Industry and Technology Research Deliverable

Greengineers (Team 40):

Building Energy Management and Smart Buildings

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I. Industry Research and Analysis

Our product challenge "How might we optimize and monitor energy performance to lessen the environmental impact of existing buildings?" falls into the broad industry around energy. Within the traditional energy supply chain (depicted below), the energy performance aspect for buildings is relevant in the distribution, sales, and energy services steps of the value chain.

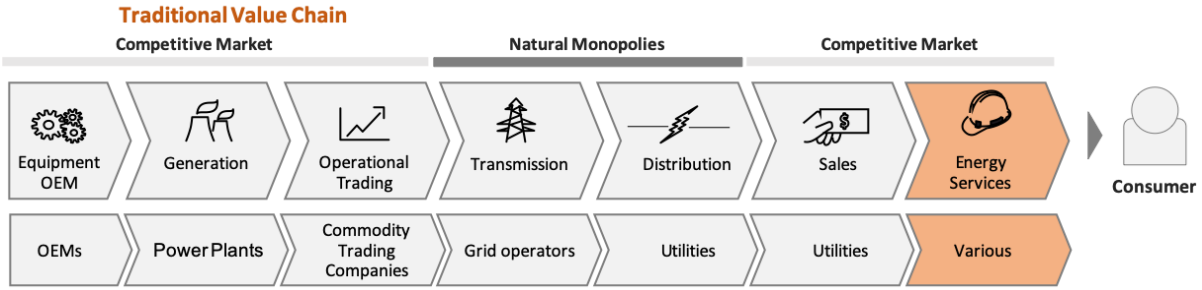

Figure 1: Industry Supply Chain and Players. Source: Fabio Daiber, Capgemini Invent internal documents (edited)

Players and competition vary strongly along the supply chain. In energy generation and equipment, there are a handful of large incumbents in the market, but none are of a large enough size to considerably control the market. In transmission and distribution, however, we generally have natural monopolies that act as the only provider in a certain area. A number of countries have deregulated the energy market over the last decades, but in many cities, buildings source energy still from only one provider. For instance, ConEdison is the sole provider for energy in the city of New York with the exception of the Rockaways Beach area (Chapter 6: Utilities p. 109). The last piece of the supply chain is energy services, a wide-ranging category of services that cover everything from sustainability consulting to energy management and monitoring. We defined our market segment as 'Building Energy Management and Smart Buildings', a subsegment at the intersection of energy services, architecture, and building engineering.

The building energy management market is highly segmented along a spectrum ranging from smart sensors and meters to a fully integrated building management solution that controls and integrates all processes and flows of a building (BEMS, ClimateTechWiki). Incumbents in this

market are traditional utility companies. Many utility companies such as ConEdison have started offering smart meters that offer real-time usage statistics and recommendations based on the energy usage (How Will a Smart Meter Help Me?, Con Edison). Challengers in this segment are manufacturers of smart meters and smart sensor technology. Among the largest providers of energy management software and solutions are energy equipment manufacturers such as Siemens, Schneider Electric, ABB, and GE (Hardesty).

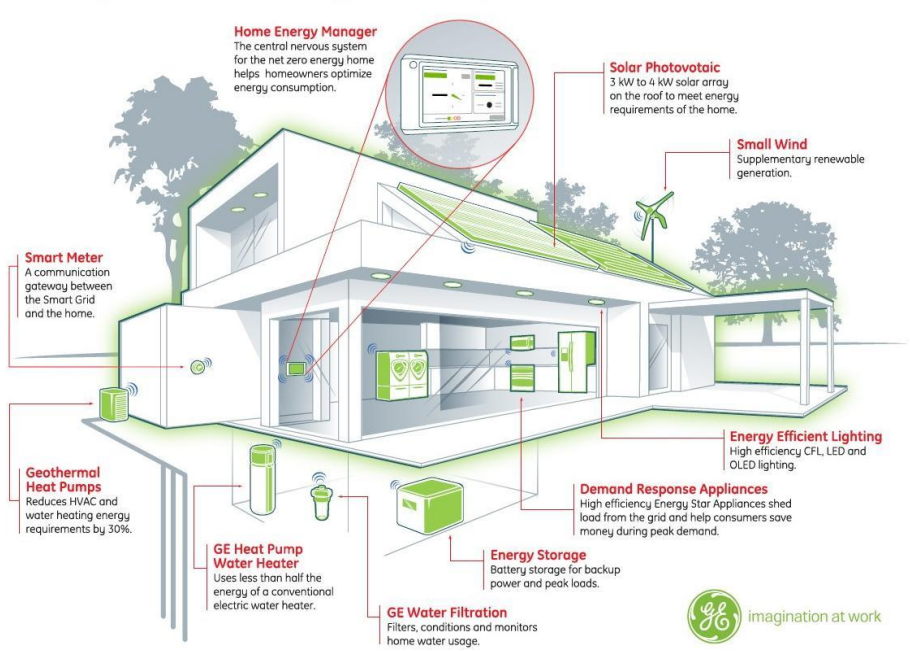

Figure 2: GE's energy management solution for a private home (BEMS, ClimateTechWiki)

Digital Challengers are both large technology companies such as IBM as well as smaller technology startups. In the B2C or home market, Amazon and Google have also entered the smart home market. We looked at some of the digital challengers' B2B solutions in more detail. Various challengers offer similar solutions – to better monitor energy consumption and recommend ways to both save on energy usage and reduce a building's carbon footprint. A main differentiation is the scope of the monitoring solution, ranging from energy only to the entire building. Lucid with its BuildingOS platform offers a comprehensive building management software that allows, among other features, to monitor and analyze energy usage of the building (Energy & Resource Analytics, Lucid). Verdigis offers a more focused solution

with its own Energy Meter in combination with an analytics platform (Smart Building Management, Verdigris). Iconics offers an energy management that integrates with existing sensors (Energy Management, ICONICS).

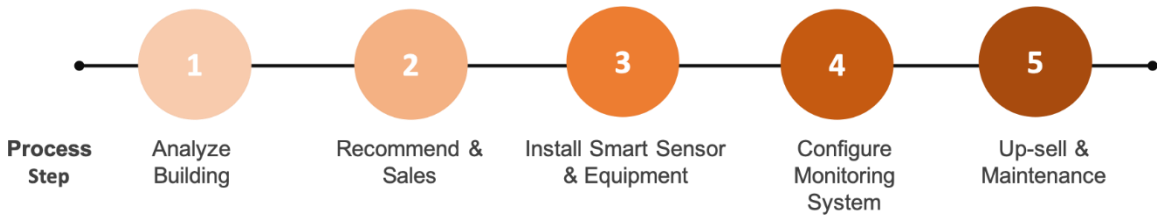

Figure 3: Typical process for an energy management solution

Coming from the broad supply chain view to a business unit view of energy management, we defined a typical process for energy management. Step 1 depends on the solution that is offered. For customizable energy management solutions (Siemens, GE, etc.), there is a much stronger focus on the analysis and recommendation of the building than for an off-the-shelf solution (e.g. Verdigris). After a recommendation and sale of a fitting solution to the building manager or owner, smart sensors and equipment will be installed, and the monitoring and improvement platform is configured for the client. The process concludes ideally with up-selling potential and maintenance services performed on an ongoing basis.

The business model in the entire energy industry largely depends on the section of the supply chain. Energy generation, transmission, and distribution are characterized by very high fixed costs for power generators, grid installation, and cable routing while operating or variable costs tend to be very low. Typical capital costs for power plants, for instance, range from $500 to $5,000 per kW while operating costs range from $0.01 to $0.10 per kW. Hence, asset utilization is of great importance for these players in the supply chain (Blumsack). The largest portion of the profits for manufacturing firms are generated with long-term maintenance contracts. Digital

services such as asset management or analytics and optimization are a tremendous market opportunity with over $1 trillion in revenue potential from 2016 to 2025. [1]

The building energy management business model usually has two revenue-generating components: an upfront sales price of the equipment and a monthly subscription to the analytics platform, maintenance, and other services. Equipment such as smart meter, sensors, and monitoring devices is typically sold at a relatively low price as a majority of the profits are generated with the subscription model. Verdigris, for example, charges a $99 installation fee for the equipment with its lowest subscription model that also charges $99 per month. Important drivers of costs are up-front development costs for the analytics and management platform as well as ongoing development costs for maintaining and extending the platform as well as salesforce expenses for customized solutions.

We already covered a variety of players in the energy ecosystem along the entire supply chain. Most notably, suppliers of energy management solutions are smart devices, sensor, and technology equipment manufacturers such as GE, Siemens or Schneider Electric. Further suppliers are utilities as they can provide data on the current and historical energy consumption of the building. At the same time, utilities can function as channel partners for both energy management and smart building solutions. Utilities have a direct connection to potential customers that is highly valuable for energy management providers. Yet, it has to be stressed that there always is a potential conflict of interest: While utilities are interested in lowering peak demand and offering more sustainable solutions to their customers, less energy demand indicates less direct revenue from those customers. Another important channel partner are green organizations, such as the U.S. Green Building Council, the developer of the LEEDs certification as they could include standards for energy management solutions in their

[1] Capgemini Invent internal research documents (accessed by Fabio Daiber); Digital Transformation of Industries: Electric Industry, World Economic Forum

requirements. Similarly, architects and building engineering companies can be an important channel partner recommending particular solutions to owners whose buildings have to undergo a retrofit. Lastly, the federal and local government are important players in the ecosystem as they may set standards for the energy performance and environmental footprint of buildings or requirements of energy management and smart building solutions. In particular, the City of New York with the Green New Deal laws not only requires a vast number of New York buildings to undergo a substantial retrofit in the next decades, but the city also acts as financier of retrofitting and energy performance solution as they want to provide special low- or zero-interest loans to make the retrofit more bearable, especially for individual owners of smaller apartment buildings (Fuleihan p.16).

II. Technology Research and Analysis

Analyze Building	Recommend and Sales	Install Smart Sensor and Equipment	Configure Monitoring System	Up-sell and Maintenance
• AR application, 3-D model application, Computer Vision to reconstruct building, Machine	• ML in data analysis, AR application	• Friendly UI with easy set-up	• Computer Vision for occupancy tracking, advanced sensors, IoT	• Cloud computing

learning from data				

To implement an energy management solution in the past, architects had to spent hours measuring the building. It was much worse when the targets were skyscrapers. With the development of modern computer vision technology, such a process can be cut down into a few minutes. Furthermore, with AR technology, floor dimensions can even be obtained by smartphones with reasonably high accuracy. A 3D-model of the building can easily be built based on such measurement data. “Magicplan” is one of the applications that uses AR technology to create a 3-D floor model in 30 seconds (Construction Software & Home Renovation Software, Magicplan).

Figure 4: Overview of functionality of Magicplan

After obtaining the model of the building, machine learning techniques can provide a customized design and plan for energy monitoring on different buildings based on the dataset of previous solutions. However, when it comes to data on energy consumption, there are only few technical solutions that are used for existing buildings. Different from scanning a building, energy monitoring is a long-term and periodic process that architects cannot immediately gather data for.

The next stage of the process is to recommend and sell the product to targeted people. Combining historical pricing data, data on the economy, and on customer behavor with a machine learning model could make sales forecasting more accurate. Statistics and analytics based on the usage and reduction in energy consumption and energy footprint are helpful in convincing the customer to buy the product. Another implementation of machine learning is to recognize the sales pattern to determine the most valuable customers by using publicly available data to cluster potential customer groups and identifying the ones that are likely valuable to us, which significantly shortens the process to find potential customers. The widely used AR technique can also help to recommend and sell products. Take the “IKEA Place” as an example. “IKEA Place” lets you virtually place true-to-scale 3D models in your very own space. This AR technology can be used to help customers see how smart devices, sensors, and the analytics platform would look and work in their buildings, for example. Although, the technology is used wildly in similar industries, there such an application is more difficult to implement in an energy-savings context.

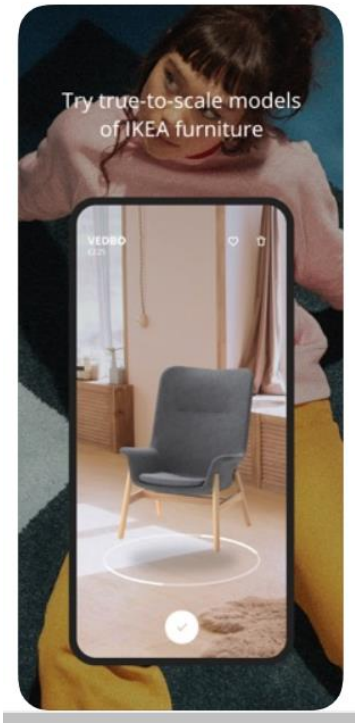

Figure 5: The AR functionality in the IKEA App (IKEA Systems B.V)

The next step is to install smart sensors and equipment. For most of the smart energy-devices, the hardware is all controlled by either screen or application on smart devices with a user-friendly UI to display the energy usage for all categories. With the rapid evolution in smart home assistants, such as Alexa or Google Assistant, the smart sensor can be connected with and controlled by such devices and with natural language processing, it is even possible to receive energy usage statistics directly via voice control.

Energy monitoring systems are built on advanced technology in terms of both algorithm and precise sensors. Take occupancy as an example, currently available technology can not only recognize the number of the occupants within a given space, but also tell identify these occupants. Based on the sensors, the system is able to control the energy usage within the room by controlling the smart devices to save energy. Internet of Things technologies are driving down the cost of building management systems, making it possible to get accurate and useful building data. Prescriptive Data NANTUM, an IoT implementation by Intel, empowers property owners to reduce expenses and optimize operational efficiency (mart Building: Prescriptive Data Nantum, Intel).

Furthermore, cloud computing enables IT to move hardware out of the internal data center and reduce the cost of daily maintenance by detecting the problem for each system from the center. Major public cloud providers, such as Amazon Web Services or Google Cloud Platform, offer services based on shared, multi-tenant servers, thus, also significantly driving down costs (Rouse).

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TOOL

The Digitization Audit

Business Name: Greengineering Inc.

	Main Activities List key activities for each business phase. You may add additional lines as necessary.	Current State of Digitization Select the current state of digitization for this activity from the drop-down menu.	Opportunities for Digitization Identify ways you can evolve this activity to the next level of digitization.
Sourcing			
	Comparing supplier prices for hardwares	Digital data collection	Collect data on prices of different hardware suppliers
	Cooperate with energy generation companies	Analog	Receive data on energy usage and analyze the factor that influences energy usage
	Cooperate with owner of the building	Analog	Create customized solutions based on energy usage for each building
Organizational Processes	Research and ayalyze building energy usage	Digital data collection	Use existing data for different energy usage
	Identity future customers with current dataset	Data analysis for business insight	Build a model to target future customers with previous examples
	Add new customers to management program	Digital data collection	Make interface for remote connection to services (i.e. individual Product Key)
Customer Interaction	Website	Digital data collection	Create a website for the product
	Customized solution for existing building	Analog	Provide a customized solution for different buildings
	Periodic feedback by phone	Analog	Ask feedback from customers after a few months using surveys and emails
	Finalize sales	Analog	Make final sales decision through company website portal
After–sales	After-Sales Maintainance	Analog	Automate system checks and updates through network servers
	Email marketing	Digital data communication and sharing	Analyze response and feedback to improve quality
	Customer support	Digital data collection	Have an automated system, AI, that responds to issues or breakdowns for customer