Market Overview of Connected Buildings

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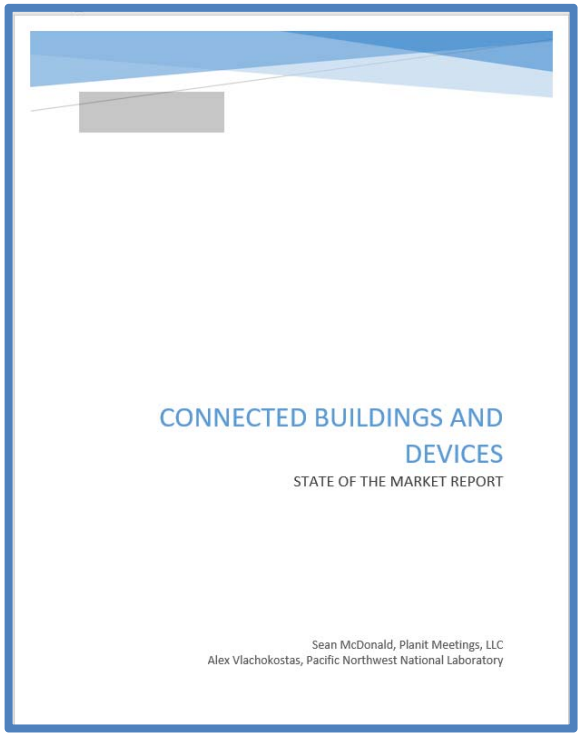
Draws Upon Previous Work Funded by BTO through Pacific Northwest National Laboratory

- Buildings-to-Grid Integration (BTO)
  - Coordinating strategies and activities with stakeholders to address the integration and optimization of homes and commercial buildings with the nation's energy grid
- Buildings-Grid Integration (PNNL) “Connected Buildings Challenge”
  - Accelerating growth of smart, connected buildings market by:
    - **Investigating consumer needs and market drivers**
    - Creating innovative real solutions
    - Testing and demonstrating technologies and success
    - Assisting in launching new business with leveraged private funds

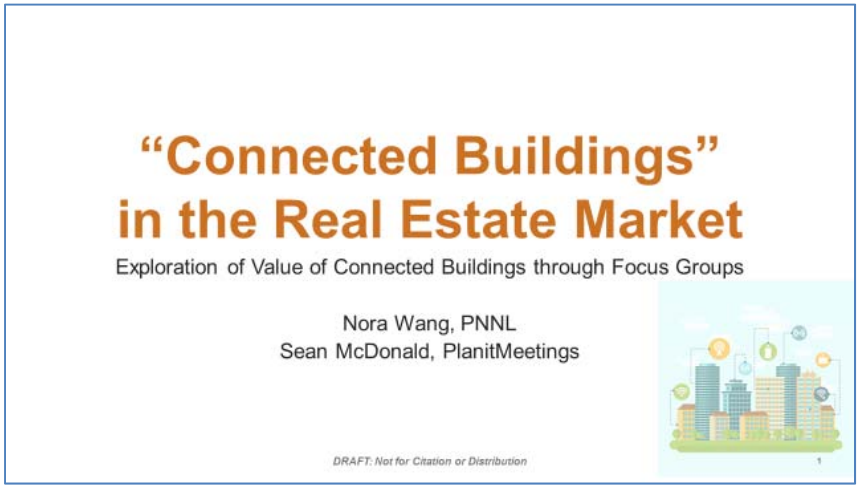
Connected Buildings and Devices: State of the Market Report (Draft March 2016)



- **Meta-analysis** of other studies
  - Current market
  - Trends, barriers, drivers
  - Future directions
- Authors
  - Sean McDonald, Planit Meetings
  - Alex Vlachokostas, Pacific Northwest National Laboratory

“Connected Buildings” in the Real Estate Market

- Exploration of Value of Connected Buildings through **Focus Groups with Real Estate Agents**
- Authors
  - Nora Wang, PNNL
  - Sean McDonald, PlanitMeetings



Connected Buildings and Devices Defined

Connected Buildings

- Residential or commercial building with **one or more devices that can be remotely accessed or programmed to control and/or automate building services**
- Services like
  - Security and safety
  - Convenience/Control
  - Comfort
  - Entertainment
  - Host of services related to building equipment (scheduling, maintenance, fault or failure detection)
- Devices **may or may not be able to be controlled centrally (in unison) and may or may not be accessible via the internet**

Devices

- Security and Safety
  - Alarm Systems
  - Wireless Security Cameras
  - Door video systems
  - Garage Door Sensor
  - Contact Sensors
  - Smoke & Air Quality Sensor
  - Motion Sensors
- Convenience/Control
  - Lighting systems
  - Door Locks
  - Indoor Smart Plugs
  - **"Smart" Thermostats**
  - Key Fobs
- **Comfort**
  - **Heating and Cooling Systems**
  - **Water Heating**
- "Smart" appliances
  - Clothes Washers and Dryers
  - Dishwashers
  - Washing Machines
  - Refrigerators & Freezers

Connected Buildings vs Smart Building

"Connected"

- "…**Networked** to enable the interconnection and interoperability of multiple devices, services and apps…
- Services and apps are delivered over multiple interlinked and integrated devices, sensors, tools and platforms
- **Connected, real-time**, **smart** and contextual experiences are provided … and individuals are enabled to control and monitor …remotely as well as within it"
  - Hype Cycle for the Connected Home, Gartner, July 2015.

"Smart"

- "Once you attach a sensor to it, a physical object [it]… starts functioning a lot like any other digital product
- It emits data about its usage, location and state; it can be tracked, controlled, personalized and upgraded remotely; and
- It can become **intelligent, predictive, collaborative and in some cases autonomous**."

That said, from this point forward we will use the concepts interchangeably

“Connected Buildings and Devices”

State Of The Market Report

Sean McDonald, Planit Meetings, LLC
Alex Vlachokostas, PNNL

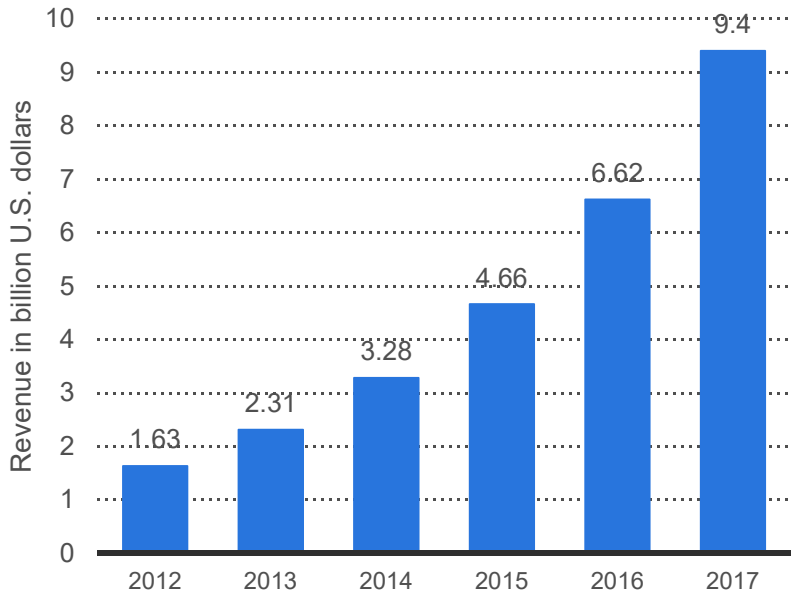
Market Size, Trends, and Ownership and Demographics

Size and Trends

- "**Smart commercial buildings will be the highest user of Internet of Things (IoT) until 2017**, after which **smart homes will take the lead with just over 1 billion connected things in 2018**."
  - "Gartner Says Smart Cities Will Use 1.6 Billion Connected Things in 2016", Press Release, Gartner, June 14, 2016
- North American "**Smart Home" revenue is expected to rise from $1.63 billion in 2012 to $9.4 billion, at a CAGR of 42%**
  - Berg Insight, November 2013, Statista 2015
- **Number of installed smart home systems in North America expected to rise from 3.5 million in 2012 to over 31 million in 2017** (CAGR of 55%)
  - Berg Insight, November 2013, Statista 2015

Berg Insight, November 2013, Statista 2015

Estimated Value of North American Smart Home Market ($Billions)



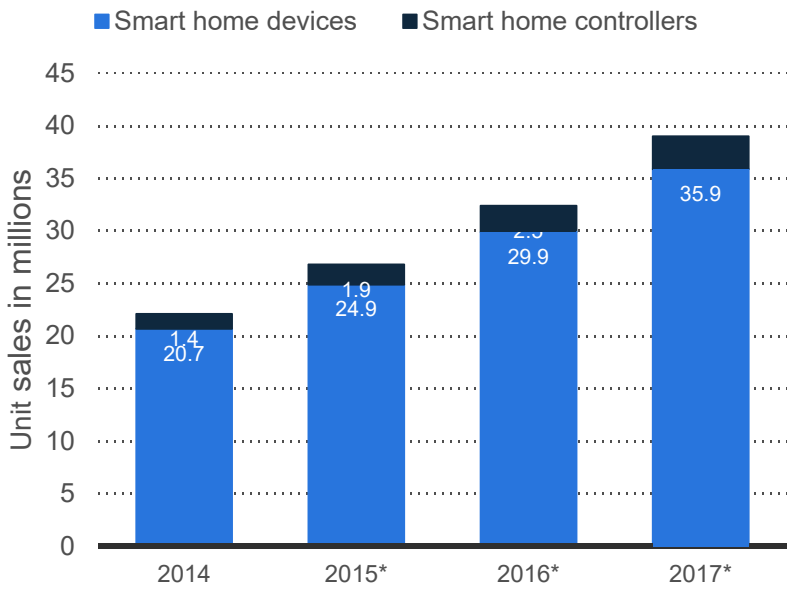
Market Size, Trends, and Ownership and Demographics

Size and Trends

- **Upward growth in the share of central controllers (hubs) as compared to individual devices** indicate a movement towards systems that centrally manage a variety of devices
- Smart home **controllers more than double** from 1.4 million units in 2014 to a forecasted 3.1 million units in 2017
- In comparison, **individual devices increase by less than 75%.**
  - Digital America", Consumer Technology Association, November 2015, page 85, Statista 2015

"Digital America", Consumer Technology Association, November 2015, page 85, Statista 2015

Smart Home Devices and Controllers Wholesale Unit Sales in the United States from 2014 to 2017 (millions)



Market Size, Trends, and Ownership and Demographics

Device Ownership and Demographics

- **Greatest percentage ownerships is Entertainment devices**: game consoles (38%), smart TVs (27%), streaming TV devices (24%) and streaming handheld game devices (15%)
  - Some of these devices arrived in the marketplace over a decade ago and hence show the greatest market penetration
- In single digits are home security devices (6%), wi-fi thermostats (5%), and internet-connected door locks (1%) and light switches (1%)
  - These devices are more recent market entrants, and are more related to security, and comfort and convenience

"Consumers Struggle to Use Common Connected Things", PlumChoice, October 7, 2015

Connected Device Ownership Among US Consumers (Percent)

Category	Device	Percentage Ownership
	Desktops or Laptops	90%
	Tablets	66%
	Routers	61%
Entertainment	Game Consoles	38%
	Smart TV	27%
	Streaming TV Devices	24%
	Handheld Game Devices	15%
	Fitness Bands	11%
Security	Internet-Connected Cameras	6%
	Smart Home Security Devices	6%
Energy Related	Wi-Fi Thermostats	5%
	Health Monitors	4%
	Smart Watches	2%
	Internet-Connected Door Locks	1%
Energy Related	Internet-Connected Light Switches	1%
	Note: Ages 18-65 who have purchased an electronic device in the past year as reported May 2015	

Market Size, Trends, and Ownership and Demographics

Device Ownership and Demographics

- Overall **smart-home devices are most popular with Millennials** (38% own one or more devices)
  - Millennials are more likely to own any one these devices (other than smart thermostats) and Baby Boomers, least likely (except wireless speakers and smoke detectors)
  - **Millennials had the highest ownership rate of any device except smart thermostats**
- Wireless speaker systems were the most commonly owned device overall (17%)
  - Ownership rates are very low (single digits) for most of the remaining products except among Millennials

"Smart Homes Appeal to Young and Old", eMarketer Inc, October 2, 2015

Smart-Home Devices/Appliances Owned by Internet Users, by Generation, May 2015 (% respondents)

Category	Device \ Generation	Millennials	Gen X	Baby Boomers	Seniors	Total
Entertainment	Wireless Speaker System	19%	18%	17%	11%	17%
Energy Related	Smart Thermostat	9%	12%	10%	15%	11%
Security	Smart/Wireless Home Security and Monitoring System	12%	8%	6%	10%	9%
	Domestic Robot (e.g., lawnmower, vacuum)	15%	3%	3%	6%	8%
	Smoke/Carbon dioxide detector that connects to WiFi/Internet	10%	3%	4%	5%	6%
Energy Related	Smart Lighting	8%	7%	3%	4%	5%
	Home Energy Use Monitor	8%	5%	4%	3%	5%
	Smart/Connected Refrigerator	8%	2%	2%	1%	4%
	Smart/Connected Laundry Machines	8%	2%	1%	2%	4%
Security	Smart door locks	7%	4%	2%	3%	4%
	Water Detector that connects to Wi-Fi/Internet	3%	3%	1%	1%	2%
	Total	38%	34%	29%	34%	34%

Millennials (ages 18-37), Gen X (ages 38-49), Baby Boomers (ages 50-68), Seniors (69+)

Consumer Preferences and Motivations

Consumer Preferences

- Consumers asked **"Which of the following features does your home have? Which, if any, would you like to have?".**
  - Response to these questions summed to represent "Any Interest"
  - Residual respondents were assumed not to have or want
- **Greatest interest in Door/window security sensors** (62%) which was also most common feature currently installed (26%)
  - Other security features also highly desired
- **Energy-related ownership lower -- 'smart' thermostats (19%), remote control lighting (11%), and window shades (12%)**
  - **Desire for energy-related devices was highest** (40% would like to have a smart thermostat and nearly same percentage (39%) would like remote controlled lighting
- Respondents age 25-34 consistently expressed greatest interest across all devices (Includes most 'Millennials')

Desired Home Features (Percent)

Category	Interest/Ownership / Feature	(1) Any interest	(2) My home has this	(3) I would like to have this for my home	(4) I do not have this and do not want it
		%	%	%	%
Security	Door/window security sensors	62	26	36	38
Energy Related	A 'smart' thermostat	59	19	40	41
Security	Outdoor security cameras	56	17	39	44
	Water leak/flood detection	52	11	41	48
Energy Related	Lighting throughout the house that can be controlled remotely	50	11	39	50
Security	Indoor motion detectors	48	20	28	52
Entertainment	Multi-room audio system	47	14	33	53
Security	Keyless door locks	44	11	33	56
	Automated cleaning devices (e.g., iRobot Roomba, Neato)	43	11	33	57
Energy Related	Mechanical window shades	42	12	31	58
	Lighting fixtures with light bulbs that change colors	37	9	27	63
Energy Related	A refrigerator that tracks its contents	36	9	27	64

"Smart Homes – US", Lightspeed GMI/Mintel, April 2016

Consumer Preferences and Motivations

Consumer Preferences

- When considering **purchases in the next 12 months**, cameras, thermostats, and lighting topped that list with **about one-third** of all respondents saying they would be **likely to make such a purchase.**
- However, **half or more of all adults age 25-34** stated that they were **likely to purchase each of these devices in the next 12 months.**
- "With millennials estimated to spend more than $200 billion annually starting in 2017, and $10 trillion in their lifetimes, we expect these numbers to increase as this younger generation grows older and newer generations begin to naturally embrace this technology."
  - 2015 State of the Smart Home Report, iControl Networks, 2015

"2015 State of the Smart Home Report", iControl Networks, 2015

What Consumers Say They Are Likely To Purchase Within The Next 12 Months

Category	Option	All Respondents	Adults Aged 25-34
Security	Connected Home Camera	37%	56%
Energy Related	Connected Thermostat	37%	54%
	Connected Lighting	34%	54%
Security	Connected Door Lock	34%	53%
	Smart Home Hub	32%	52%
	Smart Home Services	31%	50%
Energy Related	Connected Appliance	25%	50%

Consumer Preferences and Motivations

Motivations

- Motivations can vary, but broadly grouped into
  - Cost (including energy savings)
  - Convenience (including time savings)
  - Security
- There are hedonistic motivations such as first to own and altruistic motivations like benefiting the environment
- Of 26% of respondents who stated they were interested in purchasing a smart home device within the next two years:
  - **Almost half (44%) said they would do so in order to reduce resource consumption**
  - Approximately 1/3 desired devices to reduce complexity or increase security
  - Another 30% looking to reduce costs while only 20% sought to purchase such devices just for fun

Motivation for Purchasing a Smart Home Device

Motivation	Respondent (%)
To reduce energy, water or other resource consumption	44%
For more convenience	43%
To simplify life	34%
For more security	33%
To reduce costs	30%
For greater control over my home and/or family	22%
Because gadgets are fun	20%

"Consumers Struggle To Use Common Connected Things: Device Makers And Sellers Missing Millions (Maybe Billions) Of Opportunities To Engage And Drive Product Adoption", IoT Device Adoption and Technical Support, Benchmark Report, Plumchoice, October 2015

Consumer Preferences and Motivations

Motivations

- **Consumer motivation** is important as it **gets to the value proposition** for as to why a consumer would want a device for a particular application
- **30% or more of respondents expressed a desire for greater control of the energy features** of their home (lighting and space conditioning)
- **Safety also a prominent concern** (28%) as was concern for young and elderly occupants and pets (21%)
- Nearly 1/4 expressed a willingness to spend more on products that their home more environmentally friendly (24%)
- Relatively small portion of respondents expressed a pure hedonistic motivation for purchase of such devices (14%).

"Smart Homes – US", Lightspeed GMI/Mintel, April 2016

Motivations for Adoption in Homes

Which of the following statements are true for you?	Positive Response (%)
I would like to set the temperature in each room of my house independently	37%
I would like to be able to turn all the lights in my house off from my bedroom	30%
I would like to be able to use my phone to control my household's environment (e.g., lights, air conditioner)	30%
I worry about the safety of my home	28%
My household likes to entertains guests	27%
I would like to be able to use my phone as a remote control for electronics in my home (e.g., televisions, speaker systems, etc.)	25%
I am willing to spend more money on products that make my home more environmentally friendly	24%
My household has occupants I need to check on frequently (e.g., pets, children, elderly)	21%
I have or would like to have a dedicated home theater room	20%
I like people to be impressed with the technology in my home	14%

Market Barriers

Price

- Consumers were asked what would cause them to make such a purchase and fully **44% stated cost as the highest barrier**
- **Another 44% said they would buy such a device if it saved at least $500 yearly on utility bills and household expenses**

"Americans Ready for the Smart Home", Results of the Coldwell Banker and CNET Smart Home Survey, Coldwell Banker Real Estate LLC, August 2015.

What Would Make You Purchase a Smart Home Product? (for Americans who do not have the technology)

		Age		Parent of Child(ren) under 18 at Home	
Factor	**Total**	**18 - 44**	**45+**	**Yes**	**No**
If smart home technology was less expensive	44%	57%	36%	51%	42%
If it would save me at least $500 yearly on my utility bills and household expenses	42%	50%	37%	49%	40%
If I had more information about how smart home products worked	21%	24%	18%	26%	19%
If I had more information about smart home product benefits	20%	23%	18%	19%	20%
If they were simpler to understand	18%	14%	20%	13%	19%
If I had more information about how to install smart home products	15%	19%	13%	14%	15%
If there was one integrated solution for multiple aspects of my home	15%	20%	11%	15%	14%
If smart home technology became more mainstream	14%	14%	13%	14%	13%

Market Barriers

Price

- For a one-time purchase, respondents were **willing to spend the most to control heating and cooling ($99** on average)
  - Millennials were willing to spend about 50% more ($144) while those over 45 were only willing to spend about $60
- **Respondents were willing to pay less ($73 on average) to be able to just monitor** temperature or other environmental conditions
- **Respondents, on average, were willing to pay $60 for the ability to remotely monitor and control lighting from anywhere**
- Of least value, was the ability to turn an oven on remotely ($33)

"Americans Ready for the Smart Home", Results of the Coldwell Banker and CNET Smart Home Survey, Coldwell Banker Real Estate LLC, August 2015.

Average Dollars One Would Be Willing to Spend for Specific Smart Home Items (Among those with Smart Home Products in the Home)

	Age		
Factor	**Total**	**18 - 44**	**45+**
Heating/cooling efficiency/temperature control	$98.50	$143.80	$59.40
Monitor the temperature or other environmental conditions (e.g., air quality, humidity) in multiple rooms	$73.30	$110.50	$41.30
Monitor my home lighting and turn my lights on and off from anywhere	$59.90	$89.80	$34.10
Watch both live and recorded TV footage from multiple locations, both inside and outside my home	$59.60	$86.20	$36.70
Receive a notification on my mobile phone if a sensor in my home detects a water leak	$55.60	$87.50	$28.10
Open and close my garage door remotely	$46.40	$71.60	$24.70
Water the lawn automatically	$46.40	$72.40	$23.90
Open my front door without digging for my keys	$45.10	$68.90	$24.50
Watch both live and recorded TV footage from inside one room in my home	$38.90	$58.00	$22.40
Monitor the temperature or other environmental conditions (e.g., air quality, humidity) in one room	$35.40	$56.60	$17.10
Turn my oven off or pre-heat it remotely	$33.30	$61.50	$9.00

Other Market Barriers

	Lack of Information	Security	Ease of Use
Plumchoice	**48% did not see the need and 12% were uncertain as to what to purchase**	20% of respondents expressed concern about privacy and security	8% concerned how to use technology and 14% returned device due to difficulty installing or use
Accenture	23% expressed uncertainty of value	47% concerned about privacy & security & 24% postponed purchase due to concerns	**64% experienced a challenge when using a new IoT device (**17% found IoT devices too confusing)
Smart Home Survey	21% how products worked, 20% benefits, and 15% how to install		
iControl Smart Home Report		71% concerned PII might be stolen and 64% feared it would be sold	**60% wished devices did better 'talking to' one another and 49% agree devices not working together causes more stress in their lives**
BI Intelligence		16% cited security concerns	31% believed they lack sufficient knowledge to properly operate devices
Coldwell Banker			18% wish easier to understand and 15% wish for integrated solution for multiple devices

Overcoming Barriers

- Reducing Cost (Accenture)
  - Technology companies need to **improve the value equation** in consumers' minds to increase adoption.
  - Companies must either keep price points as they are and enhance the perceived value of devices and ease of use or find ways to take cost out of the system and reduce price.
- Providing Better Information (Passport Opinion)
  - **Quantifying potential energy savings would help consumer determine the value of a purchase.**
  - Also non-tangible benefits such as "remote commands to appliances from a smartphone at home or even miles away …and how analytics can help consumers in managing lifestyle."
- Protecting Privacy and Increasing Security (Passport Opinion)
  - Manufacturer need to **step up its security protocols** to prevent possible data breaches
  - Collaborate with IT security firms during the initial design phase instead of it being an afterthought
  - **Government also has a role in regulation of "manufacturers and third party service providers on the data usage and cloud analytics to protect consumer privacy."**
- Reducing Complexity and Enhancing Interoperability (Gigaom Research)
  - **Device interoperability** is already being achieved through custom rules and "if-then" types of structures, but this is unlikely to be viable on a much larger scale
  - **Better solution is deploying network and device abstraction so that devices may characterize themselves to the platform and other devices using consistent service frameworks or APIs.**

“Connected Buildings” in the Real Estate Market

Exploration of Value of Connected Buildings through Focus Groups

Nora Wang, PNNL
Sean McDonald, PlanitMeetings

Goals of this effort

- Determine the current market understanding of connected building concepts
- Understand the value proposition for building control including maintenance and potential cost savings
- Gain insight into user preferences, like and dislikes, of connected buildings and associated devices
- Identify barriers, and accelerators, to the purchase and use of connected devices in buildings

Approach

- Focus Group approach to create a discussion of connected buildings in real estate transactions
- Comprised of real estate professionals from various cities in different regions of the U.S.
- Selected by National Association of Realtors (NAR) for their cognizance of building automation technology
- Two sessions were conducted by Sean McDonald, PlanitMeetings (one in Chicago; one in D.C.)

Conduct of Focus Groups

- Participants queried as to their understanding of these devices, user preferences, marketing and valuation of “connected building” features
- Questions targeted towards their professional experience and expertise, though personal opinions allowed
- Ninety minute recorded sessions, with summary transcripts without attribution

Findings

- Nearly Zero Market Awareness
  - **Real Estate market not aware of the term "Connected" homes**
    - **"Smart", "Green", and "Connected" used interchangeably**
  - **Knowledge of smart devices largely limited to Nest thermostat and security systems**
- **Smart (or green, efficient) homes occasionally marketed in the high-end rental units**
  - Younger people and families with small children have greater interest
- **Value of a smart or connected home has not been established in the market**
  - Buyers do not inquire, sellers do not promote, inspectors do not know, appraisers do not consider
  - People use building vintage to approximate efficiency and are more concerned about older homes
- Market Will Evolve
  - Buyers equate energy efficiency and connectivity
  - **Expectations for high tech and "go green" have driven auto market and will drive real-estate**
    - **"Would not be surprised if in the future buyers expect or demand these features"**

Recommendations (What's Required to Jump-Start Market)

- Educate the Market Players
  - Use trade shows and other means to educate Realtors, Inspectors, and Appraisers.
- Create Competition
  - Make "green" efforts visible to friends and neighbors (via social media)
  - Make this the social norm (like "FitBit" for health competition)
- Make the products easier to understand, install, and use
  - Easy to install and control (multiple apps, one "world" (vendor) of devices acceptable)
  - Give recommendations but allow owners to make decisions (what to do, which vender to choose, etc.)
- Offer a higher saving (>10%) and quicker payback
- Balance information sharing, privacy, and control
  - Detect problems and alert owners, but let owner's decide what happens next (e.g., service call)
  - Give control of security options to owner (who sees what, and what they can do)