Smart Manufacturing

Summary of ACEEE Report by Ethan A. Rogers

"The Energy Savings Potential of Smart Manufacturing" July 2014 Report IE 1403

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The report “The Energy Savings Potential of Smart Manufacturing” written by Ethan A. Rogers covers some interesting points regarding Smart Manufacturing and the use of Information and Communication Technology (ICT).

The purpose for this summary is to gain industry & team support from those that we are engaged with and to further educate ourselves in the topic as we evolve. ***I believe that this is an ideal focus topic for developing training initiatives for contractors on the installation side & utilities on the incentives program side (utility demand response/efficiency gains)***.

When we look at the ACEEE research, they indicate that the manufacturing sector could realize savings of $7-25 billion in annual energy costs by 2035 by investing in Smart Manufacturing technologies, it gets my attention! Particularly since the study only assumes a 1-3% increase in investments over current trends and they will pay for themselves in two years.

Ethan manages the industrial program at the American Council for an Energy-Efficient Economy and has expertise in industrial energy efficiency, sustainable manufacturing and workforce training. As a consultant in all of those areas, ***I am engaged in soaking up knowledge on this topic***. It is clearly the direction and the future of the energy efficiency space at some level, depending on how we collectively address the challenges. ***Our team is vested in developing, promoting and communicating through educational & outreach activities on this subject***. That being said, let’s delve into the subject matter and the report itself. I am attempting to summarize much of the report in my own words and the interjections except where Ethan is quoted, are my own, so I ask the reader to be advised that it is my interpretation of the report.

Ethan starts out the report by summarizing what Smart Manufacturing is. He describes it as a broad based and at times confusing subject but summarizes that it is “the integration of all facets of manufacturing, regardless of the level of automation, and all the individual units of an organization in order to achieve superior control and productivity.” The purpose of this integration is to provide a means for “informed, data driven decision making”. Ethan contends that energy efficiency can be optimized through “adaptive & anticipatory decision making”. Ethan describes it as “the ability for everyone in the organization to have the actionable information they need, at the time they need it, so that they can contribute to the optimal operation of the enterprise through informed, data-based decision making.” ***Well, when you put it like that, it has far reaching impact for the industrial client base and the future of US manufacturing***.

I thought this was interesting too, the author states that “If one measures productivity as the ratio of throughput to the value of capital equipment and operating costs, then improvements in productivity can come from greater output, lower value of equipment, or lower operating costs.” He goes on to say that because energy is a variable cost of production, it is important to companies as a component of this larger metric. So, when productivity improves (process, facility workforce or company-wide productivity) as a result of an investment, there is typically a resulting energy savings. He contends that ***Smart Manufacturing reduces the energy intensity (total energy used/production volume) of manufactures products***.

Smart Manufacturing is possible because of the combination and availability of ICT and conventional automation; the ability to connect devices to another device or person. ICT consists of hardware, firmware (devices sold with embedded software), software, communication protocols, networks & interfaces. Automation includes, devices, sensors, systems, processes & controls. It is no small wonder that this is a monumental task for industrial, plant engineering, which is why energy efficiency consultants, product manufacturers, plant engineers and the contractors (installers) need to be continually improving and expanding their knowledge base.

Ethan contends that it will completely transform industrial plants and impact their utilization of resources such as; energy, raw materials and even labor over the next twenty years. I agree. This of course, will greatly impact organizations bottom lines, as the plants use less energy and improve processes. An article titled “Industrial Internet: Pushing the Boundaries of Minds & Machines” written in 2012 by GE, stated that cost savings and new revenues that could add $10-15 trillion to Global Domestic Product (GDP) over the next two decades.

Part of our job as consultants in the energy efficiency space is to educate ourselves, our vendors and our customers & communicate these possibilities to our customer & contractor base.

Some examples of Smart Manufacturing are:

- Sensors & devices with embedded software that can communicate with one another & other systems in a given network
- Automated Controls, integrated manufacturing & networking; improving productivity through shared information & improved decision making tools
- Utilizing cloud-based tools to improve M & V capabilities
- Capturing & utilizing big data to analyze & improve and trouble shoot operations; even to gain an understanding of customer interests
- Combining Enterprise resource Planning (ERP) and production management systems & connecting them with design systems
- Evaluating Cradle-to-Grave environmental impacts for products

Where the rubber meets the road for consultants, product vendors and contractors is the fact that the steps to making a plant a Smart Manufacturing facility is both a business & technology journey.

In order to explain the hierarchy of technologies, in the report, Ethan uses an illustration of a water pumping system that pulls water from the city water supply and moves it to a tank several hundred feet away. The hierarchy of technologies in this example ranges from basic to intelligent efficiencies with adaptive, anticipatory and network capabilities. He uses this example as a simple illustration to explain system level savings due to Smart Manufacturing. The same principles/thought processes can be utilized for facilities, entire companies and throughout the supply chain.

It is easy to see, many things from this example; why the contractors installing this equipment need to be highly trained; why consultants need to understand the big picture & future requirements/demand; why Intelligent Efficiency and Smart Manufacturing is important to the bottom line; why proper design/product specification is critical, etc.

Water Pump Example:

Level	*Technology*	*Description*
0	Manual on/off	Controlling speed of motor with on/off switch
1	Reactive on/off	Utilizing a level sensor that turns the motor on or off automatically- fills pump to certain level then shuts off. Turns pump on when to low.
2	Programmable on/off	Instructions in the water pump's programming determine certain conditions like time, tank level, production scheduling.
3	Variable response	Pump motor is connected to a variable speed drive that speeds up or slows down the pump in response to an instruction (from a sensor or program).
4	Intelligent controls	Smart technologies tell central control how much water it needs, when and uses the information to fill it to the required level (maintains pressure and volume)- fully integrates technologies with additional software component that analyzes past performance and adjusts system outputs in anticipation of future requirements.

Next, the author discusses process level savings, facility level savings. Enterprise level savings and energy savings through the supply chain.

Process level savings can be thought of in terms of the water pump example. For example, say the water pumping system is part of a larger manufacturing process. The network that provides the schedule to the pump for its supply schedule each day also allows each system in the production line to optimize its use of energy. The system may accept the information or it may pass it through to a production manager for decision criteria/input. The process level efficiency again optimizes savings (energy & other resources).

Facility level energy savings is realized in Smart Manufacturing because it integrates communication between the production processes and the business management side (accounting, payroll, ERP). Ordering raw material is an example of where the information integration is critical. Also time and labor hours per product shipped is data that becomes readily available and manageable.

Enterprise level energy savings comes about when the integration of multiple production facilities makes asset and resource utilization visible to management. For example, evaluating optimal production levels becomes dynamic, integrating customer demand, supplier issues, and production capabilities and capacities at each facility across a portfolio.

Energy savings throughout the supply chain becomes possible through integrating customer relationship and supply chain management systems. Customer demand, production and supplier data all becomes more streamlined and more cost effective as it runs more efficiently; less waste equates to energy saved.

In the report, Ethan goes into all of the ***components of Smart Manufacturing***, broken down into hardware & software. He also details and breaks out components of conventional components.

Components of Building Blocks for Smart Manufacturing consist of:

The term ***"Smart Devices"*** is referenced as technology that leverages ICT to improve efficiencies in production areas and enable network integration. "Smart Devices" improve convenience, value or energy efficiency. The following example is given: a dumb device has no embedded logic, a smart device has embedded logic and an intelligent device is one that is networked and has adaptive & anticipatory capabilities.

Sensors are the initial step in obtaining data; they can indicate things like motor speeds, pressure, rates of flow, temperature, heat distribution, etc. Embedded software with connectivity enables remote control, monitoring and a tool for analytics. Sensor technology has moved toward wireless, self-configuring devices.

Input/output Devices are bidirectional communications capabilities which allow devices to communicate with other devices & respond to them; they provide remote monitoring. An example of I/O from the water pumping scenario is the control interface for the variable speed drive (VSD). In bidirectional data transfer, both devices need to have the capability to accept, store and transmit data at the same time. Common software must be embedded to have this occur (TCP/IP). Software architectures that enable communications between devices across networks are sometimes referred to as "platforms". The platforms enable control of devices & processes and support other software programs with different functions. According to the report, software platforms turn data from a sensor or meter into information, then into knowledge, then into wisdom that creates cost efficient processes and that leads to efficiency strategy development within the organization. ***The software that contains the user interfaces determines how easy it is to obtain the efficiencies***. A case study is profiled in the report that reviews Google's use of neural networks to optimize energy consumption in their data centers. ***The computer system gathered data on electricity, water and external temperature factors and developed a predictive model to identify ways of improving efficiency***.

Smart parts have RFID tags or other mechanisms that enable them to communicate with a production line. It makes possible mass customization in which each final product is tailored to the needs and desires of the customer (vs. mass production which assumes a one-size-fits-all approach). For example, Ford uses RFID tags in its engine production line and BMW uses them for entire cars. This system provides for ***streamlined quality, better tracking and lower energy consumption***.

Control Systems improve productivity through controlling processes. An example is a speed or flow regulator on a simple scale. Set points can be established and instructions used to turn things on or off, or speed them up or slow them down. Control Systems improve productivity (volume, quality and costs). ***Distributed Control Systems*** have controls distributed throughout the manufacturing process. Ethan uses the example of a control loop consisting of a pressure sensor that communicates with a controller (through an I/O device), then when the measurement reaches the set point, the controller opens or closes the valve. This provides for a manufacturing process to be automatically controlled. PLC's are real time digital control devices that have control programs to control machine operations. In the manufacturing process, ***PLC's connect devices & systems to supervisory control & data acquisition (SCADA)***. Newer systems include security features to predict & prevent faults as well as collecting data form more nodes and performing more complex data analysis. ***The upside is savings in time, material and energy.***

The report states that “A Smart Manufacturing Platform will provide a foundation for unified communications, network enablement tools, system virtualization (modeling & simulation) technologies, and software infrastructure for interactive applications. The benefit will be improved production control and simpler worker experience and interaction”.

Systems Applications “apps” are programs that provide functionality. A networked device will have an embedded application that have a display to determine its status, energy consumption, performance and needs for replenishing consumables. ***Vertical Applications include*** Asset Management, Supply-Chain Integration, Customer Support, Energy Management and Security Management. ***Horizontal App’s*** provide functionality across a system vs. Vertical Apps which integrate people with business processes and assets. Horizontal Apps include status, monitoring and diagnosis; control and automation; upgrades & configuration management.

The key is that the existence of an open-access platform will drive the cost down for development and deployment; allowing applications that can be used by multiple clients.

Dashboards are interfaces that provide system performance characteristics meaningful, actionable way through leveraging smartphones, tablets & social media applications. Dashboards are used at the machine control level, operation level and enterprise level. There are specific dashboards that are energy visualization systems that correlate energy and process data. These can provide such information as kWh per part manufactured or KWh per square foot of space in the facility or Btu per million gallons. The system can track, trend and analyze the data. The report outlines a case study where a food processing company installed a heat & energy recovery system and new automated controls & monitors. The system tracks water, air, gas, electric and steam (WAGES) data through the dashboard. They were able to reduce gas consumption by 38% and save 100 million gallons of water annually. Throughput increased 90%. This is what I’m talking about!

Intelligent Maintenance and Smart Design are also means to reduce costs. The author talks about a case study at Toyota where automation software was used to improve maintenance troubleshooting. The cost savings for reduced rework and scrap equated to $550,000 annually. If the production manager knows the condition of the machines in the plant, they can estimate overall impact on things like material flows and production volumes, which they may then synchronize with other tools such as ERP and CRM. ***There is a significant impact on the cost of energy because only the inventory required by the customer is manufactured.***

Regarding Smart Design, Nissan has a program called Value Up for Product Process and Program Innovation Initiative. They use product life cycle management software in three plants to improve product development performance. This has resulted in reducing their development cycle from 20 months to 10.5 months as well as decreasing their design changes by 60-90%. They are now seeing an 80% decrease in post-launch problems. Another key issue is that design processes can integrate feedback from production operations so that material flow can be optimized when production is ramping up.

There are many interesting aspects to this report from the perspective of a consultant in energy efficiency space and from the contractor/installer perspective. The report is well written and thorough. The most interesting breakdown is his summary of where the energy efficiency gains lie, as follows:

1. (Efficient Device) – (Inefficient Device) = Savings
2. (Device Operating Only as Needed to Meet Production Demands) – (Device Operating in On/Off Mode) = Savings
3. (Process Operating Only as Needed to Meet Production Target) – (Process Operating in On/Off mode) = Savings
4. (Past Performances Instructing Current Performance) – (Best Guess at Optimal Settings) = Savings
5. (Smart Design) – (Conventional Design Process) = Savings
6. (Connected Systems and Business Units) – (Conventional Isolated Systems and Business Units) = Savings

A key role in the energy efficiency consulting space is assisting clients in ***navigating the utility incentive programs*** and facilitating the submittals. The report had an interesting point about leveraging energy performance data with utility efficiency programs. It states that the utility programs have focused on assets that can be purchase such as a new HVAC system or lighting retrofit. The twist is that with improved data collection and analysis capabilities of Smart Manufacturing, the utility incentive programs could change their focus to performance based initiatives.

There are inherent challenges also outlined in this report, as one would expect.

(1) The most challenging issue outlined is the lack of common standards for storing, communicating and displaying information. It is critical that hardware and software developers work toward a technology standard, establish network technologies and develop open protocols in order to gain support and expand opportunities. The report goes on to mention the formation of the Industrial Internet Consortium which was formed to address the development of standards for Internet and industrial systems and emerging technologies testing. The Smart Manufacturing Leadership Coalition (SMLC) and Institute of electrical and Electronics Engineers (IEEE) are working on standardizations as well.
(2) Low Power Sensors will need to become self-sustaining, for example, through solar power or nearby vibration or another power source other than hard-wiring.
(3) Attracting and retaining adequately trained workforce was a key concern of executives surveyed. Rockwell Automation was mentioned as a company that facilitates training through their FIRST program (For Inspiration and Recognition of Science and Technology).
(4) A new set of business models and interoperable technology infrastructures need to be developed. SMLC is working to develop approaches, standards and shared infrastructure.
(5) Cyber security is an issue and it is being addressed by NIST. They are developing a risk management framework to assist manufacturers and technology providers to assure cyber security for Smart Manufacturing.

(6) Pricing for LAN systems are very expensive. Prices also need to come down for process management systems.

The Smart Manufacturing leadership Coalition (SMLC) is focused on the following goals:

- Industrial Community Modeling and simulation platforms for Smart Manufacturing
- Affordable industrial data collection and management systems
- Enterprise wide integration of business systems, manufacturing plants and suppliers
- Education & training in smart manufacturing

Smart Manufacturing is symbiotic with Energy Efficiency Programs. Currently, with the ability to include smart automation and controls as part of the Energy Efficiency Strategy is that it will produce additional savings and provide a better method for M & V. With new analytical capabilities, data can be collected from each device at every level of production allowing facility managers to establish relationships between devices, products and energy consumption. A baseline can be created to make critical decisions about facility changes, and production requirements. ***The key is that "Intelligent efficiency provides an opportunity to move from energy efficiency programs that are device-based to programs that are systems and performance-based"***.

The Open Automated Demand Response (OpenADR) Alliance has been created to promote the growth of demand response programs. According to the OpenADR website, , the specification "provides a non-proprietary interface that lets electricity providers send signals about electricity price and system grid reliability directly to customers over networks such as the Internet. The signals can be manual or automated. OpenADR supports interoperability among control equipment and energy markets, and cuts costs for providers and consumers". OpenADR provides a means for businesses to manage their future energy consumption needs requirements & supplies. The report cites a case study that optimizes energy efficiency with an integrated lighting project with the following technology:

- Windows that adjust their tint according to intensity of outdoor light
- Lighting controls are linked to optimize indoor light levels
- HVAC & lighting are connected to a Building Management System (BMS)
- BMS has internet and smart grid connectivity so it can receive & respond to time-of-use pricing to achieve lowest energy costs while optimizing comfort levels

A tremendous benefit to Smart Manufacturing and all of the details outlined in this report, is that it will provide a definitive means to support energy efficiency financing programs. Given that the report estimates the market for energy efficiency retrofits at $900 billion with a projection of returns in the 6-10% range, with minimized risks, this could be a significant boost to financial institutions while concurrently reducing operating costs for our manufacturing plants in the U.S.

Wow, let's support this locally is my final comment!