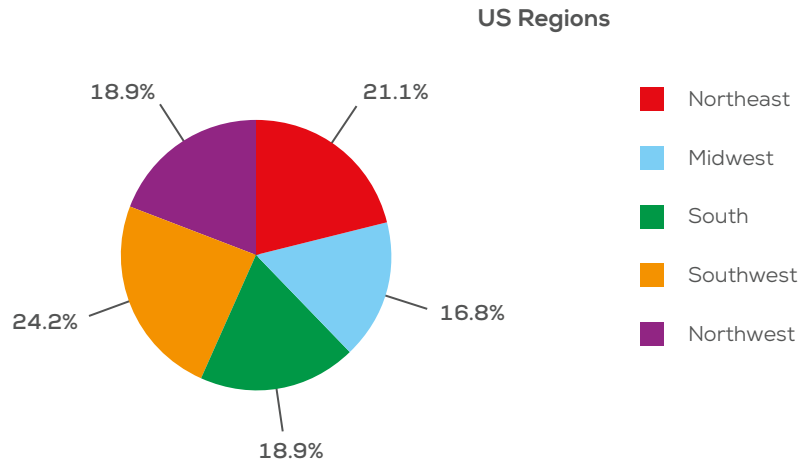
29. What is the building type of these MDUs? (check list)



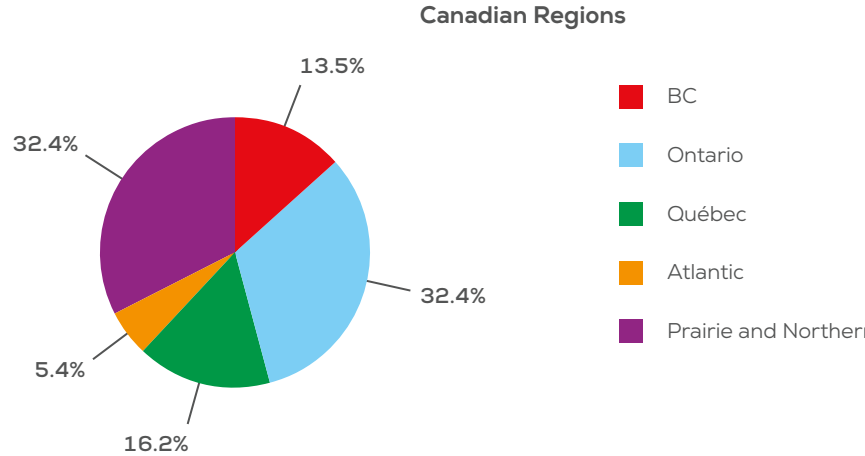
30. In which country does your firm own, manage, develop or design MDUs?



31. In which US regions does your firm own, manage, develop or design MDUs?

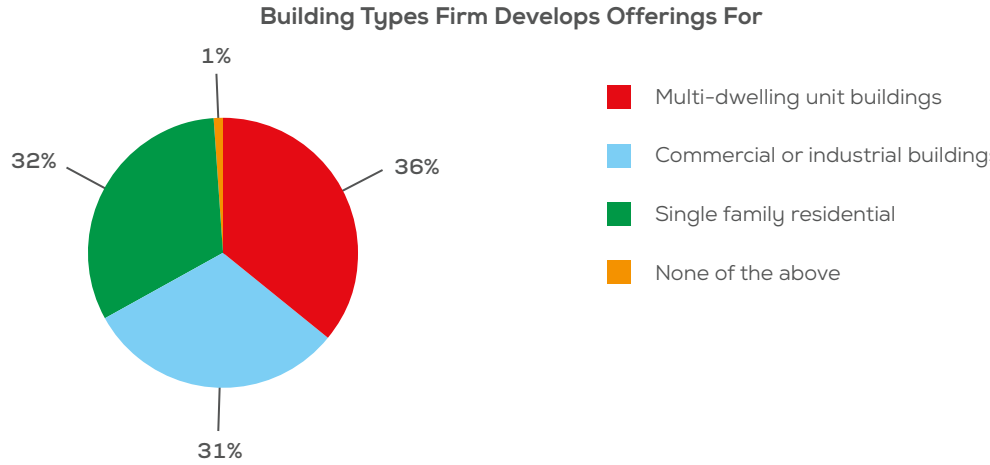


32. In which Canadian provinces does your firm own, manage, develop or design MDUs?

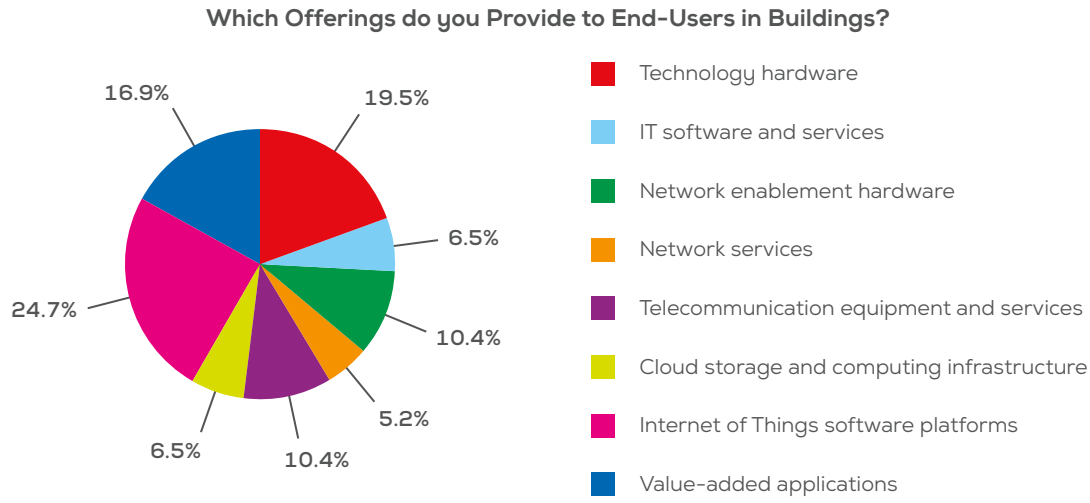


Information Technology, Network Hardware and Services, Software Platforms and Applications Providers Survey Results

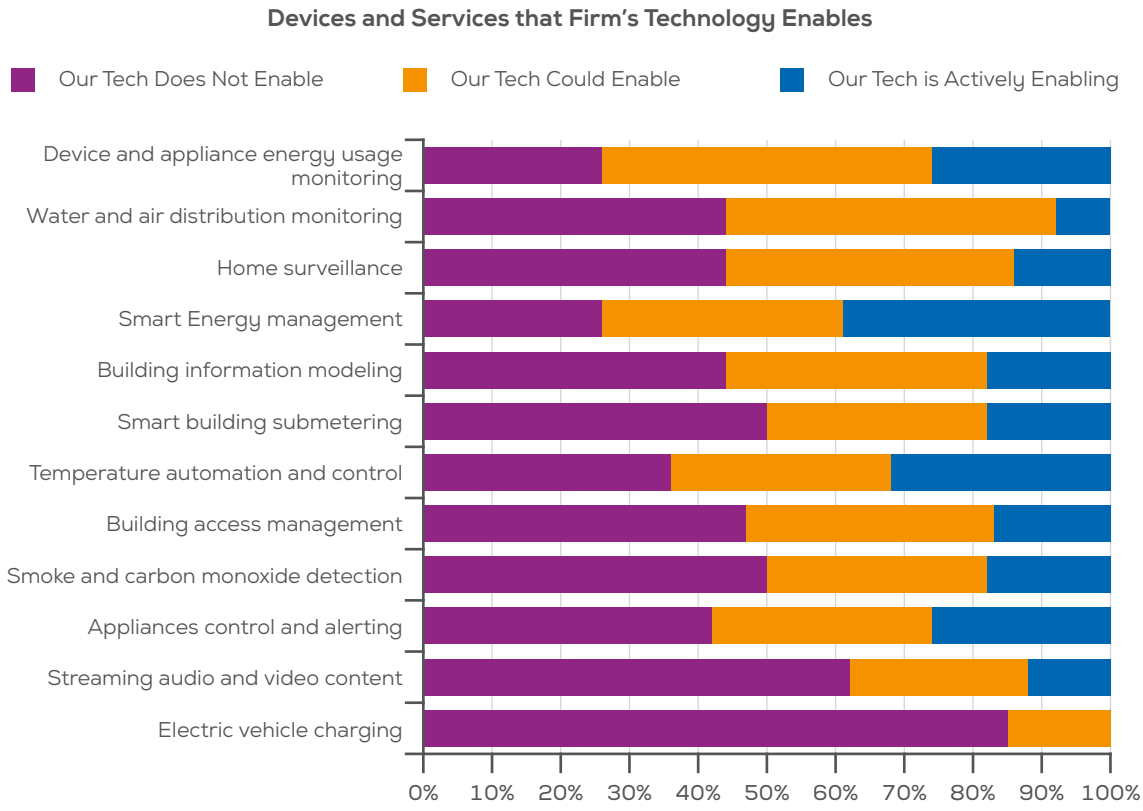
1. Which building types does your firm develop offerings for? (Select all that apply, as long as respondent chooses (b) they move on)



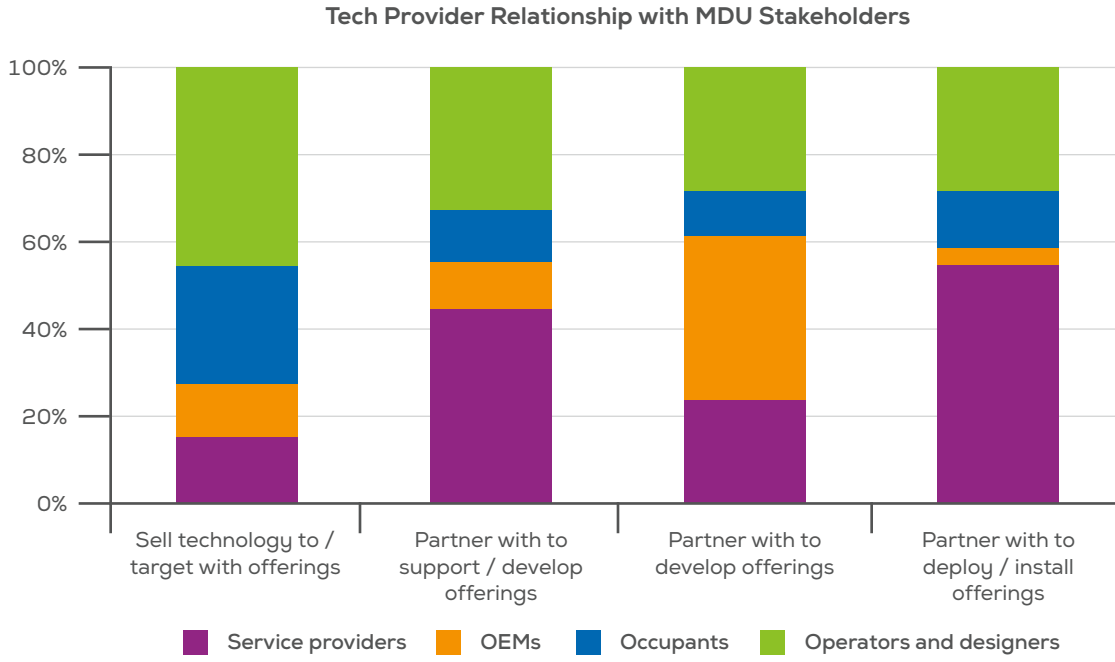
2. Which of the following offerings is your firm currently providing or planning to provide to end-users in buildings? (Select all that apply, as long as respondent chooses one they move on)



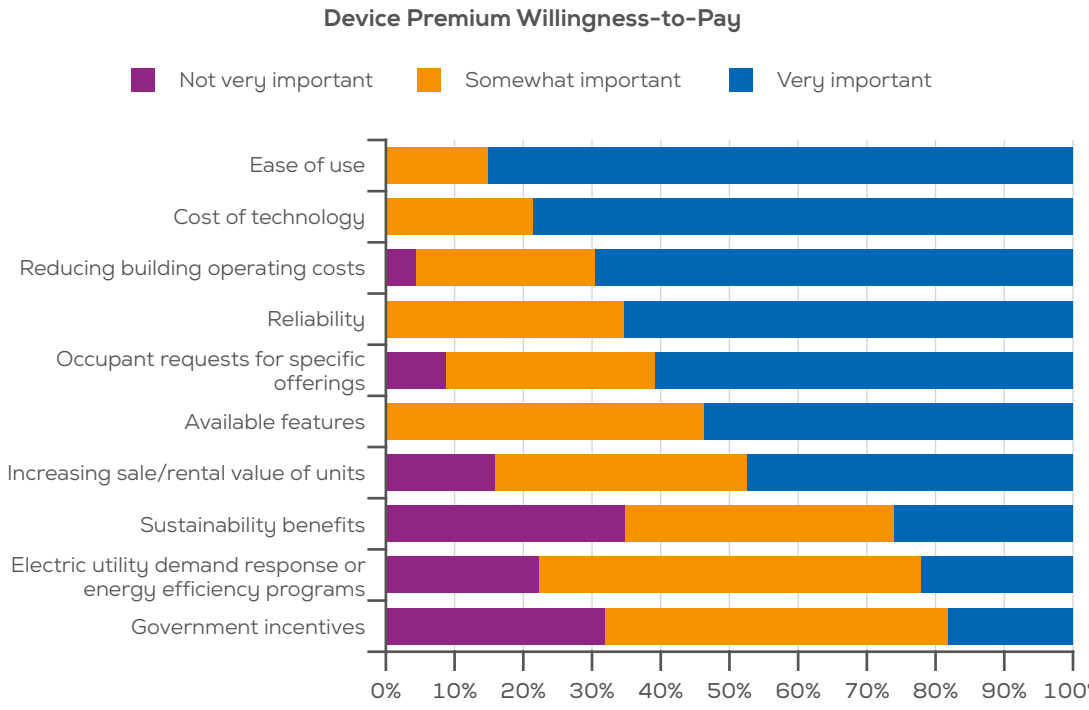
3. Which (of the below listed) devices and services does your technology enable in MDUs? (drop down)



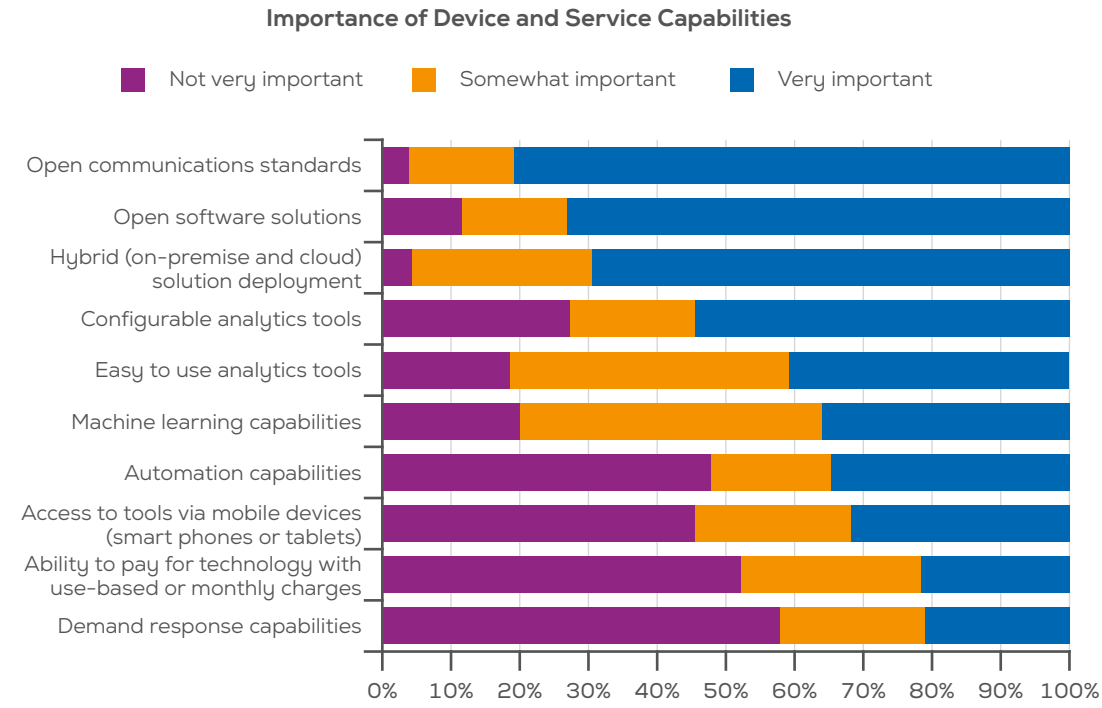
4. What is your relationship with MDU occupants, owner/operators, OEMs, and service providers?



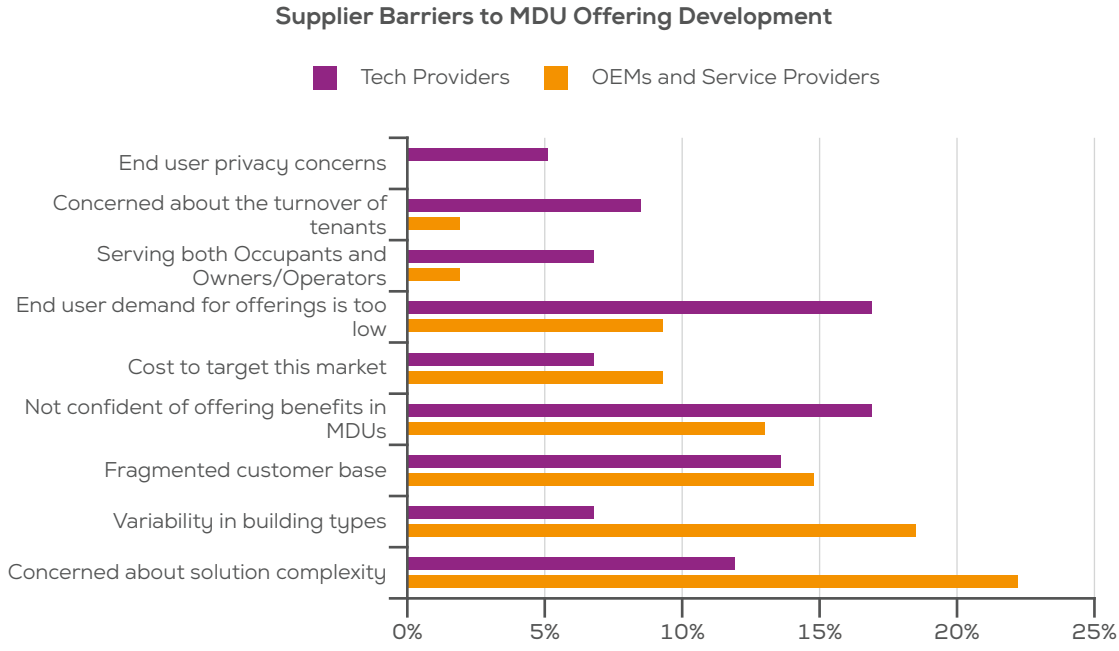
5. How influential were the following criteria in convincing customers to purchase your firm's technology? (5 = very important, 3 = somewhat important, 1 = not a factor)



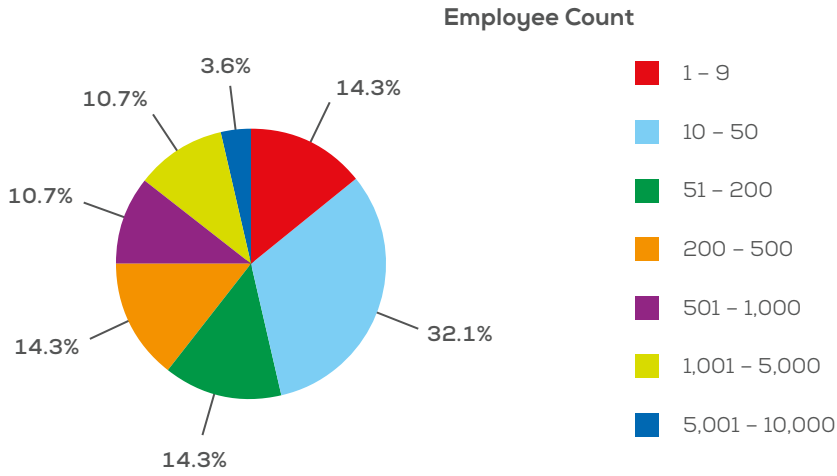
6. How important are the following criteria to customers your firm targets with technology enabling this application? (5 = very important, 3 = somewhat important, 1 = not a factor)



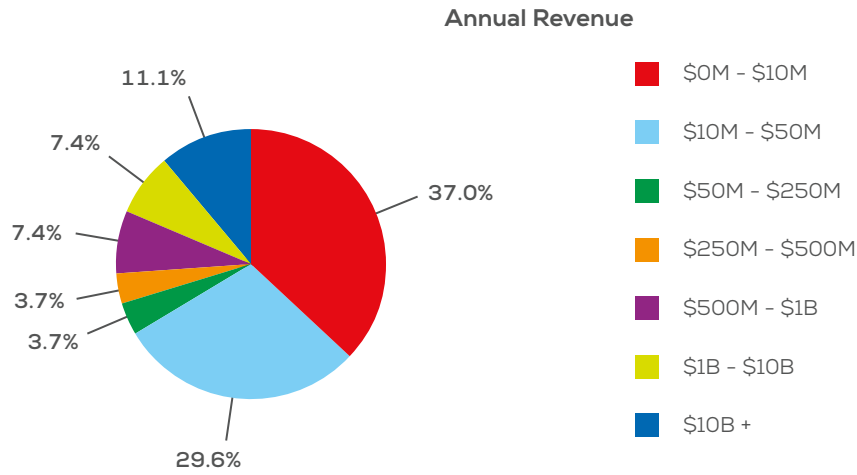
7. If you do not plan to supply technology to the MDU market, please select all factors that influence your firm's decision



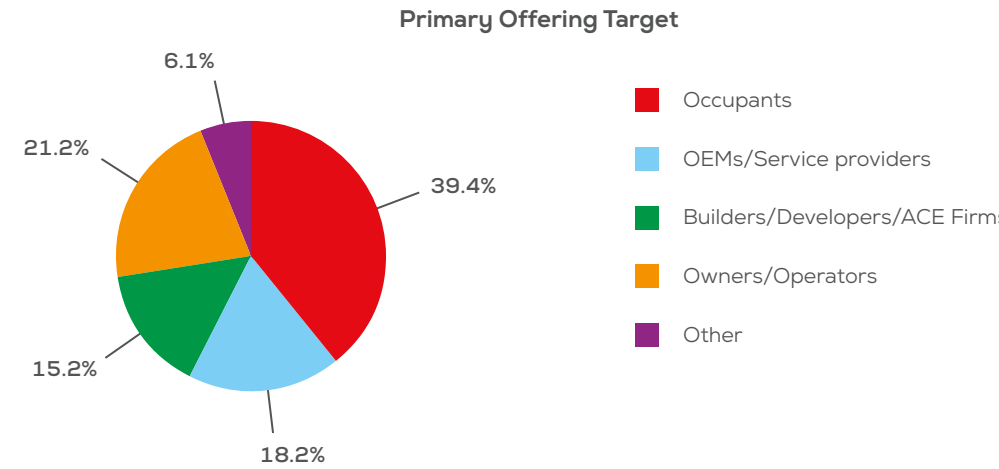
8. How large is your firm?



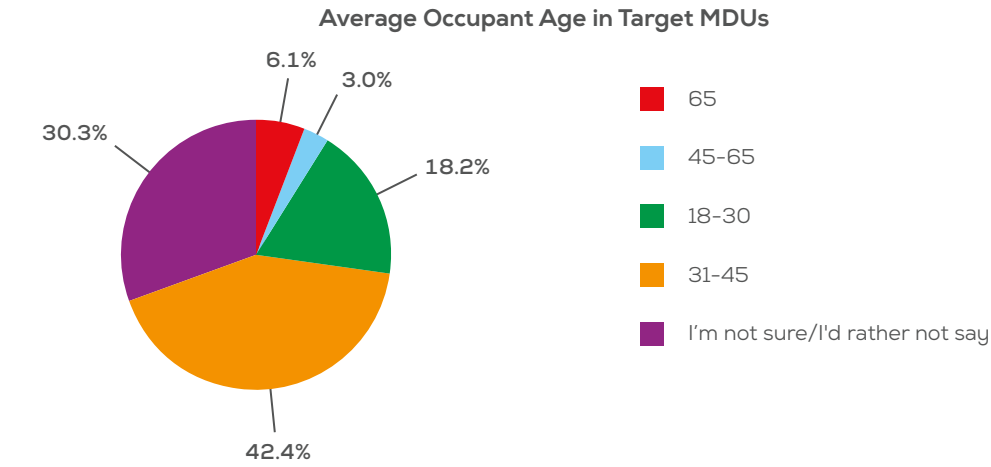
9. How large is your firm? – revenue



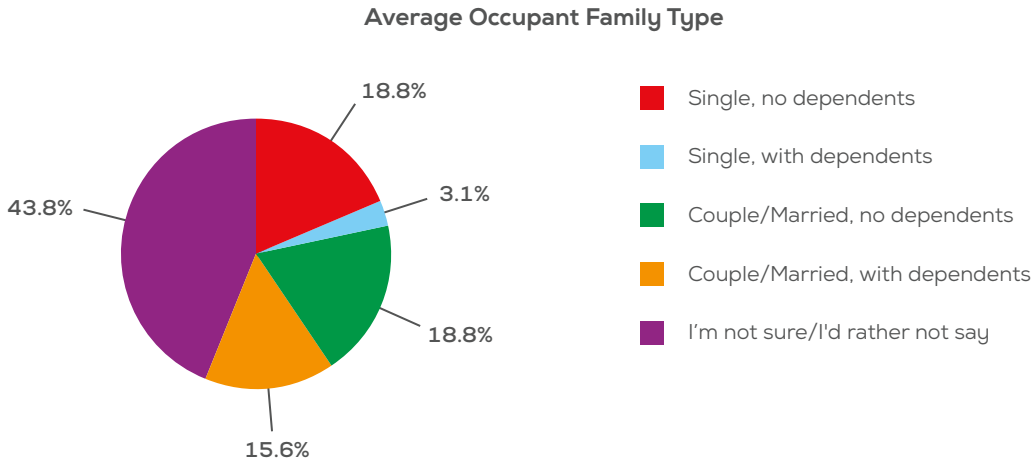
10. Who are the target end customers of your technology offerings?



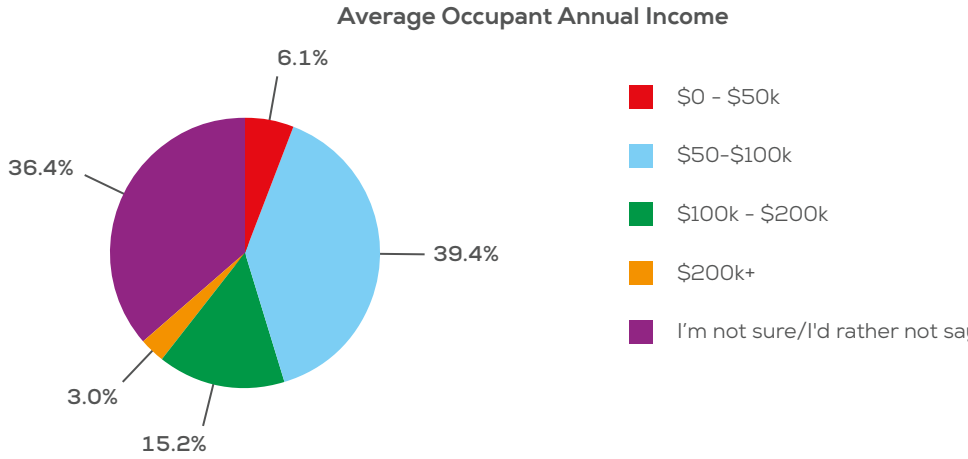
11. What is the target age of occupants in MDUs which have adopted your technology offerings? (drop down list)



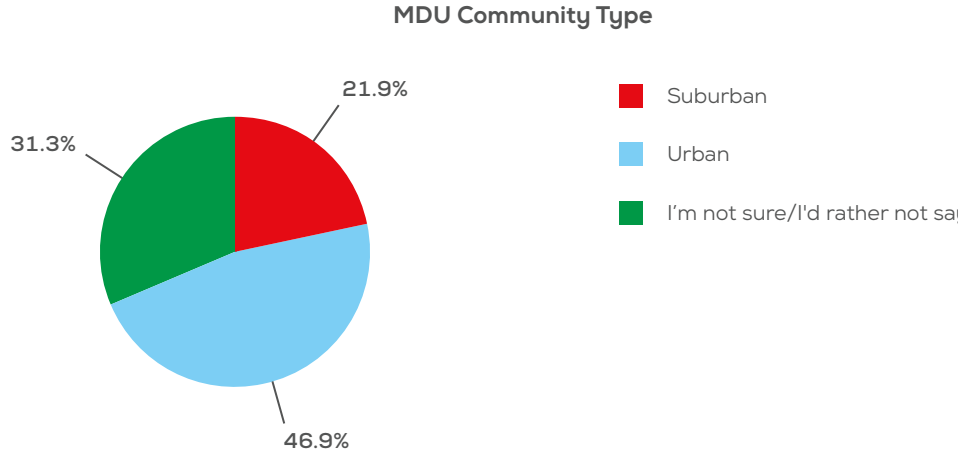
12. What is the typical family status in MDUs which have adopted your technology offerings? (drop down list)



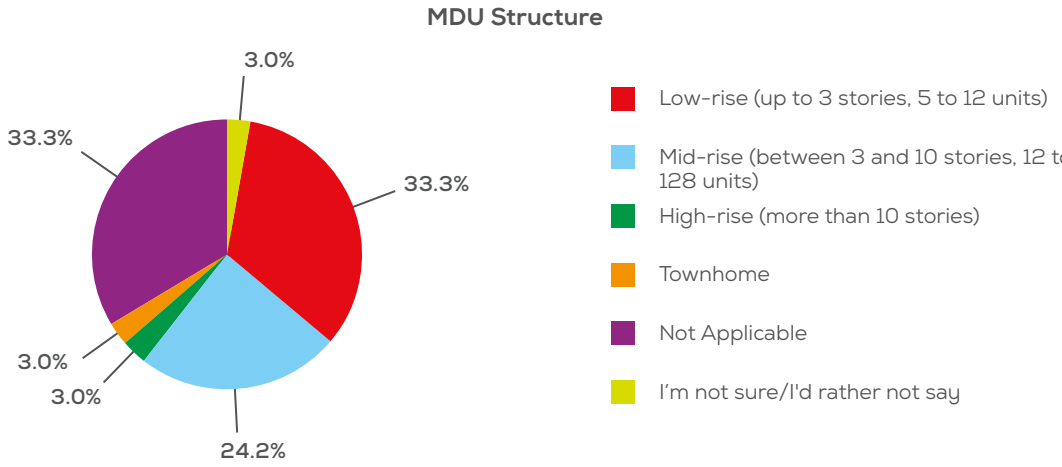
13. What would you estimate is the most common household income that have adopted your offerings? (drop down list)



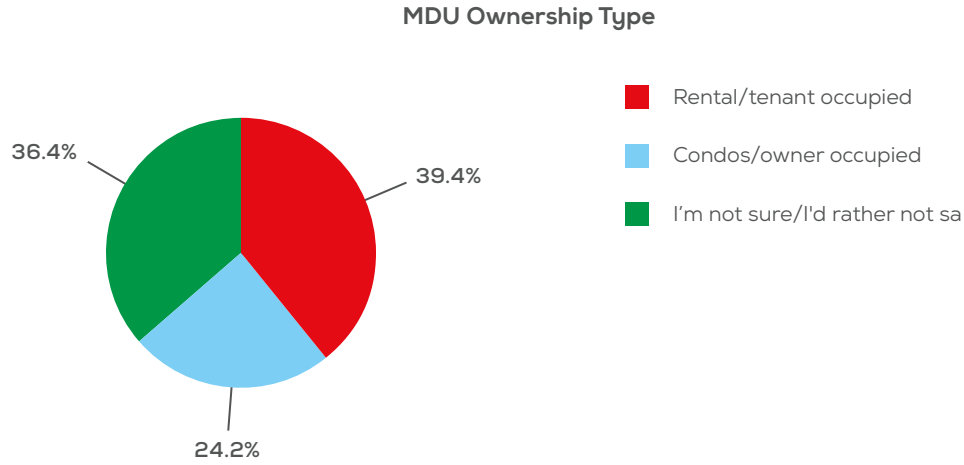
14. What type of community are MDUs in which have adopted your technology offerings? (drop down list)



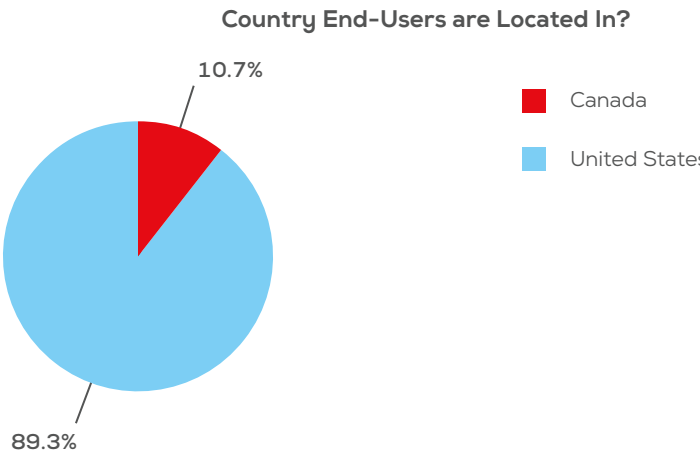
15. What is the building type of MDUs which have adopted your technology offerings? (drop down list)



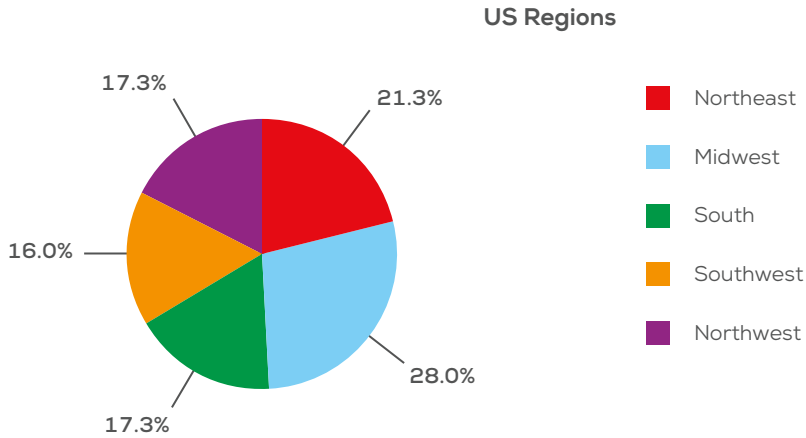
16. What is the ownership model of MDUs which have adopted your technology offerings? (drop down list)



17. Which country are the MDUs located in that have adopted your technology offerings?

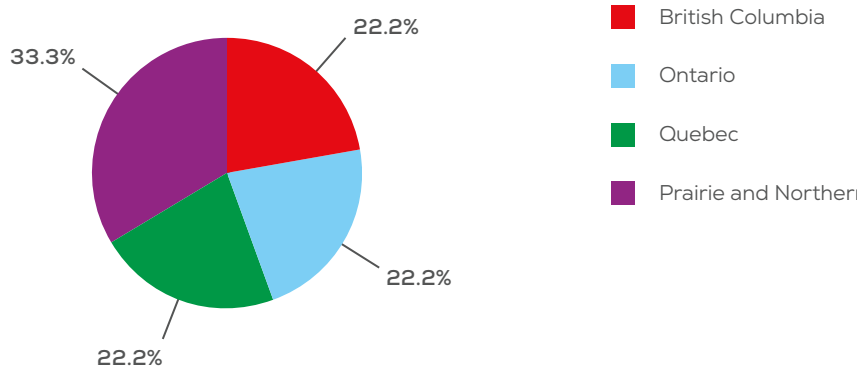


18. In which US states does your firm sell technology offerings?



19. In which Canadian provinces does your firm sell technology offerings?

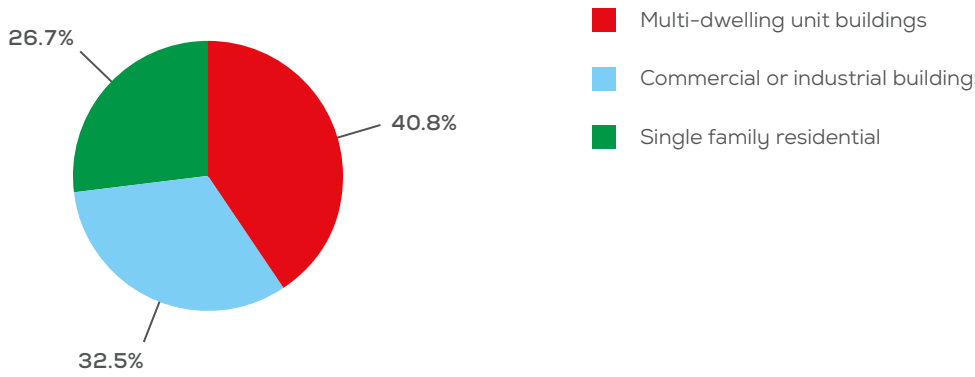
Canadian Regions



Original Equipment Manufacturers and Service Providers

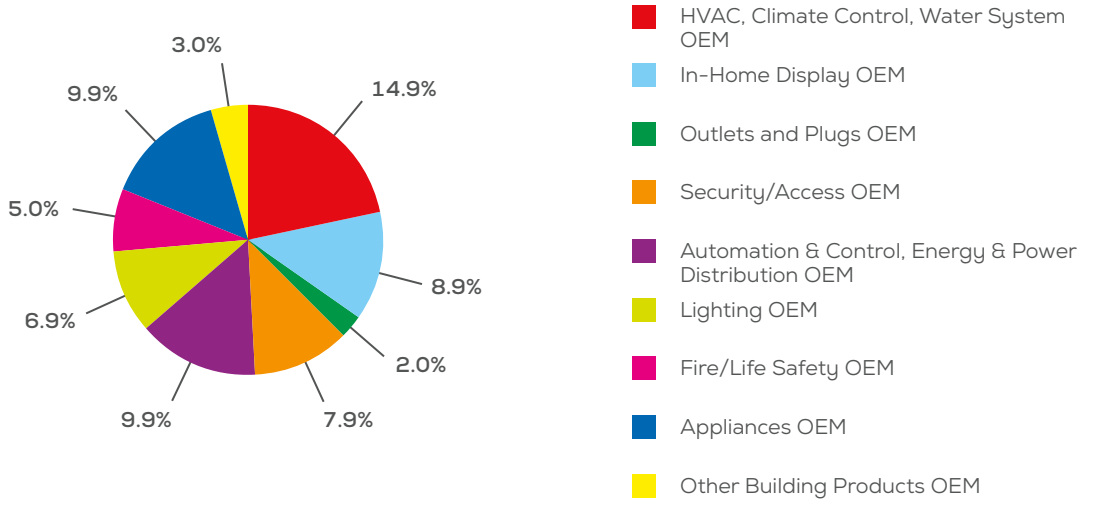
1. Which building types does your firm manufacture equipment for or provide services to? (Select all that apply, as long as respondent chooses (b) they move on)

Building Types Firm Develops Offerings for:



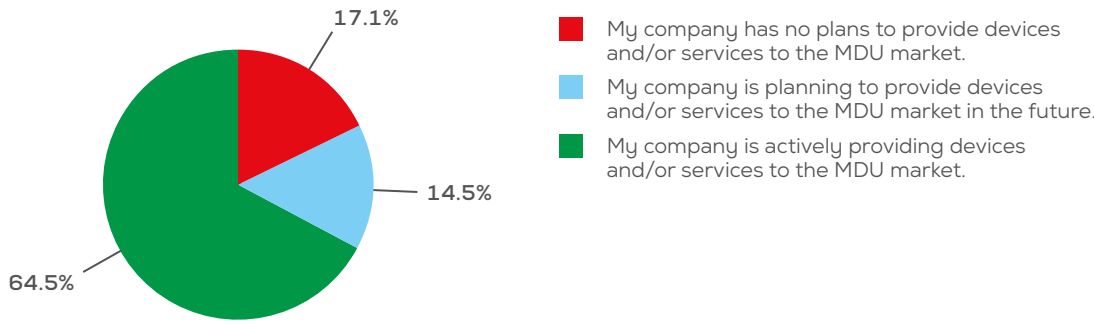
2. Which of the following best describes your role with regards to multi-dwelling unit (MDU) buildings? (Select all that apply, as long as respondent chooses one qualify)

Which Offerings do you Provide to End-Users in Buildings?



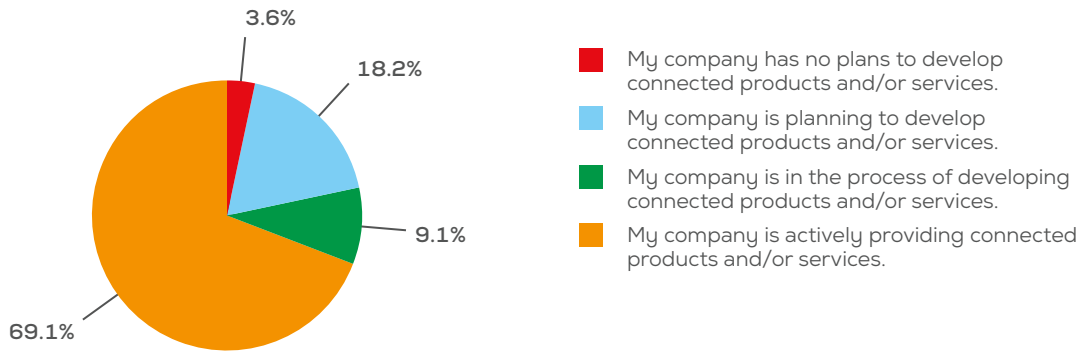
3. Which statement most closely reflects your firm's relationship with the MDU market

Relationship with MDU Market

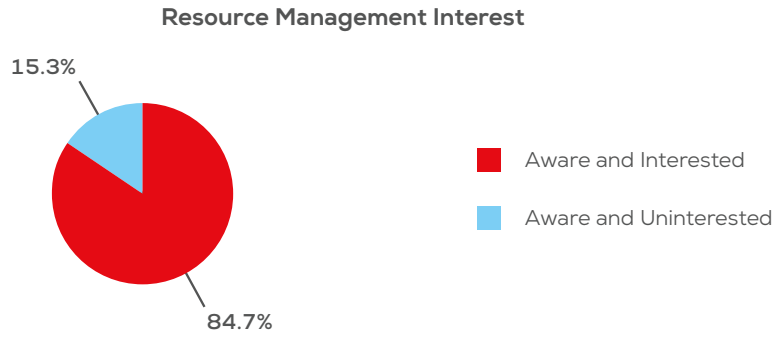


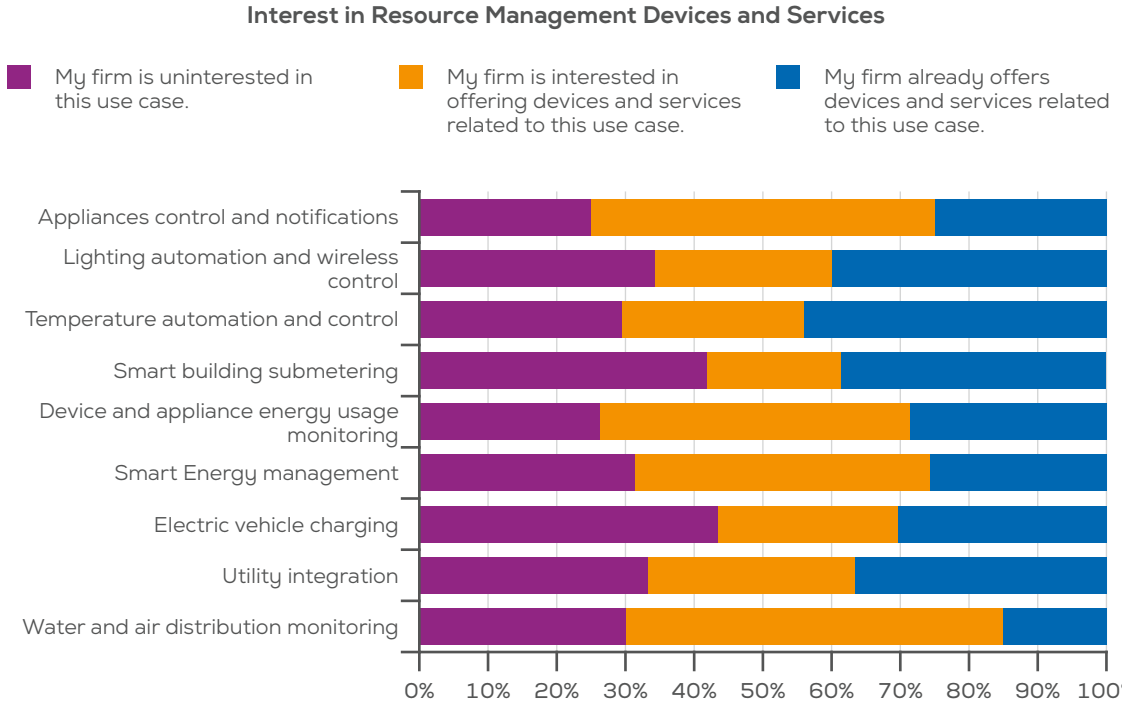
4. Which statement most closely reflects your firm's progress in developing and providing connected products and/or services?

Progress in Developing Connected Offerings

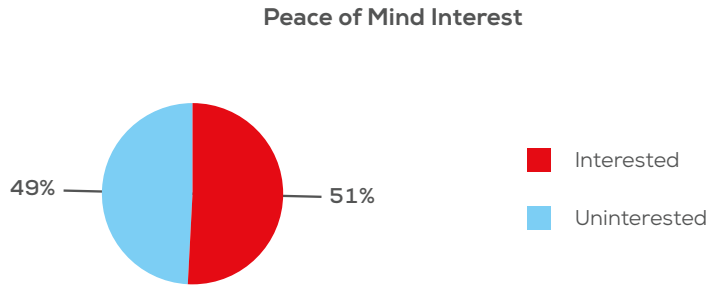


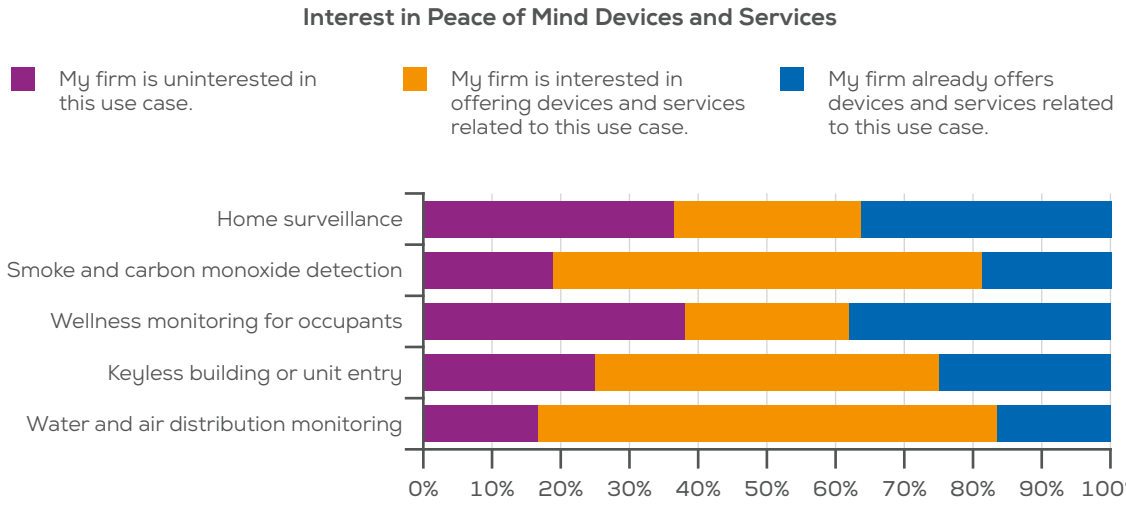
5. Please indicate your awareness of, interest in, and current offerings related to Energy and Water Waste Reduction. use cases:





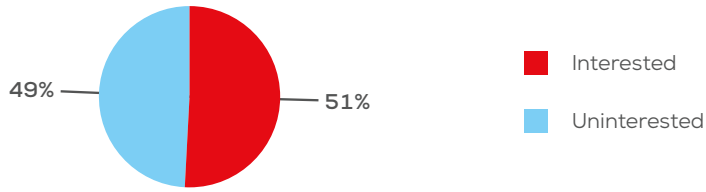
6. Please indicate your awareness of, interest in, and current offerings related to "Safety and Security" use cases enabled by connected devices:



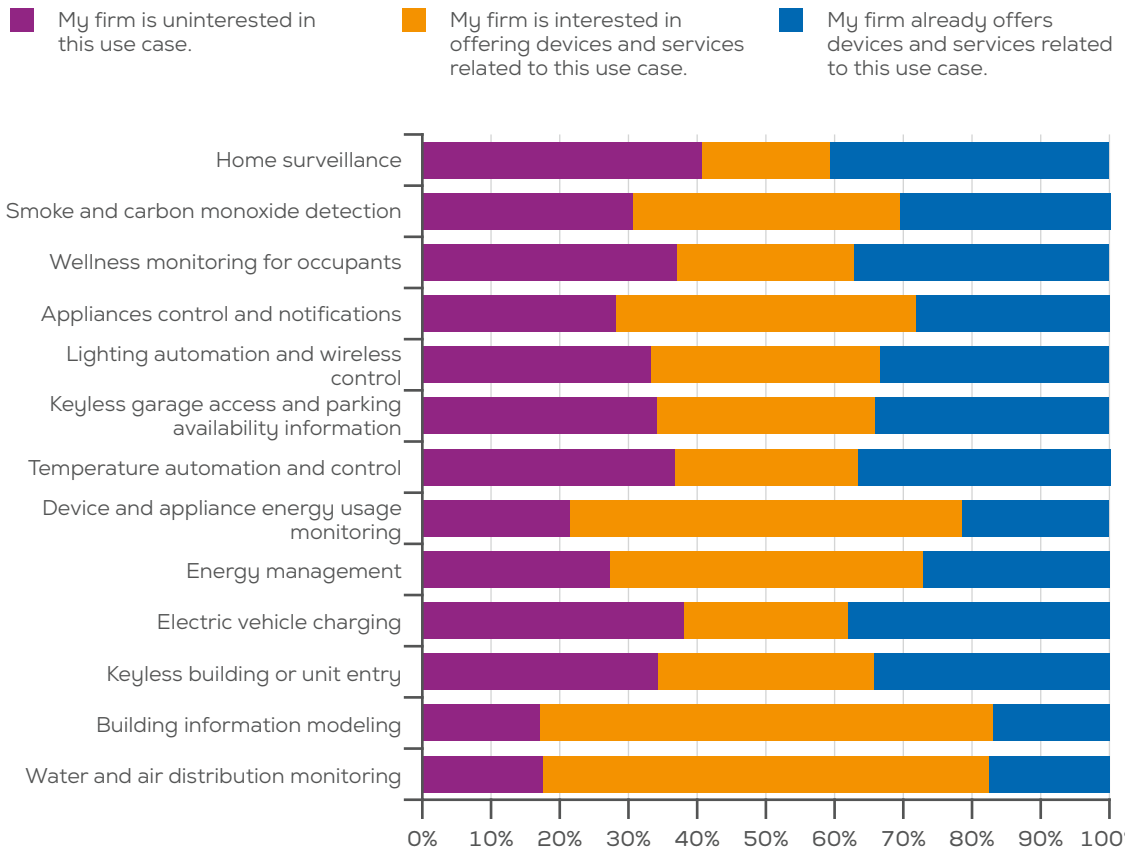


7. Please indicate your awareness of, interest in, and current offerings related to "Building and Equipment Visibility and Management" use cases enabled by connected devices:

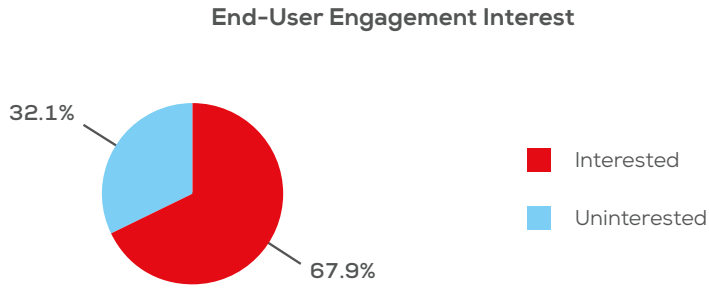
Building and Equipment Management Interest

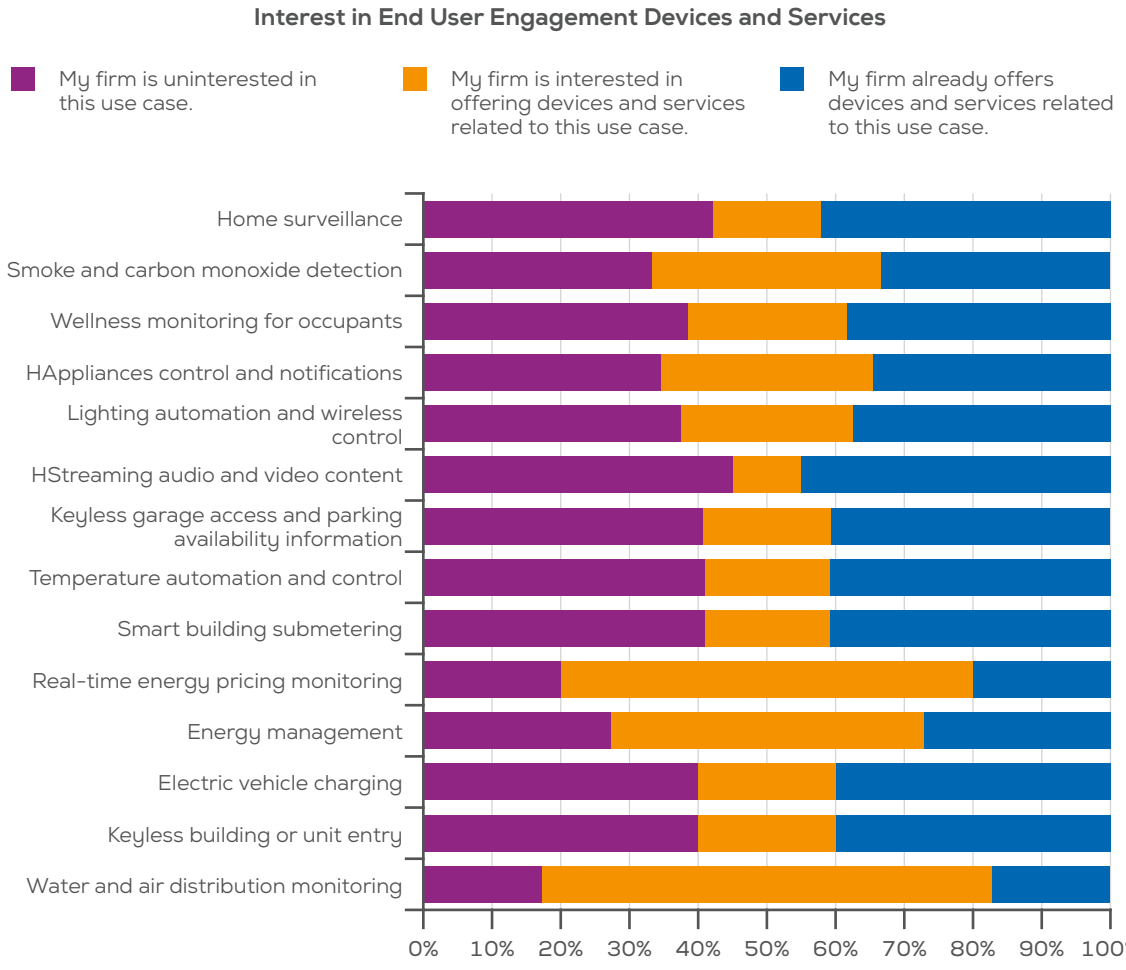


Device Premium Willingness-to-Pay



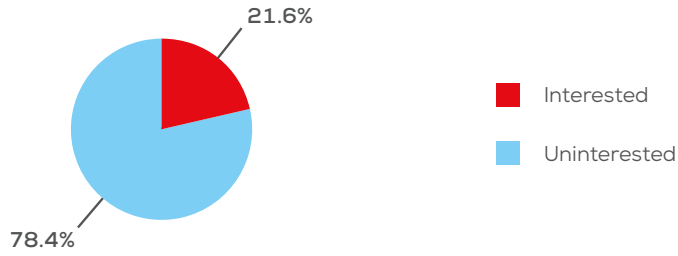
8. Please indicate your awareness of, interest in, and current offerings related to "End-User Engagement" use cases enabled by connected devices



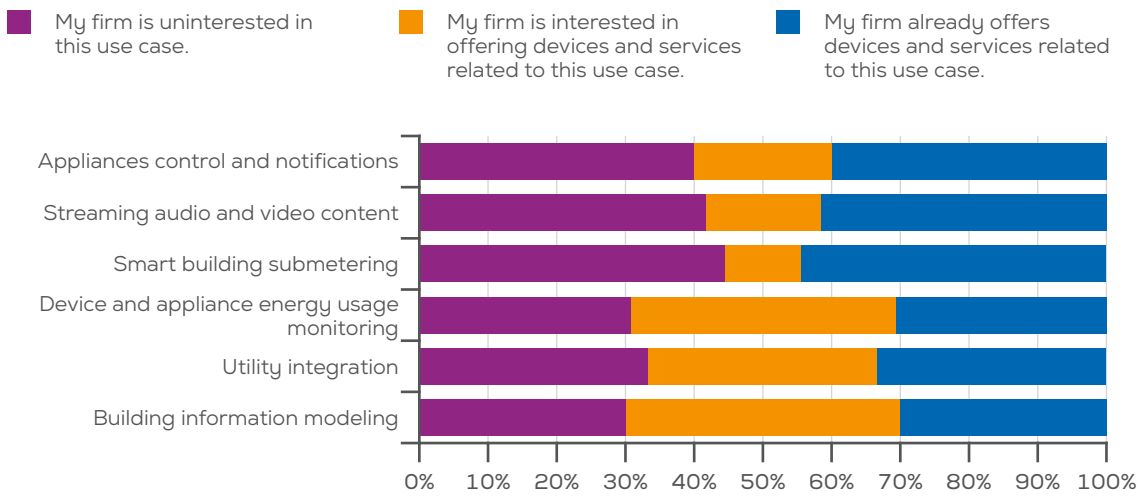


9. Please indicate your awareness of, interest in, and current offerings related to "Data Brokering and Contract Management" use cases enabled by connected devices:

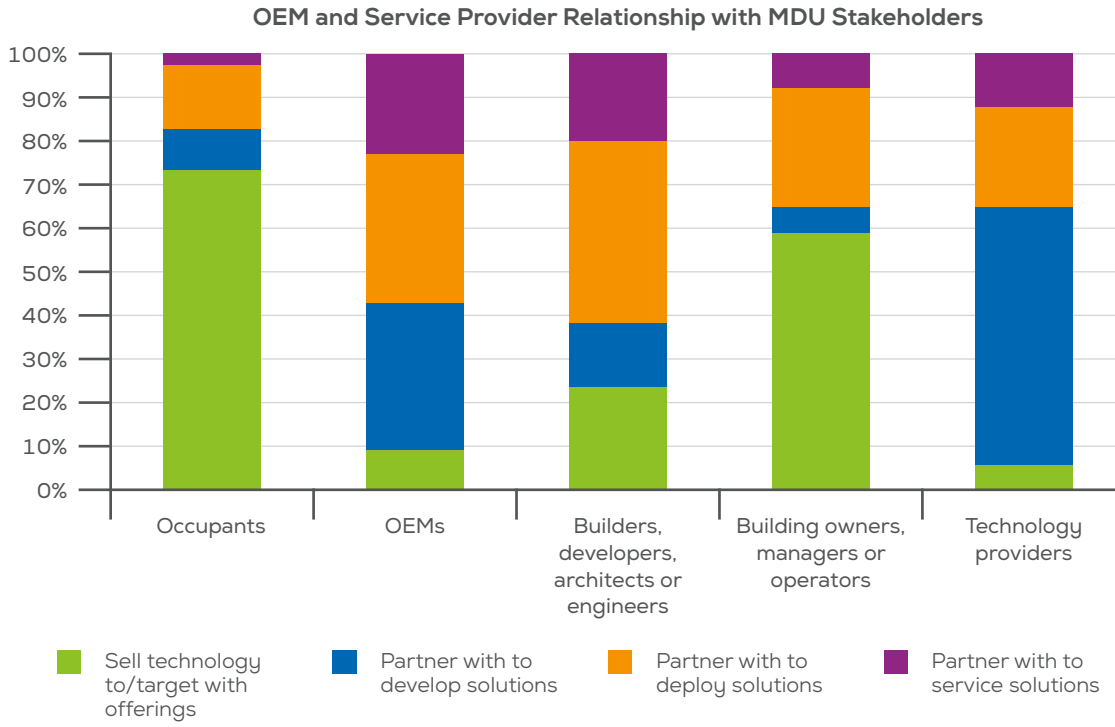
Data Brokering Interest



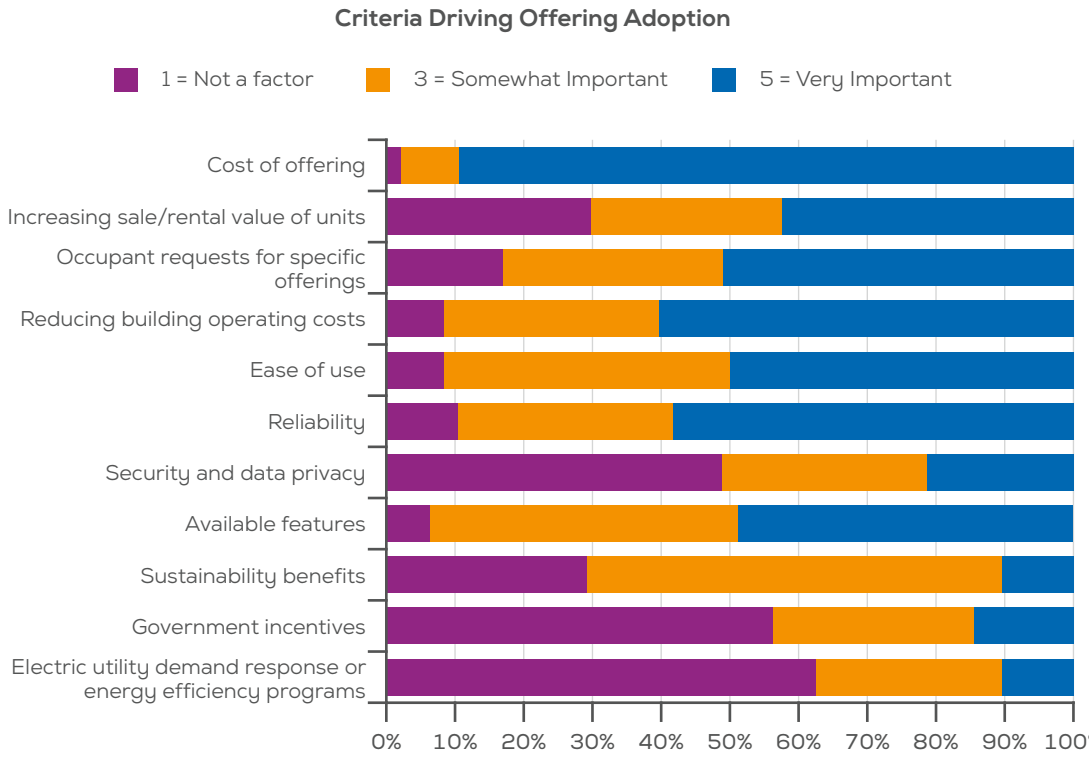
Interest in Data Brokering Devices and Services



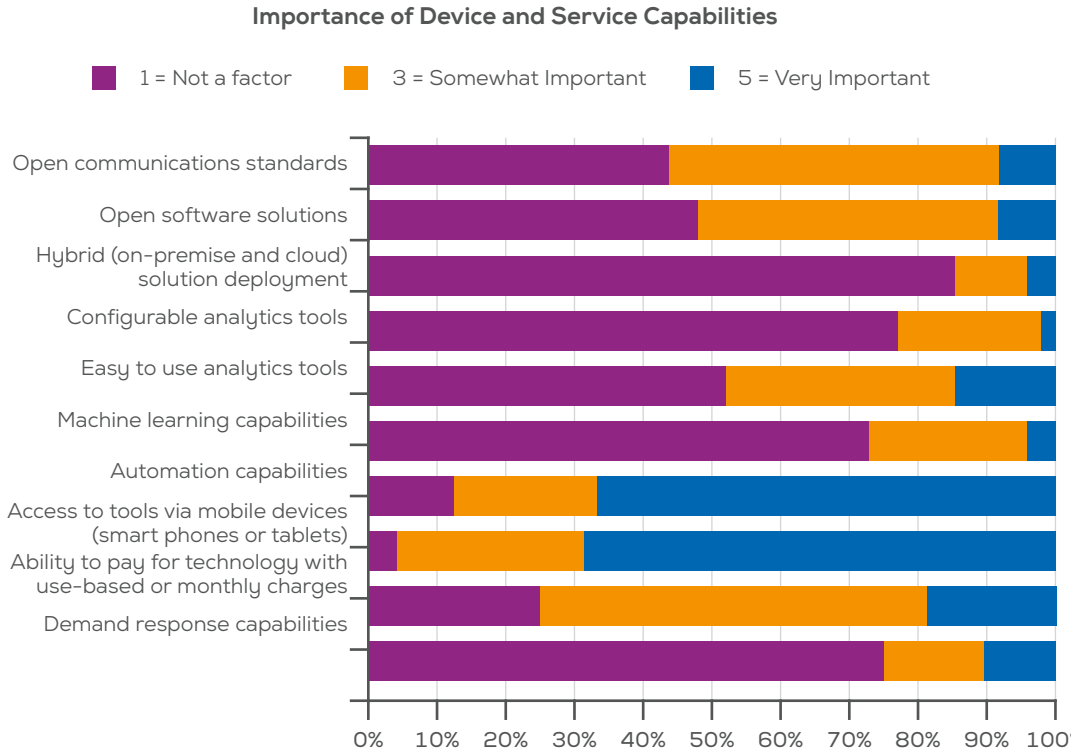
10. How would you describe your relationship with the following market participants? sell technology to/target with offerings; partner with to develop solutions; partner with to deploy solutions; partner with to service solutions



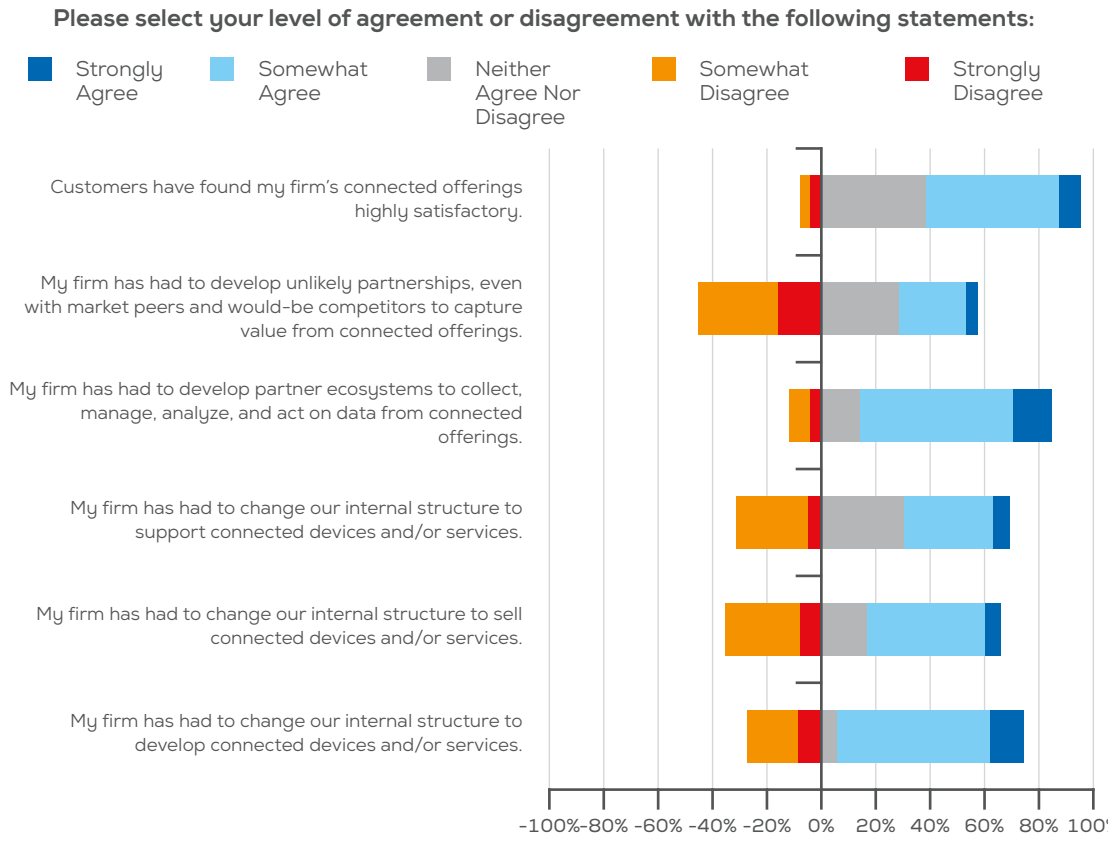
11. How influential were the following criteria in convincing customers to purchase your firm's devices or services? (5 = very important, 3 = somewhat important, 1 = not a factor)



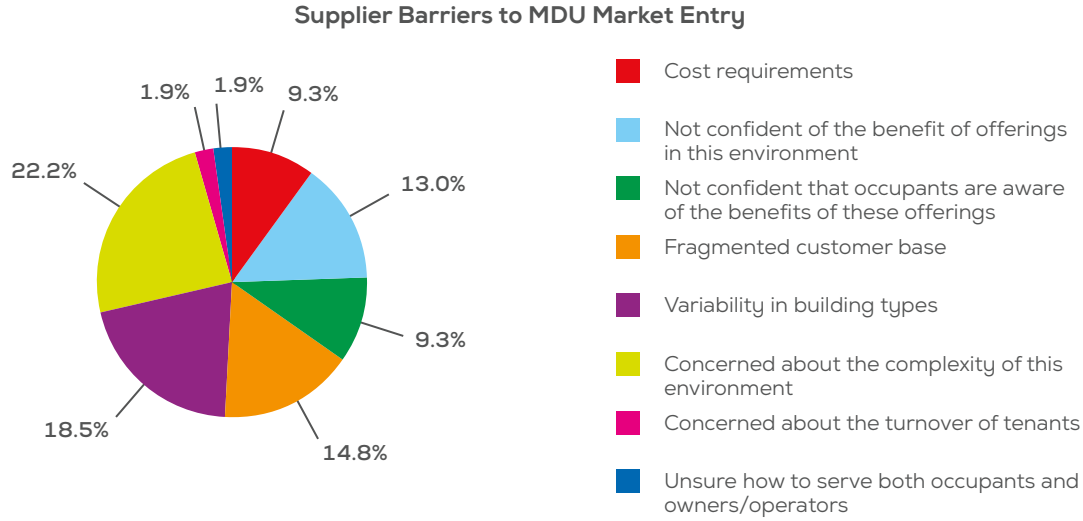
12. How important are the following criteria to customers of your firm's offerings related to connected offerings? (5 = very important, 3 = somewhat important, 1 = not a factor)



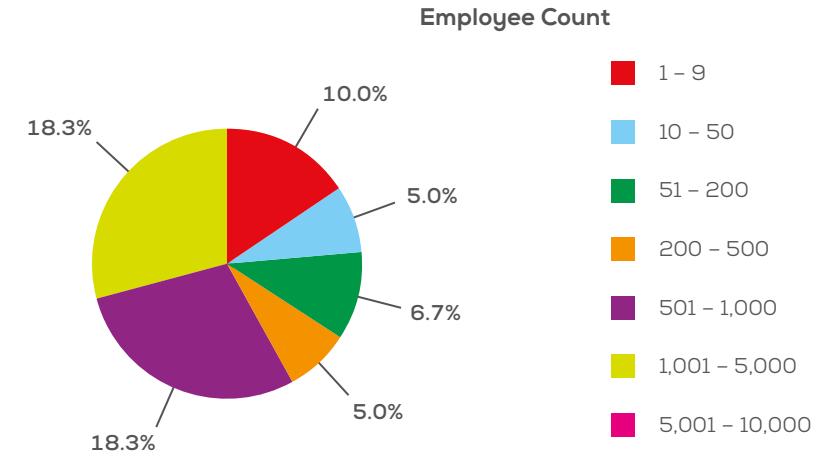
13. How strongly would you agree with the following statements (changing structure and partnerships) (5 = Completely agree, 4 = somewhat agree, 3 = neither agree nor disagree, 2 = somewhat disagree, 1 = disagree strongly)

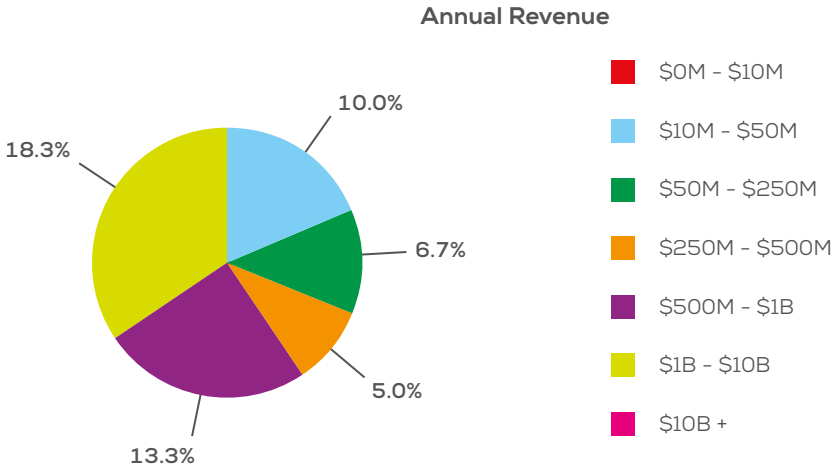


14. If you do not plan to supply technology to the MDU market, please select all factors that influence your decision

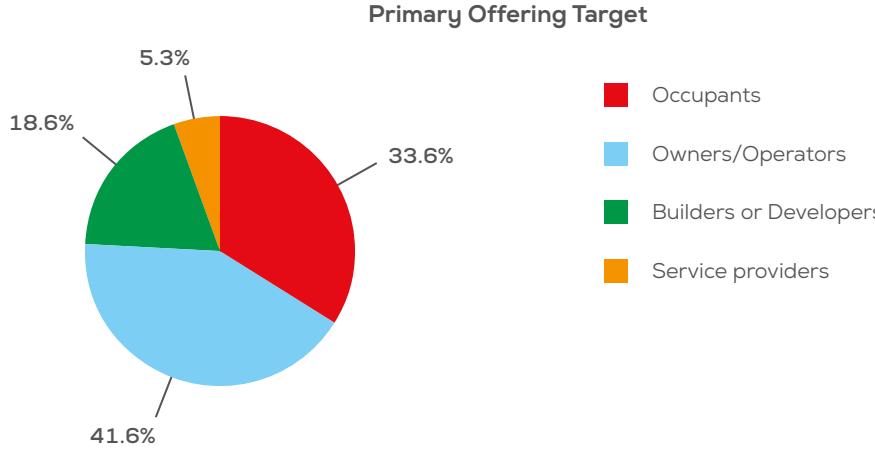


15. How large is your firm?

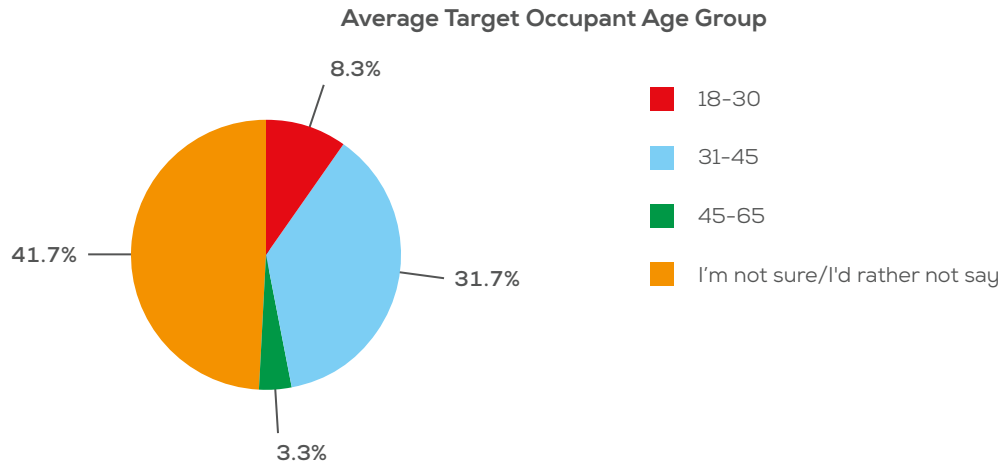




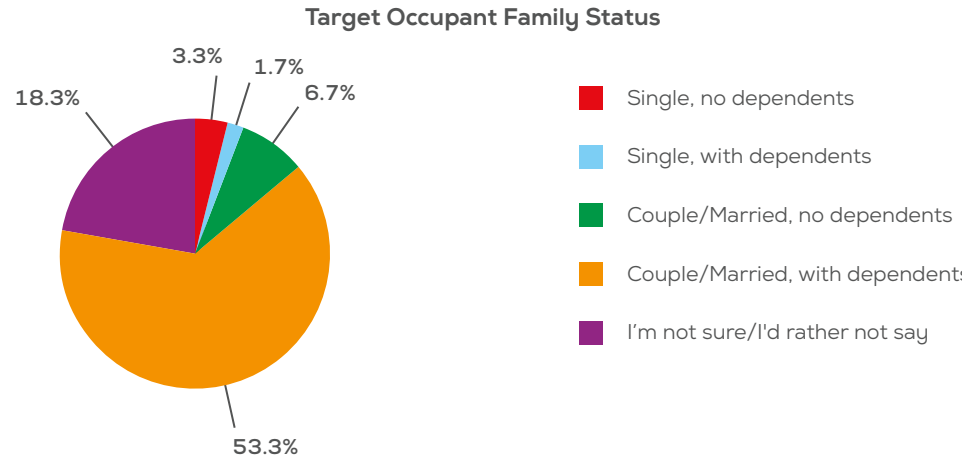
16. Who are the target end customers of your technology offerings?



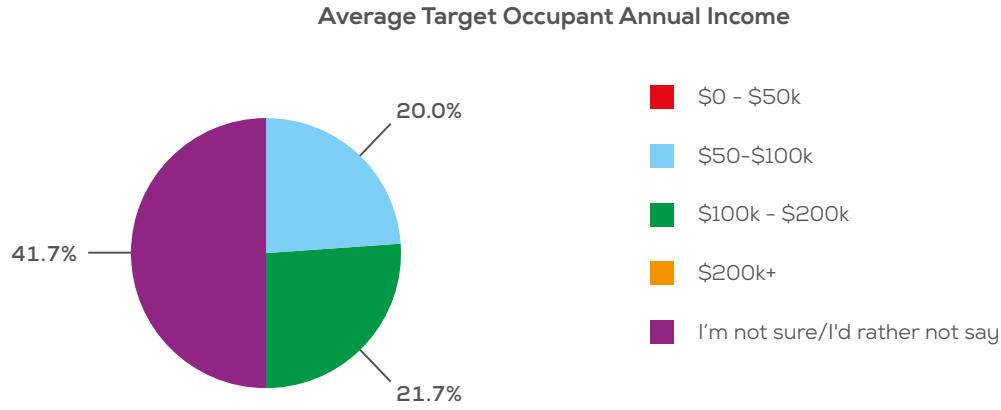
17. What is the target age of occupants in MDUs which have adopted your technology offerings? (drop down list)



18. What is the typical family status in MDUs which have adopted your technology offerings? (drop down list)

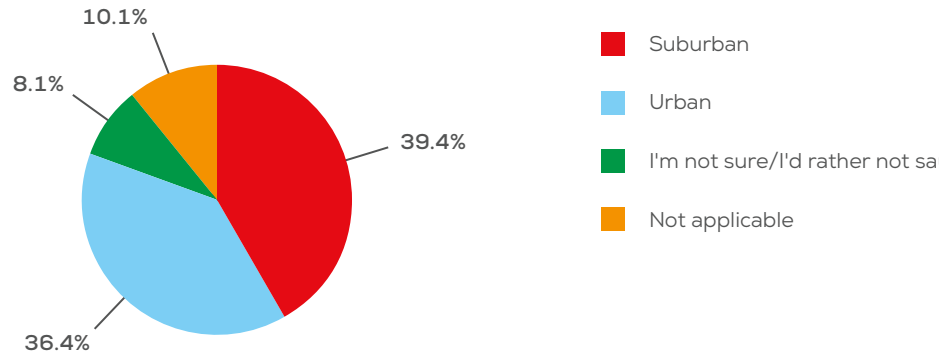


19. What would you estimate is the most common household income that have adopted your offerings? (drop down list)



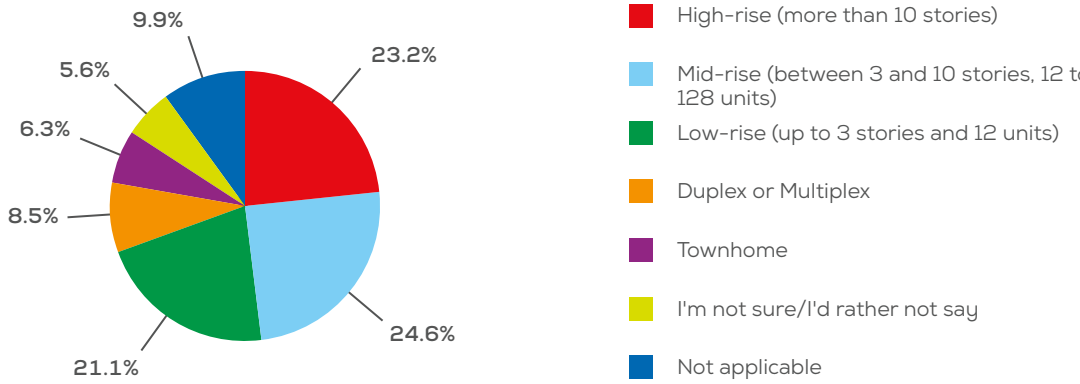
20. What type of community are MDUs in which have adopted your technology offerings? (drop down list)

MDU Community Type



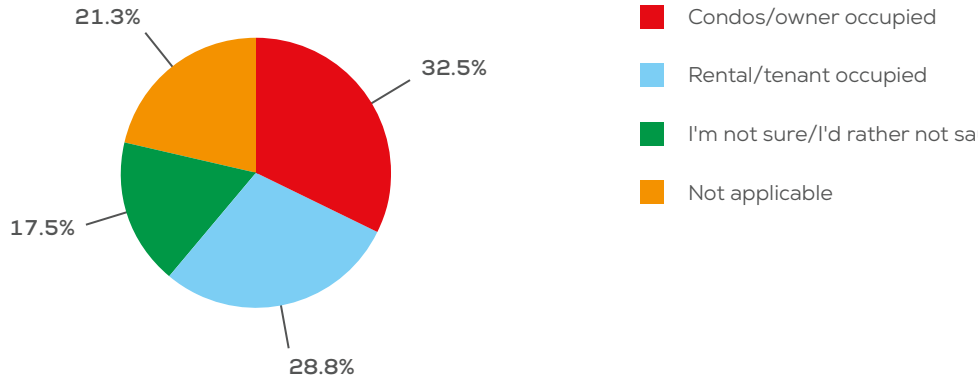
21. What is the building type of MDUs which have adopted your technology offerings? (drop down list)

MDU Structure



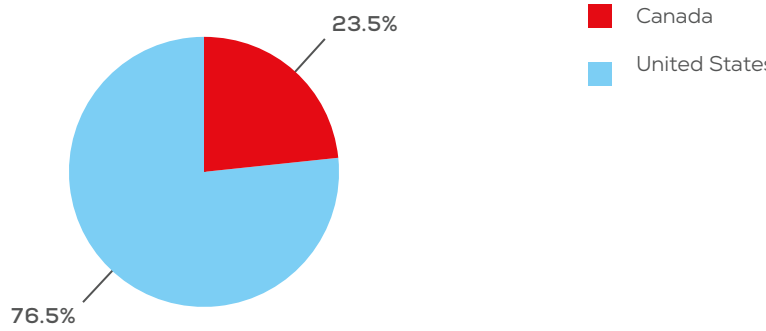
22. What is the ownership model of MDUs which have adopted your technology offerings? (drop down list)

Target MDU Ownership Model



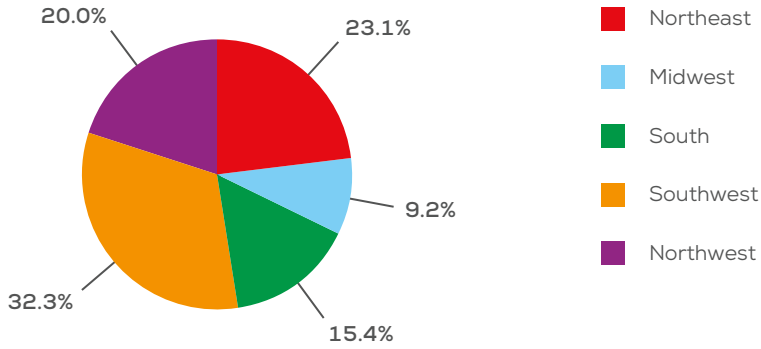
23. Which country are the MDUs located in that have adopted your technology offerings?

Countries End-Users are Located In



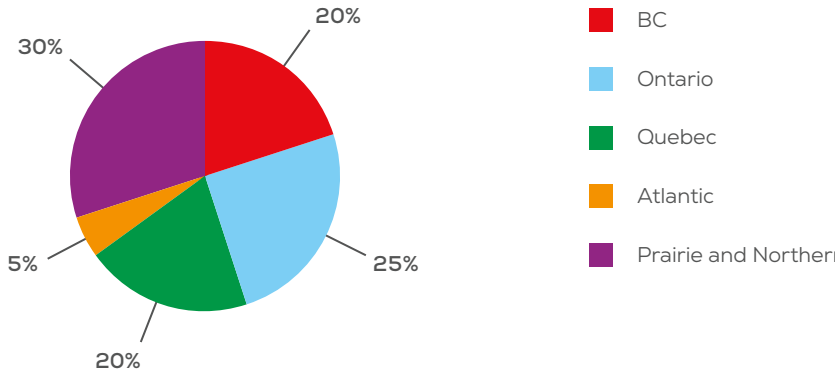
24. In which US regions are the MDUs located that have adopted your traditional or connected offerings?

US Regions



25. In which provinces are the MDUs located that have adopted your traditional or connected offerings?

Canada Regions

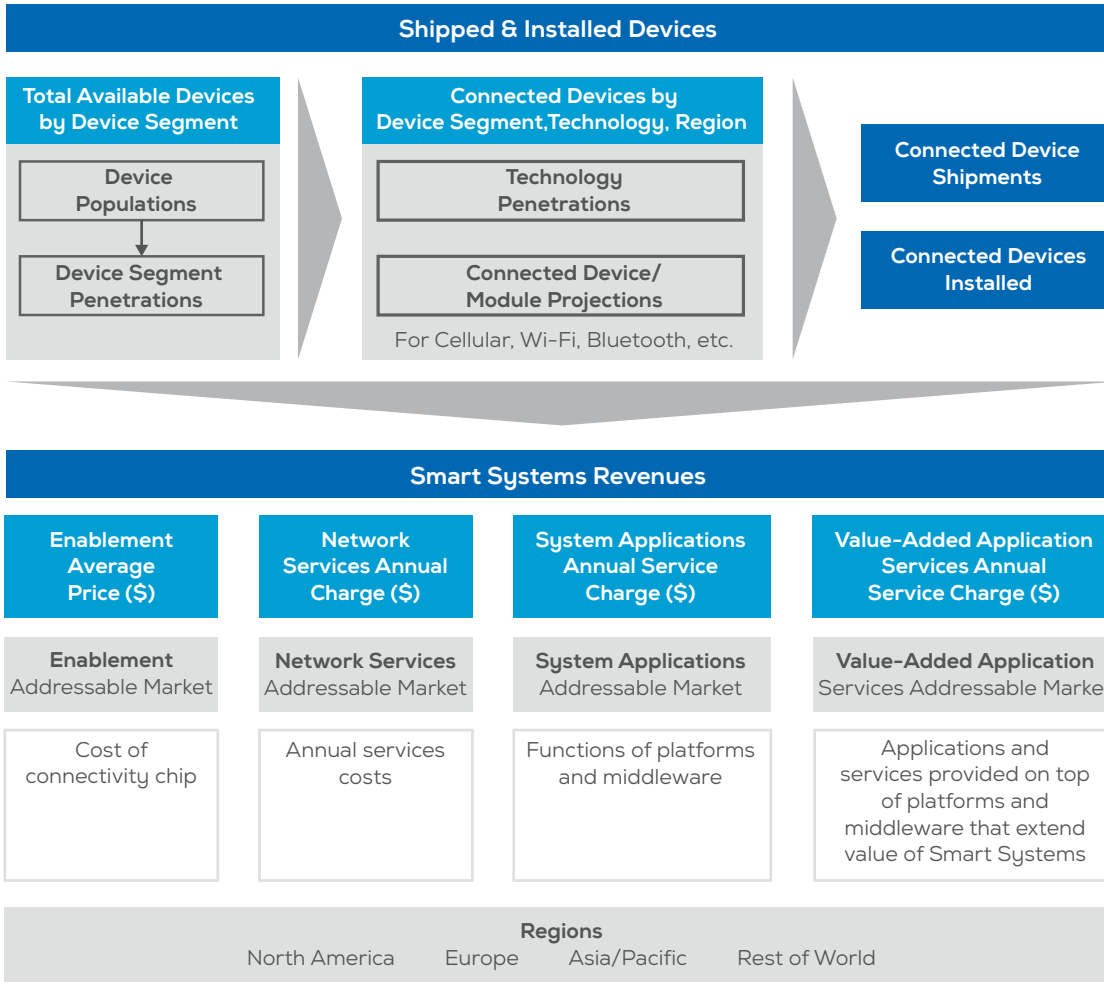


APPENDIX B: SMART SYSTEMS FORECAST MODEL RESEARCH METHODOLOGY

Harbor's Smart Systems Forecast market model segments the Internet of Things into five sectors that encompass eight venues. Within the eight venues, there are 29 customer segments with over 400 distinct connected product (i.e., device) segments that Harbor Research analyzes and monitors.

Harbor combines a comprehensive approach to ensure the most accurate forecast possible. All levels within the forecast are linked. The figure below shows Harbor's forecast methodology, determining the number of connected devices and Smart Systems Revenue Streams.

Harbor Research Smart Systems Forecast Model Methodology



Device populations have been determined from government statistics on output and installed base across the wide range of devices monitored. Data for over 400 device categories in Harbor's eight key venues has been researched in this way in order to cover all areas where Harbor sees potential Smart Systems opportunities. These numbers are cross-checked against data and analysis from alternative sources such as expert interviews, industry publications, academic analysis, market research reports, and other sources.

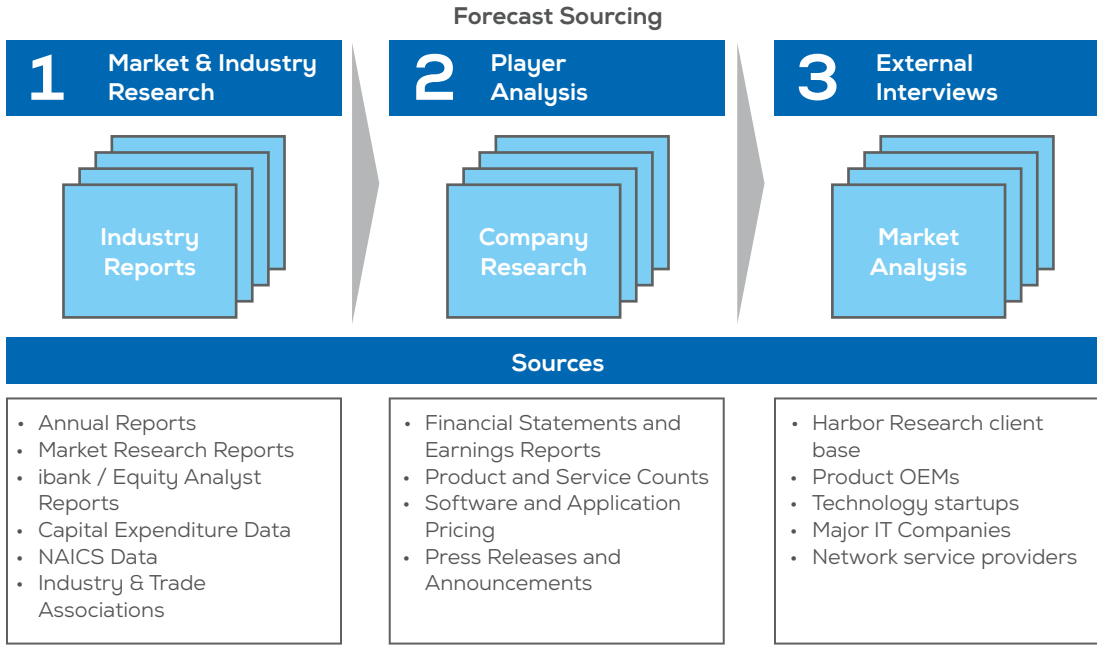
Networking penetration of these device populations has been assessed from Harbor's own estimates, based on input received from device suppliers and industry comparisons across device segments. At the same time, device categories have also been assessed for the alternative network technologies that might be used to connect them. This approach seeks to minimize the potential for double counting of devices using different connection technologies. The results of these assessments have then been cross-checked against actual connection module shipment data received from module suppliers, device suppliers and some distributors.

Data has been researched from reputable market and industry reports and other institutional sources including:

- Establishing initial segment analysis for the embedded and smart device segments based on NAICS classification tools, market research and Harbor's research;
- Government data and trade industry associations were consulted to provide real-time market data; and

- Extensive interviews of major OS and microprocessor vendors, industry experts, technology startups, network service providers, OEMs and end-users to validate and refine views on the potential of the embedded opportunity and subsequent validation of market sizing.

Forecast Sourcing



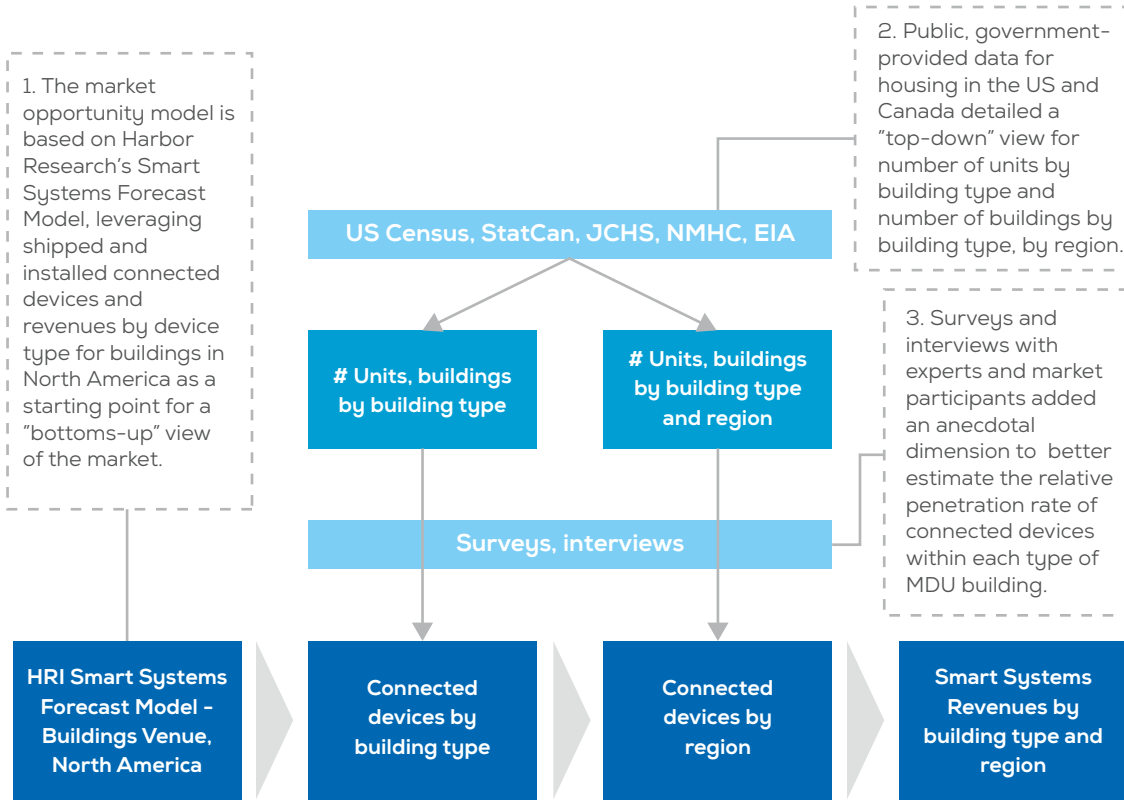
Our analysis and research is focused on understanding the strategic business implications of growth within the emerging Smart Systems arena. We are particularly interested in answering the following fundamental questions:

- What progress has really been made in driving organic Smart Services opportunities?
- What's at risk for manufacturers who continue to iterate existing products, systems and development protocols?
- Who will be the first to deploy machine data analytics applications that can leverage tools across families of interrelated devices and diverse domains?
- How well prepared are manufacturers for the advent of Smart Systems and services?

In answering these questions, Harbor's forecast provides comprehensive coverage of the intelligent device [smart device], networking and related Smart Services market.

For multi-dwelling units, Harbor Research iterated and extended its forecast of multi-tenant buildings using the research and analysis throughout this report. Leveraging publicly-available data and adding dimension and trends discovered through the surveys and expert interviews, Harbor is able to describe the opportunity for smart systems in MDUs in 10 regions across the United States and Canada and characterize how these opportunities are likely to develop over time.

MDU Forecast Methodology



APPENDIX C: GLOSSARY

Applications: Applications provide a function or a related set of functions based on a grouping of related devices (e.g. fixed patient monitoring within healthcare, fleet tracking and management within transportation, energy management within buildings, etc.)

BACnet: Building automation and control network, an open source data communication protocol that specifies rules for the functions of devices and systems on a building control network

BrickSchema: An open source initiative that builds upon Project Haystack with a hierarchical way of ordering and defining relationships among building systems to enhance data utilization within buildings

Cloud computing: Utilizing servers located remotely and managed by a third-party, rather than stored on site and managed in-house, to store data and perform computing

Competitive Trend: Business challenges and opportunities facing suppliers seeking to develop Smart Systems offerings of increasing complexity

Customer Segment: Within a venue, a customer segment is a homogeneous "served" market segment (e.g., Power Generation within the Energy Venue or Commercial/Institutional Facilities within the Buildings Venue)

Customer Trend: Forces concerning changing or persisting needs, demands, buying behavior, attitudes, preferences, user experience (could also be technology depending on the scenario), or other customer-driven trends

Device Segment: Device segments are groupings of functionally homogeneous devices (e.g., point-of-sale devices, off-road construction equipment, power distribution devices, etc.)

Distributed energy resources: Energy generators including solar PV, batteries, and wind power that produce energy across a grid, as opposed to a central generation station and thus require enhanced monitoring and control tools to maintain grid reliability

Enablement: Revenues generated from the connectivity hardware and integration

Fiber optics: A technology that uses glass (or plastic) threads (fibers) to transmit data

Green Button Initiative: A US government led initiative to make anonymized utility meter data available to consumers as well as third-parties to enable new services, including behavioral suggestions for cost reductions or efficiency gains, demand response, and others

High-rise MDU: Residential buildings with 10+ floors, housing 50+ units

IEEE 802.15.4: A technical standard which defines the operation of low-rate wireless personal area networks (LR-WPANs). It specifies the physical layer and media access control for LR-WPANs, and is maintained by the IEEE 802.15 working group

IEEE 802.11: A technical standard which defines media access control and physical layer specifications for implementing wireless local area network (WLAN) computer communication in the 900 MHz and 2.4, 3.6, 5, and 60 GHz frequency bands. It is maintained by the IEEE 802.11 working group

Information Architecture: The structures and processes in place to capture and act upon information gathered from IoT devices within a Smart System

Information and communications technology (ICT): consists of IT and telecom, broadcast media, all types of audio and video processing and transmission and network based control and monitoring functions.

Internet of Things (IoT): Sensor-equipped devices with embedded Internet connectivity to capture process or environmental information and share with other devices or central processing units over local or global networks

Low-rise MDU: Residential buildings with 1-3 floors, housing 5-24 units

Mid-rise MDU: Residential buildings with 3-10 floors, housing 25-49 units

Multi-dwelling unit (MDU): A residential building that houses two or more individual units within the structure

Network Services: Revenues generated from network services, configuration and provisioning

Network service provider (NSP): Cable, network, Internet and cellular providers who provide connectivity infrastructure and/or services to end-users

NMHC: The National Multifamily Housing Council, a D.C.-based apartment research and lobbying organization

OpenADR: Standard developed to provide a foundation for interoperable information exchange to facilitate automated demand response in the energy industry to enhance development of Smart Grid initiatives

Open Source: A data storage and transfer format whose specifications are public and available for use without restriction

Project Haystack: An open source initiative focused on developing naming conventions and taxonomies for building equipment and operational data to enable vendor-agnostic data sharing and analytics within and across buildings

Sectors: Harbor's highest order segmentation of the Smart Systems market, broken into Infrastructure, Consumer, Industry, Mobility, and Commercial and Institutional Services

Smart Systems: Networks of IoT devices combined into applications of increasing complexity that leverage connected nodes to create collective awareness of process or environmental conditions and enhance decision-making

Socioeconomic Trend: Developments concerning broader societal and economic shifts, including global or national growth patterns, changing demographics (e.g., aging populations), infrastructure needs, public and service needs, government policies, and other areas like health, the environment, economic development, or global patterns

Specialty MDU: Residential buildings with 1-3 floors, housing 2-4 units

System application: Revenues generated from service delivery platforms for device management and connectivity

Technology Trend: Forces concerning broad changes in technology or a specific type of technology, related to cost, bandwidth, security, new or changing end uses, power consumption, or other advancements or issues

Value-Added Applications: Revenues generated from application delivery services, including applications such as asset management, energy management, security management, analytics, cloud services, etc.

Venue: Harbor's second order segmentation below Sectors

Wireline: Refers to a service that connects to the public switched telephone network (PSTN) through a local loop of copper wire or glass fiber that terminates in a fixed location at a customer premises

WLAN: A wireless local area network (WLAN) is a network in which a mobile user can connect to a local area network through a wireless (radio) connection.

WPAN: A wireless personal area network (WPAN) is a personal area network a network for interconnecting devices centered on an individual person's workspace in which the connections are wireless

WWAN: A wireless wide area network (WWAN) is a network in which separate areas of coverage or cells are connected wirelessly to provide service to a large geographic area

ZigBee: An open global standard for wireless technology designed to use low-power digital radio signals for personal area networks. ZigBee operates on the IEEE 802.15.4 specification and is used to create networks that require a low data transfer rate, energy efficiency and secure networking

Z-Wave: A protocol for communication among devices used for home automation. It uses RF for signaling and control

APPENDIX D: INTERVIEW LIST

ADT
Alarm.com
Alliance Residential Company
AT&T
AutomatedBuildings.com
Ayla Networks
BC Hydro
Building Brains
BuildingContext
Carrier/UTC
Cielo
Con Edison
Cytexone
Delta Controls
Digital Lumens
Distech Controls (Acuity Brands)
Dude Solutions
Duke Energy
Duraline
Dwelo
EBM Papst
EdR
Embue
Enercare
Friendly Tech
Gables Residential
Greenwave
Greystar
GSA
iControl
IOTAS
Ironshore
Johnson Controls
LG Electronics
Lockstate
Microsoft
Navien
NMHC
Optergy
Pentair
Powerhouse Dynamics
PowerSage
RedIQ
RMI
SafePlug
Siemens
Stok
StratIS
Tendril
Verdigris
Verizon
WC Smith
WhiteSpace
WinnResidential

APPENDIX E: REFERENCES

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3. Interview with Executive at StratIS, 19 January 2017
4. Interview with VP at IOTAS, 12 January 2017
5. Interview with Executive at WhiteSpace Building Technology Advisors, 05 January 2017
6. US Census Bureau, Statistics Canada, National Multifamily Housing Council, HRI Analysis
7. Interview with Vice President at NMHC, 13 January 2017
8. Interview with VP at the National Multifamily Housing Council, 30 January 2017
9. Interview with Executive at Dwelo, 27 January 2017
10. Interview with Vice President at Alarm.com, 05 December 2016
11. Interview with Editor of AutomatedBuildings.com, 05 January 2017
12. Interview with Executive at Powerhouse Dynamics, 16 January 2017
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