

White paper:

“Green Intelligent buildings”

*Mapping of companies and activities in the
US within “smart” buildings*

December 2014

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Executive summary

This short white paper provides the reader with an overview of the market perspectives and trends for the green intelligent buildings (Smart buildings) sector. It will furthermore introduce the different stakeholders and projects in the industry, primarily from the Silicon Valley area.

The scope of the report is to give a better understanding of what types of technologies will be dominant in a near future and an indication of what research being developed at the universities. Mapping companies and activities will identify what opportunities that lie ahead for Danish companies and universities within smart buildings.

The white paper is based on desk research and a few interviews with actors in the space as well as participation in industry relevant events.

The main findings in the report are:

- Internet of things (IoT) enables buildings to become more intelligent
- The private consumer market for home automation is pushing development in to commercial building sector
- The large IT companies find the space very interesting
- Research in the area is focused on demonstration different technologies in systems
- A few challenges do still need to be resolved before the market truly takes off

The report is from Innovation Centre Denmark, Silicon Valley (ICDK), which is an organization that builds bridges between research and business - globally.

Most of the companies and institutions in the report are located in the bay area and several of them within the ICDK network. ICDK can be contacted in order to establish connections or partnerships with the mentioned companies or to be introduced even further to possibilities in the bay area and the development in this space.

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Definition and perspective

The world is becoming more digital, interconnected and “intelligent” and changing the way things and people interact with each other. This trend is primarily led by the private consumer market within home automation but has slowly moved towards the commercial enterprise sector.

Buildings are also being transformed due to the rapid development within information technology (IT) and energy technology, and are becoming intelligent or “smart” with this development.

The declining prices and size of sensors have pushed the development for devices and has given the opportunity for single devices to become multifunctional when operating in a system with several other sensors. Together with this data analytic and cloud-based software tools have made the adoption of devices easier for enterprises to integrate them into intelligent building solutions – driving an optimized performance of the physical assets of the building and making it possible to have a sustaining business case with these technologies.

What is a Smart building?

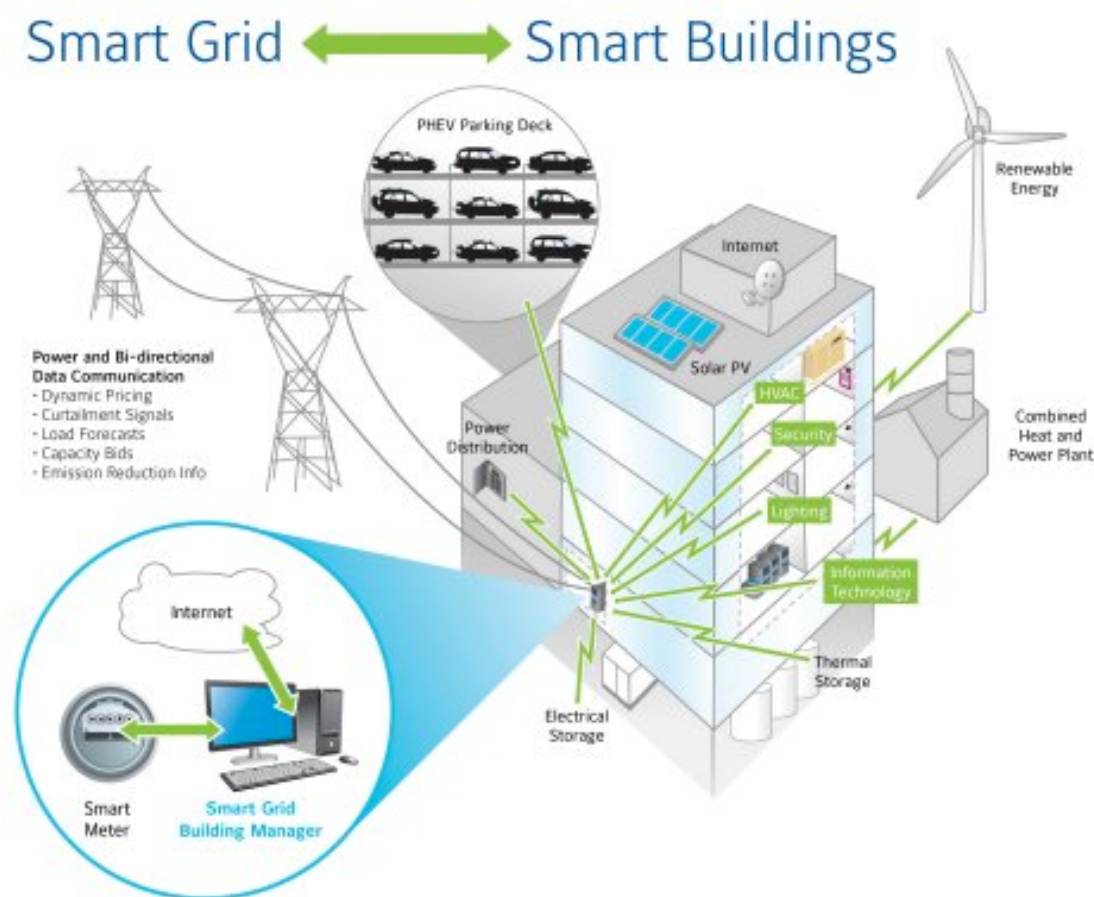
The smart building is still a relative new term and the definition has not so far been completely agreed upon. Many of the bigger companies in the space have tried to define it on their own. One of the better definitions is IBMs and will be used as a reference for this white paper:

*“Smarter buildings are well managed, integrated physical and digital infrastructures that provide optimal occupancy services in a reliable, cost effective, and sustainable manner. Smarter buildings help their owners, operators and facility managers improve asset reliability and performance that in turn reduces energy use, optimizes how space is used and minimizes the environmental impact of their buildings”.*¹

¹ <http://goo.gl/8KLk2N>

A “smart” building can use various types of sensors: monitoring temperature, motion, light, location, presence, leaks, noise, etc. All the sensors talk to a central gateway with an Internet connection that in most cases can be accessed by a device (Smart Phone, tablet or similar) from anywhere in the world. This enables the end-user to manage and control the setup of conditions of a building.

An example of what a smart building is can be viewed in the picture below.



http://www.johnsoncontrols.com/content/us/en/about/our_company/featured_stories/smart_grid.html

The need for new technologies in the smart building

With the increased opportunities from better technology there has also been an increasing need to optimize the way buildings operate and control the energy use in building.

The building sector consumes more energy than any other sector. According to Pike research is accounts for 49% of the total consumption of energy and 47% of global greenhouse gas emissions in USA.² Looking at an economical and CO2 perspective different benefits will be obtained if buildings can operate smarter and use energy more efficient.

There are several examples of new buildings that have been built with a green focus and green materials, and the newest technology but has ended up costing more because the system do not interact accordingly and the user is unavailable to adjust the settings correctly.³

Market data

By nearly any measure, buildings and the market around them is very important and have great impact. To give an indication of the size and development of this market and few key points have been selected to illustrate this.

- America has around 120 million buildings and account for 72% of the total electricity use in the country (42% of the total energy).⁴
- IDC Energy Insights has estimated that investments in the smart building solutions space is expected to triple from \$5.5 billion in 2012 to \$18 billion by 2017.⁵
- Up to 50% of the energy consumed in buildings is being wasted⁶
- California and Silicon Valley lead US in clean technology investment and innovation with investments of 12,5% of total venture capital funding in the country.⁷
- California is the state with most certified LEED projects.⁸ And the number of LEED certified building is expected to increase from six billion square feet worldwide in 2010 to 53 billion square feet by 2020.⁹

² <http://goo.gl/ZPznZz>

³ <http://goo.gl/zd7Mze>

⁴ <http://www.rmi.org/Buildings>

⁵ <http://www.idc.com/getdoc.jsp?containerId=EI240573>

⁶ <http://goo.gl/ZpDNLu>

⁷ <http://www.jointventure.org/2012index>

With the market data available, it is interesting to look into which different trends and technologies that are driving these numbers for smart buildings.

Trends and Technologies

The emergence of new technology is making innovative energy systems possible and global trends are also positively affecting the development. The following section shortly outlines some of the most significant trends pushing the development:

Internet of Things (IoT)

The term “Internet of Things” explains the technological development where all devices have an assigned IP address and networking connectivity, allowing them to send and receive data without interactions from people. The decreasing price of sensors, improved wireless and cloud-based solutions have pushed the development for IoT and each one of us will own many IoT devices in the future. According to a forecast from Gridpoint; 75 billion units will be connected in 2020 that will help push the development of smart buildings as well.¹⁰

In building this means that everything from the HVAC System down to single window will have an assigned IP address that will transfer data and talk automatically to a system. In future buildings one would be able both to measure and regulate every single room in a big office building and it will let the user customize it to individual needs and improve the energy consumption and operational efficiency of buildings.

Big data

As an implication of the many new devices being implemented more data is also being created. Buildings are and have always been large-scale producers of data points. New technologies are able to capture data in real-time and give operators (or intelligent systems) the ability to react instantly. This cloud-based data have created

⁸ <http://ecowatch.com/2013/11/08/top-10-countries-with-lead-certified-projects/>

⁹ <http://goo.gl/3lyuju>

¹⁰ <http://www.slideshare.net/GridPoint>

exciting opportunities to economically extract insight from large volumes of data and providing in-depth analysis of building performance.

Combining internal building data with external data (like weather forecasts) it is possible to create a better data mix. This will increase the ability to forecast and adjust building performance.

The vast amount of data points do also give the option to measure every single device or unit, making it easier for operators to detect irregularities in the system. In combination with the exponential growth in data points the industry does also see new software tools and programs being developed to analyze and control the data.

Mobile

With new web-based and mobile tools to manage buildings and physical assets in real-time, the user has better opportunities to make better decisions of the use of energy. The private smart home sector has been driving this development the last couple of years generating many new small devices and features from both small and big companies. This trend is also slowly starting to get into the commercial building sector as well.

IoT and cloud based services are the two most important factors that is driving the development down to mobile platforms but the design of the products being developed does also seem to play a very important role in the adaption of products.¹¹

Governmental regulations

Governmental regulation is also helping to fuel the trend of lowering use of energy in building. The Environmental Protection Agency (EPA) runs the ENERGY STAR program to help business and individuals to optimize their energy use.¹² The U.S. Green Building Council manages the Leadership in Energy and Environmental Design (LEED) green building certification system that educates people and recognizes best-in-class building strategies and practices for green buildings.¹³

¹¹ <http://www.hongkiat.com/blog/smart-devices-home-automation/>

¹² <http://www.energystar.gov/>

¹³ <http://www.usgbc.org/leed>

On a local level six U.S. cities—New York, Chicago, San Francisco, Washington, Boston and Austin, Texas—have all passed laws requiring buildings to report their energy use, submit to energy audits and lower their energy consumption.¹⁴

Large companies

Another indicator that this is an interesting space is shown by the interest and investments from the large IT companies. Besides the investments and development in the space, companies such as Google and Apple have committed to use 100% renewables for their data centers and want to increase the mix of renewables in the daily operations. A few other examples of the development in the space is provided below.

Apple: Apple has recently announced their platform HomeKit for the development of application to be controlled from your iPhone. The first products for this platform are expected to be released in the start of 2015.¹⁵

Cisco: – Cisco is taking IoT to the next level and talks about Internet of Everything (IoE). They believe that IoT will also bring together people, process and data.¹⁶ Cisco is of very course interested in this space because the deliver the backbone of the Internet.

Google: Google has entered the IoT and building space space by acquired the company NEST in January 2014. NEST develops “smart” home thermostats and smoke detectors that can program themselves and connect to smartphones.

Samsung: Samsung does already have products that are being used in the home but has also acquired the company Smarththings that is an open ecosystem for smart

¹⁴ <http://online.wsj.com/articles/big-data-cuts-buildings-energy-use-1411937794>

¹⁵ <http://www.macworld.co.uk/feature/apple/what-is-homekit-how-apple-iphones-automate-our-homes-3522416/>

¹⁶ <http://www.cisco.com/web/about/ac79/docs/innov/IoE.pdf>

devices. Samsung has also partnered with the IT giants Intel and Dell to agree on common standards for household devices.¹⁷

Another trend in the smart home space can be viewed on the crowd funding platforms (Kickstarter.com etc.) where projects in the home automation sector are being backed on a daily basis. It covers all from gadgets to monitoring of animals in the house, security systems to development kits to create own applications.¹⁸

Research

The universities are also very active in the space and are looking towards the combination of different technologies and how they operate in bigger systems (buildings). A few examples of research projects from the bay area universities and research institutions are indicated below.

NASA Ames

NASA Ames has created a governmental building project called “Sustainability base”. The building is highly intelligent and can react and anticipate to changes in sunlight, temperature and optimize to best performance conditions. It is supposed to be a test building and showcase how new technologies can be implemented in buildings.¹⁹

UC Berkeley

The research group CITRIS at UC Berkeley has been in the space for a long period of time. The lack of common data structure that was able to connect to other systems has led to the OpenBas project. This unifies data from many different building systems, allowing building managers to visualize it within a single, user-friendly interface.²⁰

¹⁷ <http://www.reuters.com/article/2014/07/08/us-tech-connectivity-idUSKBN0FD09920140708>

¹⁸ www.kickstarter.com

¹⁹ <http://www.nasa.gov/externalflash/sustainability-base/index.html>

²⁰ <http://citrisc-uc.org/bringing-building-automation/>

Lawrence Berkeley National Lab (LBNL)

LBNL is doing many different projects within the building space. One of their most interesting projects is FLEXLAB. FLEXLAB lets users test energy-efficient building systems individually or as an integrated system, under real-world conditions and can test different applications in any combination. Energy efficiency in building is the main research subject of FLEXLAB.²¹

Stanford University

The Precourt Energy Efficiency Center at Stanford does also have different research area, most with focus on efficiency and performance.²² One of the projects is developing an enhanced energy usage models and solutions for home and office buildings based on modern sensing and wireless networking technologies.

UC Davis

UC Davis has together with Honda created a smart home that showcase technologies that enable zero net energy living and transportation. In addition to showcasing a vision for zero-carbon living and personal mobility, the home will function as a living laboratory where the company, along with researchers from UC Davis and Pacific Gas and Electric Co. (PG&E), will evaluate new technologies and business opportunities at the intersection of housing, transportation, energy and the environment.²³

The above-mentioned projects show a great combination of private and public partnerships. Private companies sponsor some of the research and there is high focus on demonstrating technologies and combining it with research, which gives great opportunities for the different actors to get real life examples.

²¹ <http://flexlab.lbl.gov/>

²² http://peec.stanford.edu/buildings/faculty_and_research.php

²³ http://news.ucdavis.edu/search/news_detail.lasso?id=10876

Challenges

Even though the rapid pace of technology development creates a lot of new opportunities for the building industry there are still a few challenges that need to be considered as a part of the development. A few of the key challenges have been listed below.

Isolated technologies:

One of the biggest challenges for the building sector and the adaption of smart technologies is the current building management systems (BMS). Most BMS are not well suited for integrating with other services and difficult to customize which makes it expensive if changes have to be made. Most of the data created is still located in “siloes” due to systems speaking different “languages” and reporting different data.

Lack of common standards

Most building systems are developed decades ago and work on its own network, which makes it difficult to operate simultaneously in today’s big data challenge.

For smart building to take off a common network based on the internet need to be agreed upon to log, control and manage system as easy as an online application.

Almost every company believes in standards – The difficult thing is just to agree on which one of the standards to follow. Companies are still in competition to become standard-of-choice which is slowing the development since standards need to be vendor neutral.

Daintree network, a company in the smart building space is pushing open standards in order to get different products to interoperate and move the industry forward and give customers flexible solutions. Standard will also make it easier for new companies to enter a space and secure their products will be ready for the future.²⁴

²⁴ <http://www.greentechmedia.com/articles/read/whats-the-right-standard-if-any-for-smart-lighting>

Security:

Security is a very discussed subject at the moment and will also be a great part of the discussion on intelligence in buildings and if everything will be connected in the future it will put a higher pressure on security. What systems will be able to control and how can systems gain access to each other are two questions that need to be considered. The more devices that will be online, the bigger the surface for security attacks is and technology vendors will need to work together to make the most secure solutions for their customers.

Potential for Denmark in Silicon Valley

Denmark has great traditions in the building industry having a high focus on building green and sustainable with beautiful design. The list of US companies and institutions provided in this paper will show a selection of some of the technologies and companies present in the space, in particularly from Silicon Valley. If Danish companies will be able to integrate and combine the new products and technologies into the tradition of great design and thinking green, new and truly green buildings have the potential to be build and create opportunities for Danish companies.

Innovation Center Denmark Silicon Valley helps builds the bridges between Denmark and Silicon Valley.

Conclusion

Emergences of the Internet of Things and significant price reductions within IT have made devices available for everybody. Combined with solutions in software development, analytics and the ability to manage energy data, business will have better ways to adopt a smart strategy for controlling and minimizing their use of energy in building.

This paper described some of the key drives and challenges for the industry and cutting edge research and projects form a few of the bay area universities.

The final conclusion to this paper is that smart buildings within the commercial space in in the preface and driven by development in the home automation sector and stand-alone technologies are in the process a becoming part of larger building systems.

List of companies and research projects

| Company | Keyword | Web | Category |
|---------------------|--|---|-----------------|
| Activelogix | Internet-based enterprise automation solutions | http://www.activelogix.com/ | Startup |
| AlertMe | AlertMe is a smart energy and home monitoring system that enables users to control home appliances and devices. | http://www.alertme.com/ | Startup |
| Alyt | Smart Home Manager that combines professional security, energy management, together with multiple applications and devices to bring Internet of Things (IoT) | http://www.alyt.com/ | Startup |
| Aclara | Leader in advanced metering infrastructure (AMI) solutions for electric, water and gas utilities, | http://www.aclaratech.com/Pages/default.aspx | Company |
| Amatis | Amatis Controls designs and manufactures internet-connected devices that maximize building efficiency and performance | http://amatiscontrols.com/ | Company |
| American Automatrix | HVAC controls manufacturer dedicated to creating Smart Building Solutions that assist in reducing energy consumption | http://www.aamatrix.com/ | |

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| Apple Home | HomeKit, its iOS-based protocol for hooking up connected gadgets in the home. | https://developer.apple.com/homekit/ | Company |
| August | Smart lock | http://august.com/ | Startup |
| Bemo | BEMO° turns android and iOS devices into a SMART thermostat alternative with smart home features. | http://www.bemo.io/ | Startup |
| Berkeley Lab | University | http://cbs.lbl.gov/research-projects | University |
| Better building | Government (DOE) sponsored program on how to improve buildings | http://energy.gov/better-buildings | Government |
| Bidgely | Smart energy home device | https://www.bidgely.com/ | Startup |
| Birid | Smart Air Monitor device | http://getbirdi.com/ | Startup |
| Building IQ | BuildingIQ provides a unique Software-as-a-Service (SaaS) solution to optimize energy use in commercial buildings. | http://www.buildingiq.com/ | Startup |
| CABA | Building automation organization | http://www.caba.org/ | Organization |
| CIEE | CIEE is a dedicated group of experts who define, conduct, and manage public-interest energy research | http://uc-ciee.org/partners/other-researchers | Research |
| Cisco | Internet of Everything. Numerous projects in the space. | http://internetofeverything.cisco.com/vas-public-sector-infographic/ | Company |

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|-------------------|---|---|---------|
| Comfy | Comfy is software that enables people to adjust the temperature in their office space | https://gocomfy.com/ | Startup |
| Cyclon Energy | cloud based energy measurement, | http://www.cylon.com/about | Startup |
| Daintree Networks | Building Energy Management Solution (EMS) for commercial and industrial facilities | http://www.daintree.net/ | Startup |
| Echelon | Software that enables the development of devices, for the Industrial Internet of Things. | http://www.echelon.com/ | Startup |
| Ecobee | Wi-fi thermostat with remote sensors | https://www.ecobee.com/ | Startup |
| EcoFactor | The EcoFactor Proactive Energy Efficiency service uses data collected from Internet-connected thermostats to run patented energy algorithms, and automatically minimizes homeowner energy consumption | http://www.ecofactor.com/ | Startup |
| Enertiv | System for monitoring energy consumption | http://www.enertiv.com/ | Startup |
| Enlighted | Smart energy efficiency solutions for commercial environments, based on its innovative Enlighted sensor and analytics platform. | http://enlightedinc.com/ | Startup |

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|-----------------------|--|---|-----------------|
| Enmetric Systems | The Enmetric Enterprise Plug Load Management Software enables you to set and administer energy use policies for plug loads across your entire building | https://www.enmetric.com/ | Startup |
| Entouch Controls | EnTouch Controls develops energy management systems for small commercial facilities. | http://entouchcontrols.com/ | Startup |
| EPRI | Electrical Power Research Institute - Research within smart grid and buildings | http://www.epri.com/Pages/Default.aspx | Research |
| Flair | Climate control revolution for ventilation | http://www.flair.zone/ | Startup |
| GreenPeak | Products for smart homes | http://www.greenpeak.com/Application/SmartHome.html | Startup |
| GreenSoil Investments | GREENSOIL Investments is an investment house with a portfolio of venture capital and private equity funds focused on investing. | http://greensoil-investments.com/ | Venture Capital |
| Greenwave reality | Greenwave Systems is a global Internet of Things (IoT) software and services company | http://www.greenwavesystems.com/#whatwedo | Startup |
| Gridium | Gridium is a software company specializing in smart meter data analysis. | http://www.gridium.com/ | Startup |
| GridPOint | Energy management systems | http://www.gridpoint.com/ | Startup |
| Groov | Automation system on your mobile device | http://groov.com/what-is-groov/ | Startup |

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|--------------------------------------|--|---|------------|
| Heatworks | Digital Water Heater | http://myheatworks.com/ | Startup |
| Honeywell | Large company with various activities in the space including devices and Building Automation Systems & Controls | http://honeywell.com/Pages/Home.aspx | Company |
| HP | HP Labs is very active within the systems behind the scenes and how it can improve the network | http://www.hpl.hp.com/ | Company |
| Intel | Providing technology for IoT | http://blogs.intel.com/iot/ | Company |
| Jetlun | Integrated Building Energy Management | http://www.jetlun.com/ | Startup |
| Larwarnc Berkeley National Lab | Different research projects | http://cbs.lbl.gov/research-projects | University |
| Leeo | The Smart Alert™ Nightlight keeps track of your smoke alarms, your carbon monoxide alarms, and the climate in your home. | https://www.leeo.com/ | Startup |
| Litehouse | WiFi Module for Smart Home | http://www.lighthouse.io/ | Startup |
| Lucid | Building operation system | http://luciddesigngroup.com | Startup |
| Lutron | Lutron is the leader in the lighting control industry and offers a wide selection of energy saving dimmers and lighting control solutions. | http://www.lutron.com/ | Startup |
| Nasa Ames | Test building for integration of new green technologies in buildings | http://www.nasa.gov/externalflash/sustainability-base/index.html | Research |

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|-------------------|---|---|----------|
| Navigant Research | Navigant Research's Smart Buildings program focuses on the design, construction, and maintenance of highly efficient commercial and residential building | http://www.navigantresearch.com/research/smart-buildings | Research |
| Navitas Capital | Navitas Capital is a venture capital firm at the intersection of the IT and Energy sectors with a unique focus on the Intelligent Building & Enterprise space | http://navitascap.com/ | Investor |
| NEST | Intelligent thermostat and smoke detector | www.nest.com | Startup |
| NREL | NREL is the only federal laboratory dedicated to the research, development, commercialization and deployment of renewable energy and energy efficiency | http://energy.gov/articles/rd-100-smart-sensors-mean-energy-savings | Research |
| Onion | Onion Omega is a Linux Wi-Fi development board designed to make your IoT creation a reality. It comes Onion-enabled right out of the box! | www.onion.io | Startup |
| Optimum Energy | Building platform system. Autonomous learning | http://optimumenergyco.com/ | Startup |
| Parstream | Industry platform database for IoT | https://www.parstream.com | Startup |

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|-----------------------|--|---|---------|
| Persistent efficiency | US Berkeley spinout. Tape-on electric meter to measure building data | http://persistentefficiency.com/ | Startup |
| Qualcomm | Wireless network | www.qualcomm.com | Company |
| Samsung home | Both looking into the smart home and building energy management software | http://sds.samsung.com/popup/solution/BEMS.jsp | Company |
| Savant systems | Home energy management | https://www.savant.com/ | Startup |
| Schneider Electric | Building Management software | http://www.schneider-electric.us/en/solutions-by-schneider-electric/building-solutions/ | Company |
| SensorSuite | SensorSuite is built on cutting edge cloud and Company data technology. Access all your buildings from any browser or smartphone. | http://sensorsuite.com/ | Startup |
| Sentri | Sentri is a complete home monitoring and automation solution in one beautiful display video feed straight to your smartphone, no matter where you are. | http://sentri.me/ | Startup |
| Siemens | Building automation system | http://w3.usa.siemens.com/buildingtechnologies/us/en/pages/buildingtechnologiesusa.aspx | Company |

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|---------------------------|--|---|--------------|
| Slice Energy | Slice offers robust, low-cost, wireless control and monitoring solutions for commercial buildings. | http://slice-energy.com/ | Startup |
| Smart buildings | Smart Building consultancy | Smart-buildings.com | Consultancy |
| Smart buildings Institute | Smart Building education and learning center | http://www.smartbuildingsinstitute.org/about-the-institute.html | Organization |
| Smart Things | Platform and application that turns your smartphone into a remote to control all of the smart devices in your home | http://www.smarthings.com | Startup |
| Spark.io | Spark OS is a complete open source operating system for cloud-connected things | https://www.spark.io/ | Startup |
| Spirea | Proven, highly scalable smart grid power system solutions. | www.spirea.com | Startup |
| Stanford | Different research projects | http://peec.stanford.edu/buildings/ | University |
| Tendril | Tendril enables utilities to drive customer engagement via a rich and tailored experience for the home energy consumer | http://www.tendrilinc.com/ | Startup |
| UC Berkeley | CITRIS | http://citris-uc.org/launching-new-research-platform/ | University |
| UC Davis | Honda Smart Home | http://news.ucdavis.edu/search/news_detail.lasso?id=10876 | University |

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|------------|---|---|------------|
| UCLA | Smart Energy Research Center. Do research on how building play a part of the whole grid | http://research.universityofcalifornia.edu/stories/2011/11/adura.html | University |
| Velvetwire | Bluetooth enabled USB power solution | https://web.velvetwire.com/ | Startup |
| View | View Inc. is the pioneer in large-scale architectural dynamic glass. The company designs, manufactures, and sells a new generation of architectural dynamic windows | http://viewglass.com/ | Startup |
| Wally | Digital water detection device | http://www.wallyhome.com/ | Startup |
| WigWag | WigWag makes building intelligent environments easier than ever before supporting a variety of protocols including IP/WiFi, Bluetooth, ZigBee, Z-Wave, and Insteon | http://www.wigwag.com/ | Startup |
| Xigbee | ZigBee is a specification for a suite of high-level communication protocols used to create personal area networks built from small, low-power digital radios | http://www.zigbee.org/Home.aspx | Startup |
| Zuli.io | Control your lights and appliances from your smartphone using Zuli Smartplugs and smart home technology | http://www.zuli.io/ | Startup |