What's Next? Intelligent Energy Management Systems

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ABSTRACT

Technological advancement in the 21st century has forced the migration of traditional power grids towards a smart grid that will address some of the pressing challenges faced by the electricity sector today. The essence of such a market platform is bidirectional communication that has the potential to transform the relationship of energy supply and demand through digital information. Among the technologies that enable smart grid capabilities and facilitate information exchange between different points of energy usage and supply, energy management systems (EMS) is one of the emerging technologies that will not only impact energy consumption but also help enhance enterprise-level operation and financial decisions. As information technology (IT) redefines the way information is collected, analyzed and utilized, real-time information and data-driven decisions can lead significant energy conservation.

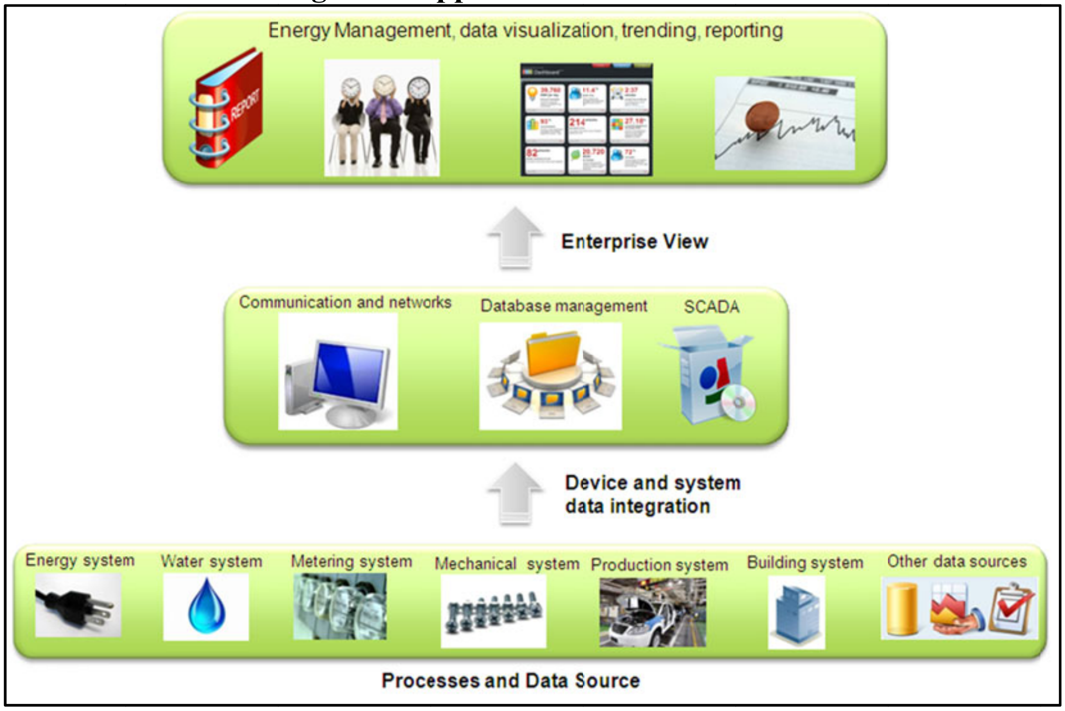
This paper aims to examine the key characteristics of EMS, the application of EMS in different sectors, and finally the discussion of market dynamics and challenges that may interfere with the growth and large scale adoption of EMS. It concludes that while the technology seems promising in light of environmental and energy security concerns; it is still more expensive than other energy efficiency options available, archaic in comparison with the automation technology in industries such as aviation, and its market is still nascent. The customers are still wary of investment in this technology due to lack of knowledge, both of technology and underlying savings. Unless the government accelerates adoption through policies or programs and customer awareness increases, the increase of EMS adoption is likely to be dismal as the market takes time to mature.

Convergence of IT and Energy Efficiency Enabled by EMS

EMS is an analytical tool which collects information on the energy use of a facility through monitoring, assessing, and visualizing real time energy consumption. The data collected by EMS helps enterprises make data-driven decisions that are critical to their sustainable growth and competitiveness by reducing their overall energy consumption and lowering operating costs.

Error! Reference source not found. exhibits the various applications of EMS that use data analysis to drive enterprise-level decisions in energy consumption and asset management.

Figure 1. Application of EMS

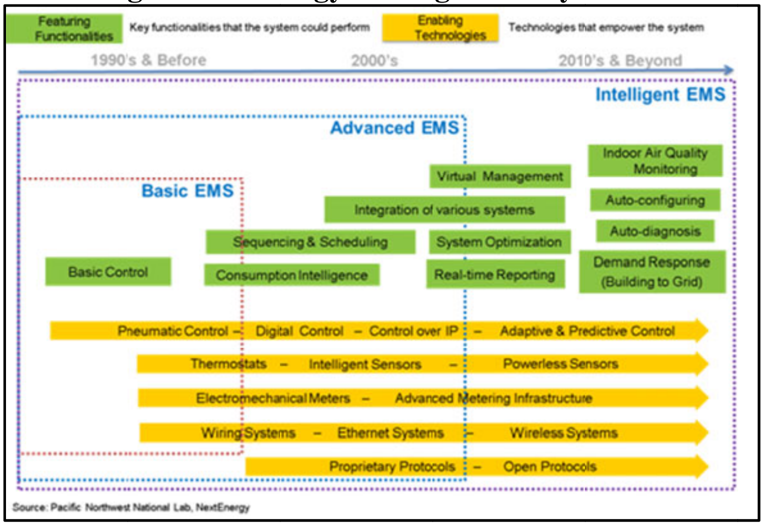


Source: NextEnergy. 2012

As today's world is largely characterized by rapid changes and uncertainty, challenges arise in the context of energy crises and resource constraints which make energy management and power consumption particularly important for the long term success of any business. One of the emerging technologies which can help to better address these energy issues is advanced EMS. The concept of EMS is spurred by the development and cost reduction of sensors, controls, and information and communication technologies (ICT). The convergence of information technologies (IT) and energy makes it possible to collect, analyze and share information that is critical to effective energy management across different consumption levels.

Figure 2 shows that the technology for energy management has come a long way over the last 50 years. Pneumatics, also known as air based energy control systems, were primarily dominant in the early 1960s and 1970s but were soon replaced by analog electronic control devices in 1980s to provide faster response and higher precision. With the introduction of digital controls in the 1990s, features such as automation became widely adopted and revolutionized the development of energy management. The technology is still evolving with adaptive and predictive controls forming the current theme. As the application of this technology scales up, a uniform coding standard platform for EMS with better user-interface is expected to be developed.

Figure 2. Convergence of Energy Management System with ICT

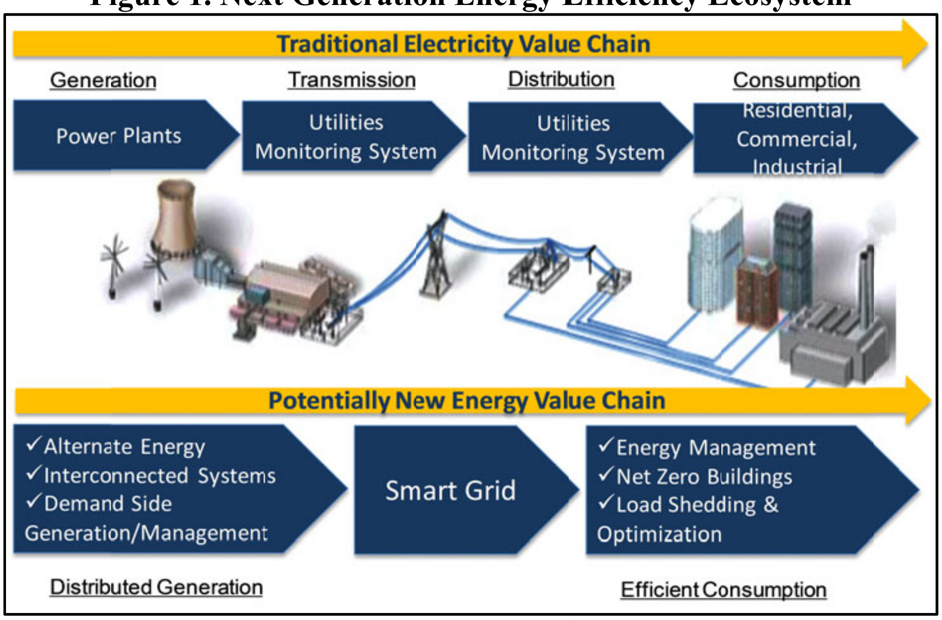


Source: NextEnergy. 2012

EMS as Key Enabler of Smart Grid

Each component of the electricity supply chain, as shown in **Error! Not a valid bookmark self-reference.**, needs advancement in order to make the grid more intelligent. For generation and transmission systems, monitoring and control technologies such as wide-area situational awareness (WASA) and wide-area monitoring systems (WAMS) generate data to inform decision making and improve network reliability. At the distribution end, the utilities use communication devices, system control and resource planning software to enable two-way exchange of information with the grid.

Figure 1. Next Generation Energy Efficiency Ecosystem



Source: NextEnergy. 2012

Equally critical is the establishment of communication between the grid and end-users to enable a two-way flow of information to transmit data on electricity prices and provide utilities with information including time and amount of energy consumed. The EMS is seen as a technology that enables these functions as it provides a platform to initiate bidirectional communication between the grid and the electricity users.

As such communication requires digitalization of the information at both the electricity supply and demand side, many states in the U.S. such as California, New York and even Michigan have improved the grid infrastructure by adding a digital layer to enable data flow and information management; at the end user side, EMS allows the consumers to feed information and transmit consumption data back to the grid.

Thus, it serves an integral role in enabling interaction between the power supply and consumption system[1]. The fact that EMS can measure, share, and control energy usage and patterns in real time provides the following opportunities for efficient energy consumption through integration of EMS with the smart grid:

- Enhanced Services: The ability to track and manage the energy consumption in real time enables utilities to increase the consumer participation in programs related to energy efficiency.
- Better control: The EMS also allows consumers to set their energy consumption in response to the time-of-the-tariff. Conversely, it also helps utilities better manage the demand across the grid.
- Reduced fluctuations: By managing consumer demand, utilities can help shave the peak load by better understanding and accounting for the consumer response to peak power price.
- Behavioral Changes: The real time monitoring and visualizing of the energy consumption shall drive an inherent change in the consumer energy consumption pattern, making them more conscious, aware and wise.

EMS and Buildings

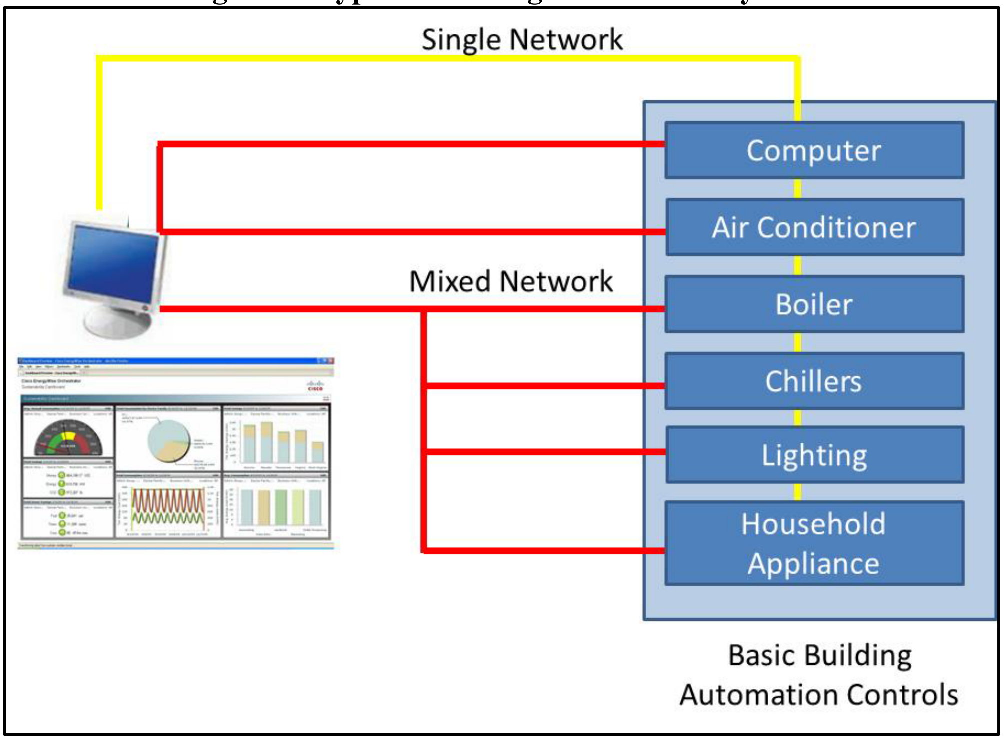
Energy Management Systems applied in buildings are generally referred to as Building Automation Systems (BAS). By managing the operational performance of the facility while ensuring the comfort and safety of building occupants, BAS helps to reduce the operational cost over the life cycle of the facility. It provides data about the energy consumption pattern of the building, which is extremely useful in making intelligent decisions related to energy use.

Most buildings use simple controls to manage mechanical, electrical and plumbing systems. For instance, heating, ventilation and air-conditioning (HVAC) and lighting systems are always controlled along with the control of its components such as chillers, boilers, air-handling units, rooftop units, fan coil units, heat pumps, etc. However, with the use of more sophisticated tools and programming, greater levels of controls can be implemented to optimally maximize the energy conservation. Such measures include varying air handler fan speed, controlling enthalpy economizers, installing carbon dioxide sensors, checking speed of circulating hot water and condensed water pumps, controlling intensity of light and many others.

[1] ***"**It's one thing to collect a bunch of energy data. It's quite another to create intelligence from it**"*** **–** Miller, Troy (Glenmount Global Solutions). 2012. Personal Communication.

A standard BAS is represented in Figure 2. An automation system, which includes sensors and controls, is embedded in a hardware device such as thermostat. These provide input data to the centralized computer and managing equipment based on established parameters.

Figure 2. Typical Building Automation System



Source: NextEnergy. 2012

Generally, system integrators or control contractors may install, manage and/or operate the BAS or provide training to facility staff for in-house operations and management. With the recent advancement of wireless BAS, the need for human interference to control the system is reduced. While some technical challenges such as short battery life or lack of communication standards remain to be addressed, continuous research and development will make BAS application more user-friendly and intelligent. Furthermore, the growing use of open sources is expected to facilitate and catalyze the adoption of communication standards.

EMS and Industrial Sector

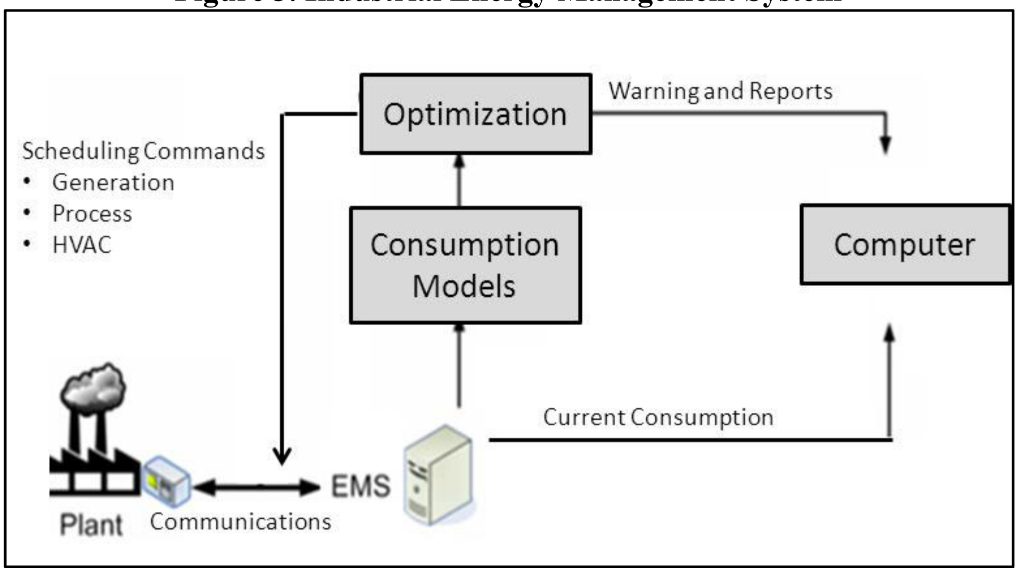
Industries are generally the prime energy consumer in an economy. For industries like oil refineries, steel, aluminum, paper, chemical, or other manufacturing units, energy constitutes a bulk of their operating cost and most of them use electricity in a 24-hour cycle. Furthermore, as environmental regulations become more stringent, industries continue to strive to make their processes clean and efficient. All these factors make it imperative for industries to monitor their energy consumption and manage it for optimal consumption.

The industrial EMS provides a medium to visualize the energy consumed throughout the enterprise including the manufacturing process and building operation. These systems provide monitoring and regulating capabilities to manage the process, and enable companies to participate in programs such as time-of-the-day tariff.

A typical industrial EMS includes devices that are networked in a plant to determine its energy footprint. Through a network, these devices are then connected with a web-based energy management system. Based on the consumption standards and/or power prices, the software initiates optimization of the plant's energy consumption. In most cases, the EMS systems may also have the capability to control the carbon footprint of the manufacturing process, thereby reducing the environmental impact.

Figure 3 shows the design of an industrial EMS that incorporates a suite of components including electrical nodes, meters, physical nodes with display, digital input-output node, computer with EMS Software.

Figure 3. Industrial Energy Management System



Source: NextEnergy. 2012

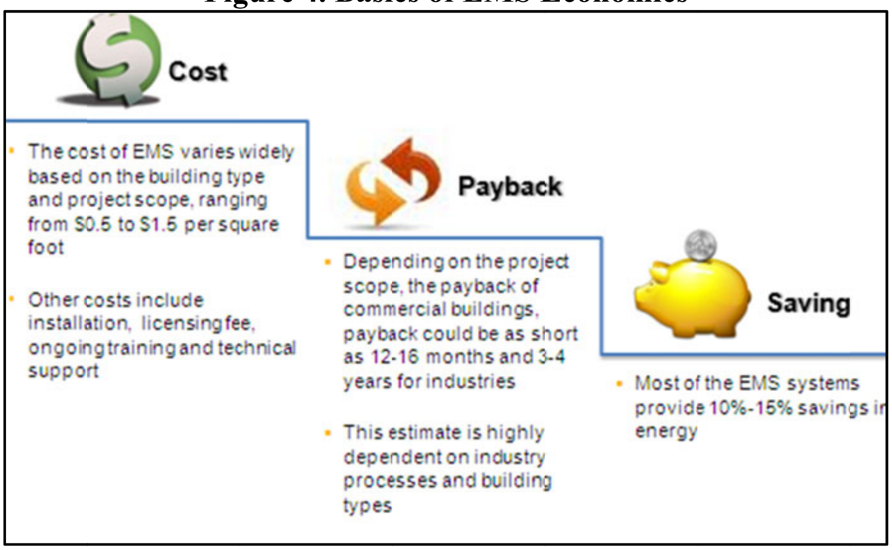
The system also includes a dashboard that visualizes the real-time energy consumption and has capabilities to enable companies to respond to real-time energy balancing market which helps to shave the peak load and achieve energy efficiency improvements. This opportunity, viewed from a magnifying lens, helps to avoid investment in additional generation sources and improves grid reliability not only at a utility level but at a national level. Other demand response programs that are made possible by such system include manual customer response, price-responsive appliances and programmable thermostats that can be controlled through EMS by utility operators.

Market Landscape

Based on the extensive research conducted through industry interviews and secondary sources, NextEnergy predicts the following key market characteristics for general market place of EMS in the next few years:

- Vendor landscape: The current vendor landscape is primarily dominated by big players such as Siemens, Honeywell, Johnson Control, etc. who account for more than 65% of the EMS market. While many smaller companies also offer platform-agnostic software that can be easily integrated into a company's current enterprise systems, other factors such as distribution channel, bargaining power and R&D capabilities make it hard for small firms to compete. Hence, market consolidation can be expected through alliances formed between the local and multinational companies.
- EMS economics: Based on NextEnergy's research, the payback of EMS systems is comparable to those deemed low-hanging fruits at initial installation. Also, as the energy saving opportunity from the cheap energy efficiency measures continues to shrink, the market is bound to shift towards the next-in-line option for efficiency gains at the least cost. EMS provides a system-wide approach for integrating the entire energy value chain to maximize the impact for companies at a reasonable cost. Figure 4 outline NextEnergy's findings on average cost, payback period and overall savings as a result of EMS adoption.

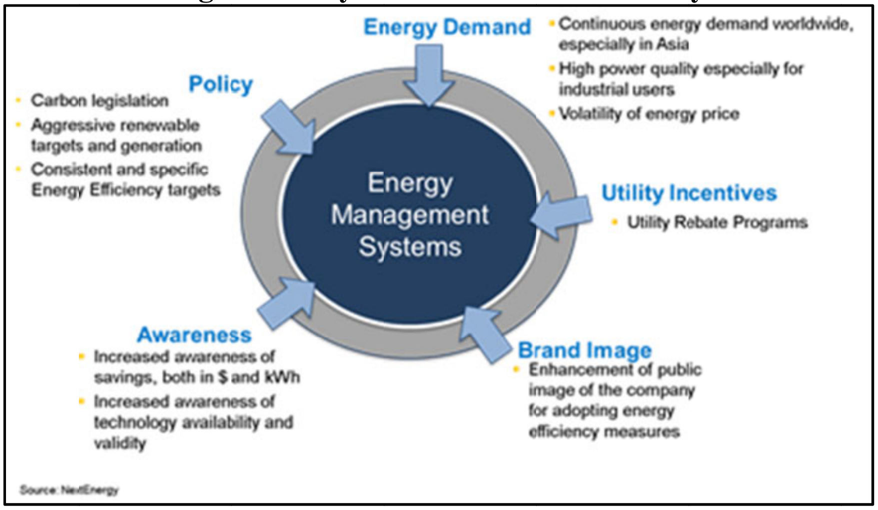
Figure 4. Basics of EMS Economics



Source: NextEnergy. 2012

- Market forces: Figure 5 outlines a number of economic and market forces, such as effective policies, increase in awareness, introduction of utility programs et al., which the industry experts believe can impact the overall adoption and development of EMS. As more aggressive carbon and energy policies are expected to be announced, coupled by pricing volatility, the value of EMS will extend beyond enterprise-level energy management and provides value to strategic planning of energy supply and procurement.

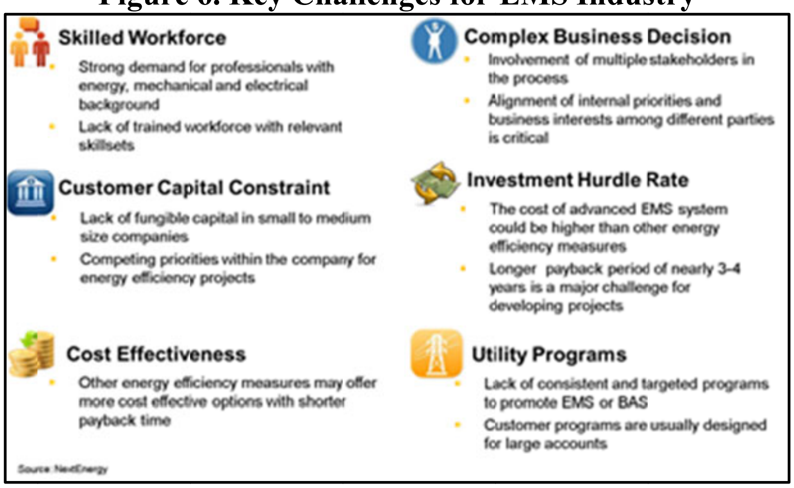
Figure 5. Key Drivers of EMS Industry



Source: NextEnergy. 2012

- Market Challenges: The capital spending on energy efficiency improvement is highly correlated with the financial health of a business. As the economy recovers in the U.S. and globally, capital spending by companies and government expenditure towards energy efficiency programs is likely to increase, thereby addressing the challenge of capital constraint. However, EMS is only sufficiently economical. The technology is still expensive as compared to other options for energy efficiency improvement and will gradually become cost effective as the technology scales-up.
  In addition, addressing challenges, as listed in Figure 6, such as the lack of qualified workforce which is conversant in both IT and energy system is essential for the development of EMS.

Figure 6. Key Challenges for EMS Industry



Source: NextEnergy. 2012

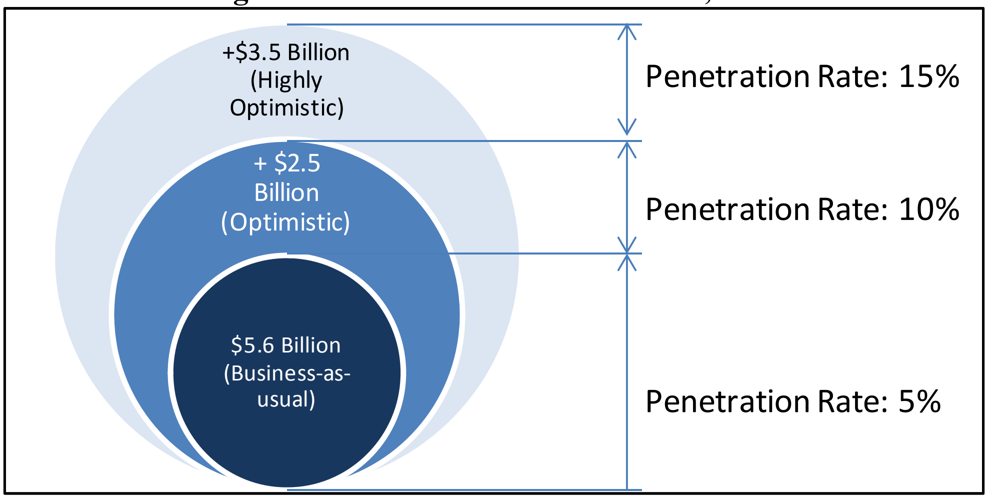
Market Forecast

The forecast of energy savings by EMS is based on a primary research conducted by NextEnergy. Through a series of interviews with Michigan-based technology developers and international EMS providers, it was concluded that the application of EMS in a commercial building yields an average10-15% savings, and around 4-5% savings in industrial settings. In order to estimate the market size of commercial and industrial EMS markets, several assumptions were made based on literature review and industry interviews. Two key assumptions among these were consumers' willingness to pay[2] and the technology penetration rate, which indicates consumers' technology adoption rate.

The latter was used to formulate three different scenarios. The penetration rate was set at 5% and 10% to represent business-as-usual and an optimistic scenario respectively, whereas a15% penetration rate was assumed for a highly optimistic scenario based on the implementation of aggressive policy measures and other incentives.

Based on the above assumptions and the energy demand projections from EIA, the market size for Energy Management for 2020 is estimated at $5.6 billion in a business as usual scenario and up to $11.7 billion under a highly optimistic scenario.

Figure 7. EMS Market Size Forecast, 2020



Source: NextEnergy. 2012

[2] Consumers' willingness to pay represents the cost that consumers are willing pay for investments on energy efficiency measures to save energy.

Limitations. It is important to note the inherent limitations of the data and estimates used in the model. . The energy demand forecast is a projection based on known factors, whereas the technology penetration rates in different scenarios and levelized cost over time are subject to change based on the actual market condition and policy implementation. Estimates such as average savings in commercial and industrial sectors are generalized from projects implemented by the interviewees and may vary depending on the nature of the projects. Whereas efforts were made to capture important parameters and benchmark data, it is important to recognize potential variance may exist that renders deviation and difference between the real world situation and the conceptualized model.

Conclusion

As the potential of energy savings from low-hanging fruits declines, EMS provides the next likely option for industrial and commercial energy users to use energy efficiently through data analytics and visualization. As modern enterprises increasingly rely on analytical tools to gain operation and financing intelligence, EMS will not only help drive efficient energy use but also enable companies to make data-driven decisions. In the future, EMS is also envisioned to allow predictive and prognostic capability for companies to better manage energy infrastructures.

However, the market for EMS is still nascent. Other industries, such as aviation, have much better controls and sensors which render the current technology rather archaic. The technology still needs innovation, which would in-effect reduce its overall cost.

Whereas the current marketplace is dominated by technology suppliers with broad market reach and technological capability that continue to make product enhancements, the above-mentioned market challenges may remain static without aggressive policy measures and incentives. Federal and state level policies and policy driven programs which force the user to adopt energy efficiency measures are necessary to catapult the development of market for EMS. Furthermore, the incentives must graduate from subsidy based to competition based coupled with strict compliance mechanism in order to foster actual adoption of efficient technologies such as EMS.

Energy efficiency investment is known to be highly correlated with economic cycles; current adoption rate may continue to be flat unless key market drivers identified above are brought into the picture to create the market conditions for large-scale deployment.

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