



GET SMART

*Driving the Value of Data  
with Smart Manufacturing*





## *How do we make things better, cheaper, & faster?*

Since the industrial revolution first introduced the world to the concept of machine-based production and automation, industrial manufacturing has been asking itself the same question: how do we make things better, cheaper, and faster? Today, as we enter into what has been called the 4th industrial revolution — also known as Industry 4.0 or Smart Manufacturing — that question is as relevant as ever.

Manufacturers that emerge successful from this revolution will use the power of new data sources and advanced modeling technologies to:

- Remain competitive in more **dynamic global markets**
- Comply with more **stringent regulations**
- Operate safely and with **increased automation**
- Complete more customized projects on **tighter margins**
- **Minimize environmental impact** by reducing consumption of material and energy resources



### INCREASED PERFORMANCE AND PRODUCTIVITY

Based on research, CESMII predicts smart manufacturing could increase manufacturing performance and productivity by 15-20%, with even greater returns likely over a ten-year period. According to models, even a modest 5-10% adoption rate of smart manufacturing technologies by the American manufacturing industry could result in:

- More than **\$175 billion** in revenue
- A **15%** reduction in energy use
- More than **1 million** new jobs

## American Smart Manufacturing Initiatives

In an effort to take on these challenges, American industry and the U.S. government have both invested in various smart manufacturing research, development, and partnership initiatives.

In one such partnership, the Department of Energy (DOE) has sponsored the Clean Energy Smart Manufacturing Innovation Institute (CESMII). The DOE is providing \$70 million in federal funds to be matched with \$70 million in partnership funding

from CESMII member institutions to accelerate and sustain the development of Smart Manufacturing. As a coalition of commercial, university, federal and state institutions, CESMII has been chartered to investigate how data and advanced analytics can increase U.S. manufacturing competitiveness.

Specifically, CESMII has focused on going beyond current Industrial Internet of Things technologies (IIoT). Using advanced sensors, controls, application platforms, and modeling solutions for global manufacturers, they have developed the Smart Manufacturing Platform to facilitate the use of data and IIoT technology in advanced manufacturing.

CESMII's Smart Manufacturing Platform focuses on ways to make data insights available at the right times across the supply chain, constructing data and modeling applications that are both secure and reusable across many different types of systems.

*CESMII's goal is simple:  
to help manufacturing  
enterprises of all sizes  
implement advanced  
analytics and operational  
data systems ten times faster  
and at a tenth of the cost.*



CESMII is one of 14 national public-private partnerships around the country that emerged out of national discussions concerning how to keep American manufacturing competitive in a rapidly transforming market. Each institute represents at least \$140 million in investment coming from both the government as well as industry, academic, coalition and state partners. Combined, the institutes represent about \$2 billion worth of investment. Among the 14 institutes, CESMII is one of two focused on the role of data in manufacturing — Smart Manufacturing and Digital Manufacturing and Design.



In its research, CESMII looked at over 50 different operational data opportunities tracking them across multiple industries within manufacturing segments including paper, steel, metals, glass, food, microelectronics, oil & gas, chemical, plastics & composites, coatings, utilities and aerospace. The operational problems they investigated included issues often encountered throughout the manufacturing industry, for example: how to effectively control and adjust product recipes; how to manage the flow of information from machines to modeling applications; and how to minimize energy or product waste. Through these investigations, CESMII also gathered information on common tools, methods, and best practices — valuable information used in the development of the CESMII platform.



# Smart Manufacturing's New Challenges

In addition to finding the data commonalities among operational problems within the industry, CESMII's research into the state of American manufacturing also revealed several barriers to wide-spread adoption of IIoT technologies and tools. Some of the common challenges faced by those interested in smart manufacturing technology are outlined below.



## DATA STANDARDS

Smart manufacturing produces a lot of valuable data. But unlocking that value requires effective data ingestion, management, and contextualization. Data can only be effectively analyzed for decision-making if labeled, interpreted and examined within an operational context. Often in smart manufacturing, however, data comes from a range of different sources: equipment, processes, sensors, human input and applications from different vendors using differing protocols and different time frames. Certain data can be structured for reuse while other data is specific to a particular model or application.



## DATA CONTEXT

The challenge is to find ways to collect, organize, and orchestrate the use of data within meaningful contexts. Operations managers need to be able to look at the information and see immediately what actions need to be taken to accomplish a production objective such as faster output or more precise fabrication of a product. When properly organized, data and modeling can be used to analyze, visualize, control, predict, optimize, monitor, diagnose, and self-interrogate production processes, leading to an abundance of insight for manufacturers.



## THE OLD INDUSTRY MINDSET

Apart from cost, part of the resistance to smart manufacturing technologies comes from workers feeling overwhelmed or like the right tools are not accessible to them. Manufacturers may feel uncertain about whether these new analytic tools will really help solve production problems or whether investing in these new tools will provide adequate ROI. In the past, manufacturers have tended to want a full understanding and to outline predictable ROI at the outset of production.

The tools available through CESMII's smart manufacturing platform allow for a more fluid and iterative production process. New savings and opportunities to increase value reveal themselves as manufacturers gain greater insight into and control over their production processes through the use data and modeling tools. Often, small changes to a production process like the expanded management and oversight of a small detail such as regulating the heat within a furnace can unlock abundant unforeseen value and ROI.



## COST

For small and mid-sized enterprises, implementing new technologies and investing in software development can often be prohibitively expensive. One of CESMII's mandates in building their platform was to find a way to give smaller enterprises affordable access to smart manufacturing technologies.



## BALANCING SECURITY WITH DATA ACCESSIBILITY

Smart manufacturing often relies on data coming from different operations involving different plants, organizational units and even different companies or vendors. This interconnectivity demands new interfaces, which if not addressed systematically, can create security and business weaknesses.

# The CESMII Smart Manufacturing Platform™

CESMII strove to put together a secure and seamless data infrastructure to help enterprises navigate data management stumbling blocks. There are many products that address the ovals in Figure 1 — sensing, contextualization, analytics, and modeling, as well as many tools to deal with data, information, insights and intelligence when they are generated. The SM Platform goes after the infrastructure represented by the arrows in Figure 1 so that data, tools, IT and operational sensing, contextualization, analytics and modeling can all come together. By focusing on the life cycle of applied data, the SM platform addresses multiple uses of data in smart manufacturing initiatives.

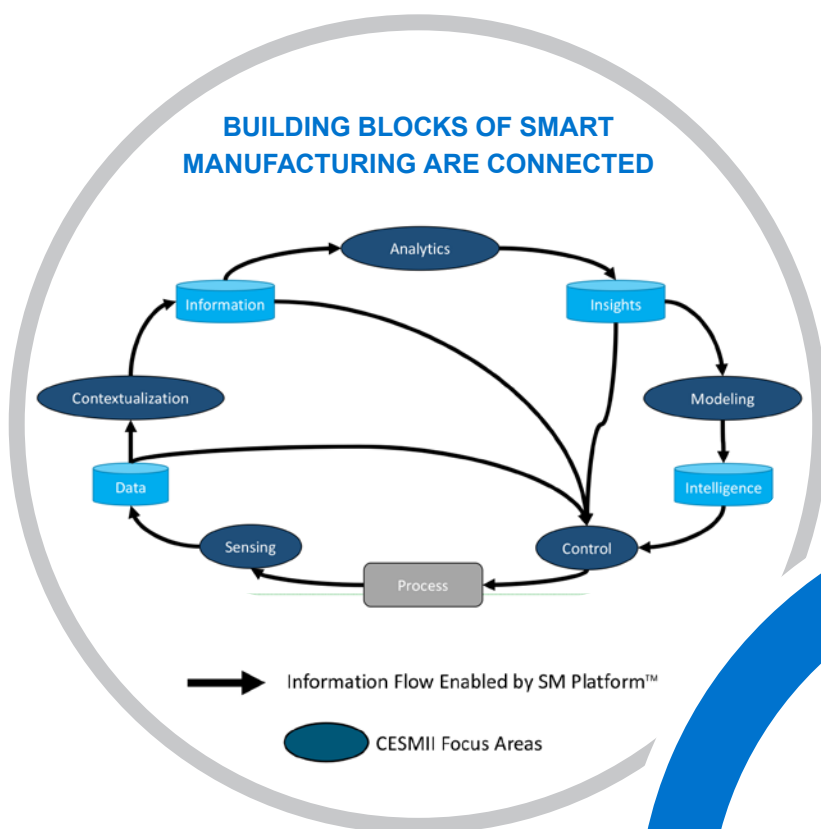


Figure 1

## DATA LIFE CYCLES

**Different types of data become valuable at different stages of their life cycle.**

**Real-time data streams**, for example, are valuable for immediate action such as how fast or slow to run a particular process, whether batch parameters need to be adjusted to keep a product on spec, or whether certain vibrational anomalies are within acceptable range or need to be addressed because they represent safety or environmental threats.

**Trend data from data historians**, contextualized data for different models and analytics, and archived data about the application and execution of smart manufacturing system can all add value at different points in the process.

## It All Comes Down to Data

At its core, as illustrated in Figure 2, the CESMII Smart Manufacturing Platform combines cloud service technologies with on-premises edge resources for best of breed data ingestion, contextualization, visualization, analytics, and modeling. CESMII's platform has built in interconnected cyber security and can be used on premises, off premises and/or as an on and off premises interconnected system. The platform

eliminates the need to rebuild or reconfigure the IT infrastructure for every project. The SM Platform provides a data utilization workflow as well as a marketplace where users can select analytic software and other applications that meet their manufacturing needs from vendors who have introduced their products on the CESMII platform. The platform creates pathways for manufacturers to do real-time data and modeling and enables monetization of manufacturing data.

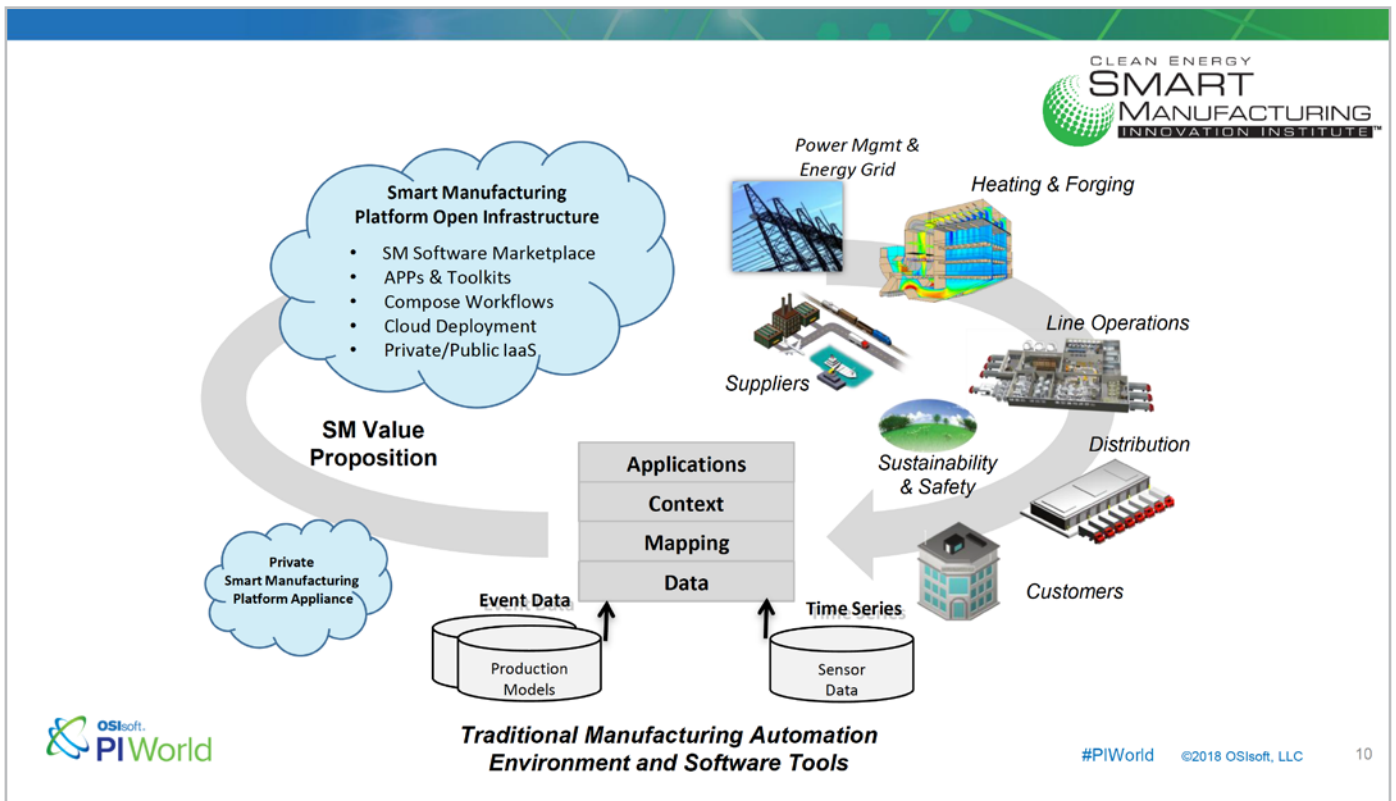


Figure 2

# The Benefits of an Industry Platform

## 1 Easy Data Transfer

Every manufacturing, distribution or supply company has an ecosystem of operational systems. As outlined in the graphic below, data needs to flow between many different systems and applications both on and off the premises throughout its life cycle, often beginning with sensors put in place to generate the data all the way through to when the data is contextualized and made visual so that operations managers can gain valuable insights from it. Moving information from one application to another can often require custom integration. CESMII's platform enables seamless transfer of information between applications and data layers by building applications once and then reusing them.

## 2 Open and Collaborative Platform

CESMII created their platform to be open standard, allowing many different systems and vendors to work together. Many IoT platforms have been developed by particular companies with specific goals in mind. The CESMII platform, however, is an open-architecture and collaborative platform which allows any company that is a member of the institute to share and sell various IoT applications, tools, and technologies to the community.

In addition, CESMII is partnering with researchers and vendors to develop increasingly rich contextualization, modeling and analytic tools that can be offered on the platform's marketplace. CESMII is especially interested in creating applications that apply specifically for one industry when they are created, but can be spread horizontally across multiple manufacturing concerns.

## 3 Cost-Effective

Small and medium-sized companies don't always have the resources to sink into building up smart manufacturing systems. It can cost a lot of money to buy servers and set up a server farm to host all the data generated by smart manufacturing sensors. On top of that, companies often have to hire developers to come up with analytics solutions specific to their manufacturing problems and system integrators to implement the integrated systems. This is where CESMII comes in. By aggregating all the technological resources and hosting these tools on a systems platform designed to integrate systems and data (system of systems), CESMII enables small and medium-sized enterprises to access these valuable analytic resources while keeping costs low.

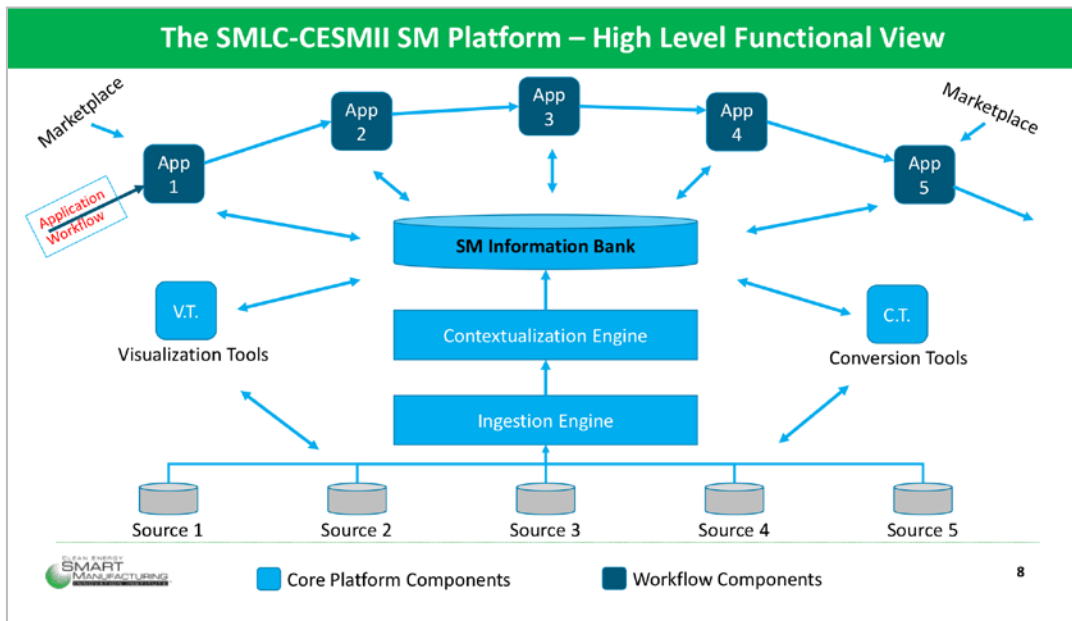


Figure 3





*“We want to be able to provide a marketplace as a search solution service where you, as a manufacturing company, can go and use our platform to find solutions that meet a need that you see for your operation.”*

Scott Miller, P.E., Technology Manager,  
CESMII Southern Regional  
Manufacturing Center

## *CESMII Industry Affinity Groups*

To develop industry segment solutions, CESMII has created what they call affinity groups. These are groups of institute members comprised of people in similar industries or people with similar operational problems working together. These groups are typically hosted by one of CESMII's three Regional Manufacturing Centers (RMCs) and enable enterprises to collaborate, sharing valuable information and solutions to common operational problems.



Aerospace



Pulp and Paper



Chemical Processing

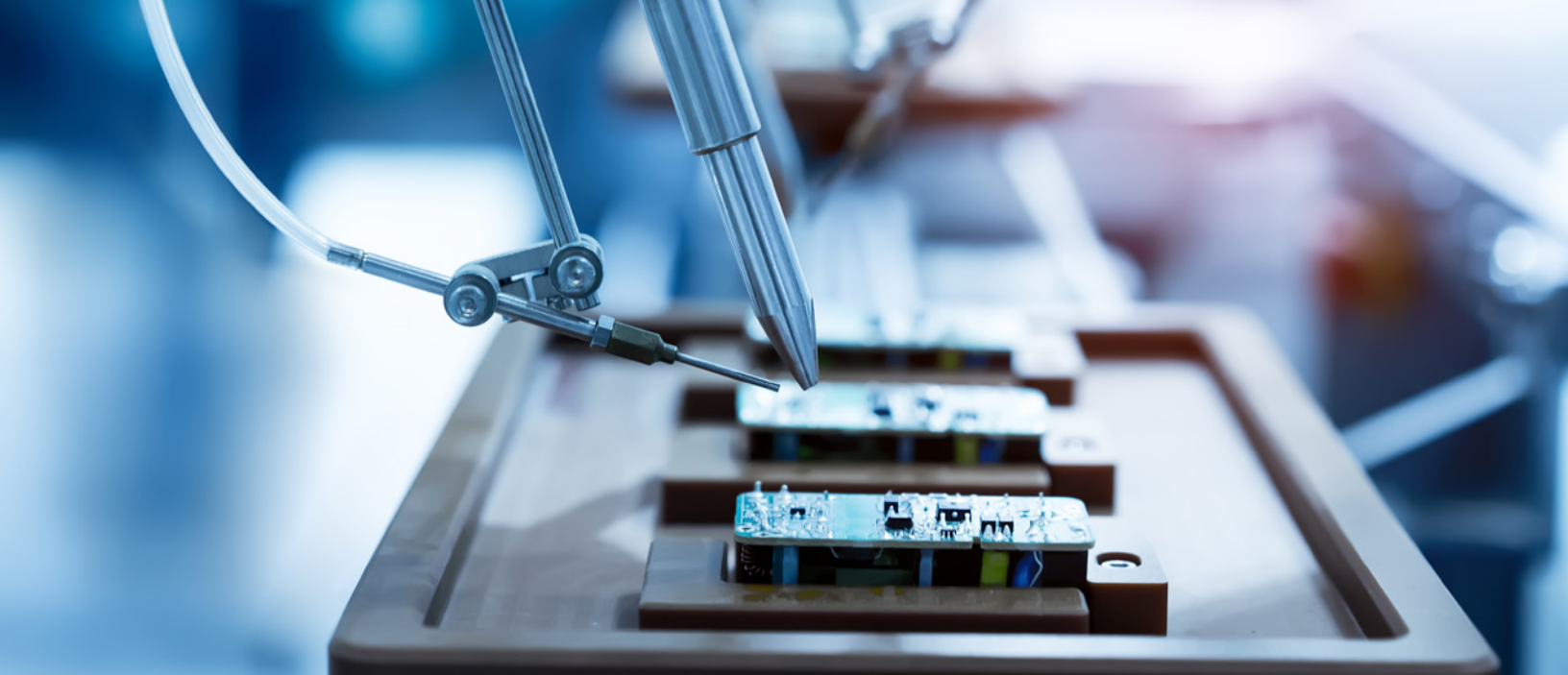


Cement Manufacturing



Food Quality and Safety

with opportunities for new groups to be added



# *The 3 P's of Smart Manufacturing*



**Precision:** The ability to adjust a product's attributes as it is being produced.



**Productivity:** Using materials, energy, processes, equipment, and people to decrease the cost per unit of a given product.



**Performance:** Increasing the efficiency of equipment and processes.

CESMII focuses on how manufacturing can leverage data, modeling technologies such as first principles, statistical analysis, AI, machine learning, and digital twin modeling, as well as new sensor technology to using data and technology to improve the 3 P's.



## **PRECISION**

CESMII's Smart Manufacturing Platform uses data and technology to increase the precision of production. Such precision requires a deep, real-time understanding of the production process and of how the machine, process and the properties of the product relate.

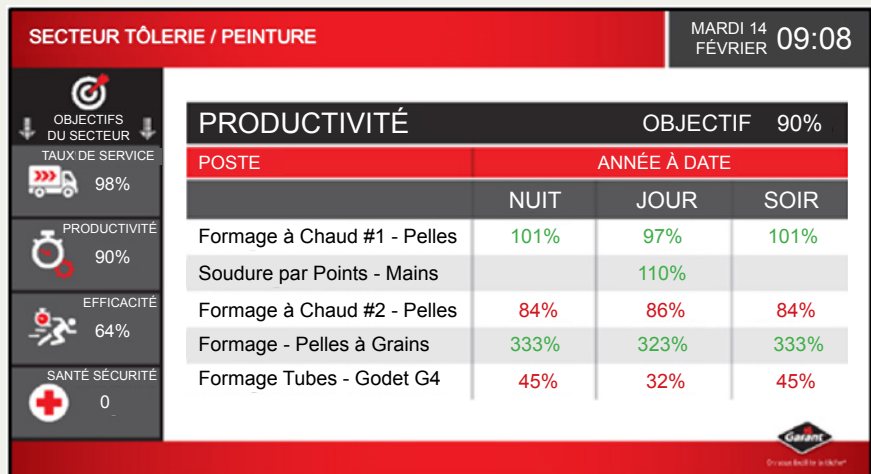
Real-time sensor data and/or models of product properties can be combined with process or equipment operating data while in production, leading to greater process control, more robust anomaly detection and significant reductions in defective parts and materials. CESMII's Smart Manufacturing Platform accommodates the advanced sensing and modeling technology, bringing real-time product property data together with operating models of the equipment to build new integrated models for control and optimization. Precision modeling creates opportunities for product customization and smaller lots, while also reducing the number of defective products.



## PRODUCTIVITY

CESMII's Smart Manufacturing Platform focuses on productivity at various stages of the supply chain, including adjusting working methods to respond to “upstream” changes and creating opportunities for dynamic management of production. CESMII's Smart Manufacturing Platform supports connecting, ingesting, and contextualizing data from different sources and accommodates the use of data in multiple vendor software applications. When data sources and software platforms span multiple companies in a supply chain, the Smart Manufacturing Platform also supports data exchange security and facilitates business agreements and/or regulations for accessing selected data.

Garant, a leading producer of gardening and landscaping tools, recently invested in smart manufacturing technology to establish a centralized data system that could monitor its production process as an enterprise. Today, 50-inch displays throughout its facilities show real-time objectives, productivity, and efficiency across manufacturing processes so end-to-end production can be viewed in its entirety. This Industry 4.0 initiative has increased productivity 12%, and Garant recouped their technology investment in less than two years.

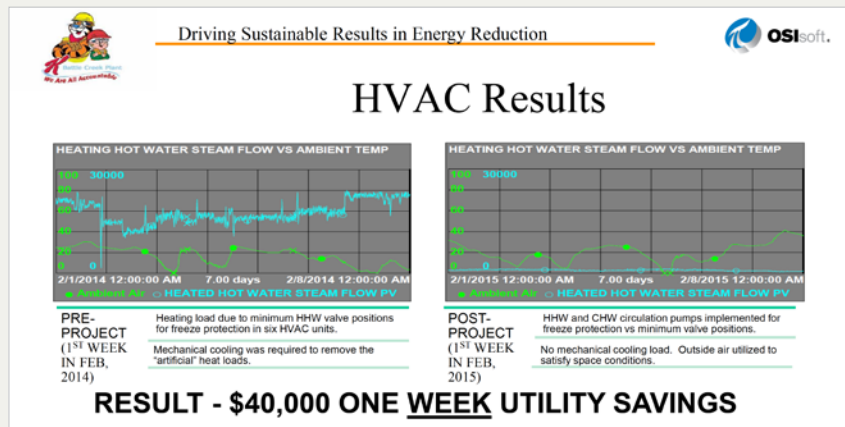




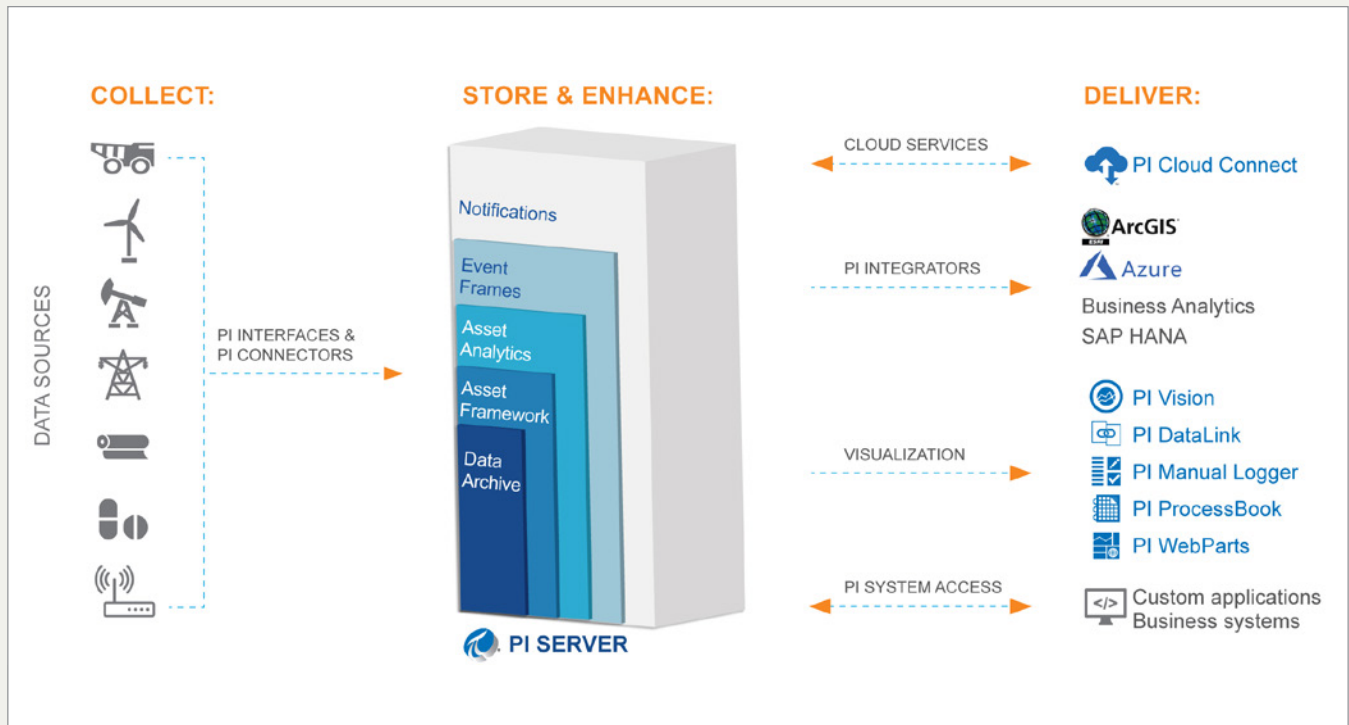
## PERFORMANCE

Additionally, CESMII's Smart Manufacturing Platform allows users to manage material and energy usage directly. It reduces operation complexity and helps manage production risks. By managing energy directly, it is often possible to operate equipment and processes on different schedules or with different production volumes to save energy and minimize costs. Energy intensive processes like heat treating may be shortened without compromising product quality. The ability to sense and better manage constraints that have led to overly conservative operations makes it possible to relax production constraints without increasing risk. For example, sensing and leveling temperature variations in an industrial furnace makes it possible to operate the furnace at a higher temperature without increasing the risk of damage. Looking for ways to increase the efficiency of manufacturing processes and equipment leads to dramatic reductions in the total amount of energy used per product unit manufactured. Reducing energy expenditure lowers cost and leads to a more ecologically sustainable production.

Using advanced pressure monitoring systems and air flow sensors for the first time, Kellogg's Battle Creek Facility was able to monitor and control building pressure to keep it within the right range. Overall, this project saved them over \$350,000 dollars per year on six HVAC units alone. Kellogg now continually looks at data to gain insights and adjust processes for better results.



# The Role of the PI System in Smart Manufacturing



## WHAT IS THE PI SYSTEM?

OSIsoft's PI System transforms the vast data streams from sensors, plant equipment and other devices into rich, real-time insights to help people improve productivity, save money and make better, more informed decisions. The PI System can be found inside wind farms, national labs, rail networks, manufacturing facilities, over 1,000 leading utilities and 90% of the world's largest oil and gas companies. Worldwide, over 2 billion sensor-based data streams are managed by the PI System.

The PI System is a core technology in CESMII'S Smart Manufacturing Platform that helps to reduce the complexity of data systems by serving as a single repository for smart manufacturing data. The PI System provides the ability to cleanse, shape, and format information so that easily consumable data sets are ready for immediate use by business analytics, machine learning/deep learning tools, and by process optimization and modeling software.

The PI System:

- **Connects** and ingests data from disparate sources
- **Enhances** and contextualizes raw production, process, and equipment data for modeling and analysis
- **Enables** data sharing across networks and from operations to business systems
- **Feeds** consumable data to operational and business applications without the need for custom coding

## Data Collection and Ingestion

The PI System has over 450 interfaces and connectors that provide pervasive data collection across manufacturing equipment, control systems, and IIoT sensors.

## Data Management

Within the PI Server, data are stored at high fidelity and with operational context. PI Connectors and Asset Framework, a part of the PI Server, contextualize multiple data streams so they can be easily visualized and analyzed without the need for custom coding or IT specialists.

## Data Accessibility

The PI System serves as a data access layer that is separate from control systems, so anyone in an organization can access data without compromising security. The PI System also interfaces with workflow

tools so that multiple applications and data sets can be orchestrated together. Built by engineers, for engineers, the PI System specializes in connecting subject matter experts to data. This value should not be overlooked. The majority of value in smart manufacturing today doesn't come from AI or machine learning, but from more basic calculations and trends on a few data streams. When that information is connected to subject matter experts, they can apply what they know for new gains in efficiency.

## Data Transfer

As CESMII's SM Platform is cloud-based, the PI System's Cloud Connect feature is crucial for insuring seamless and secure bi-directional data transfer between the customer and the SM Platform suite of advanced analytics. PI Cloud Connect provides a way to move data off premises to the SM Platform and allows users to get information out of the cloud and back on premise where that information can inform decision-making.

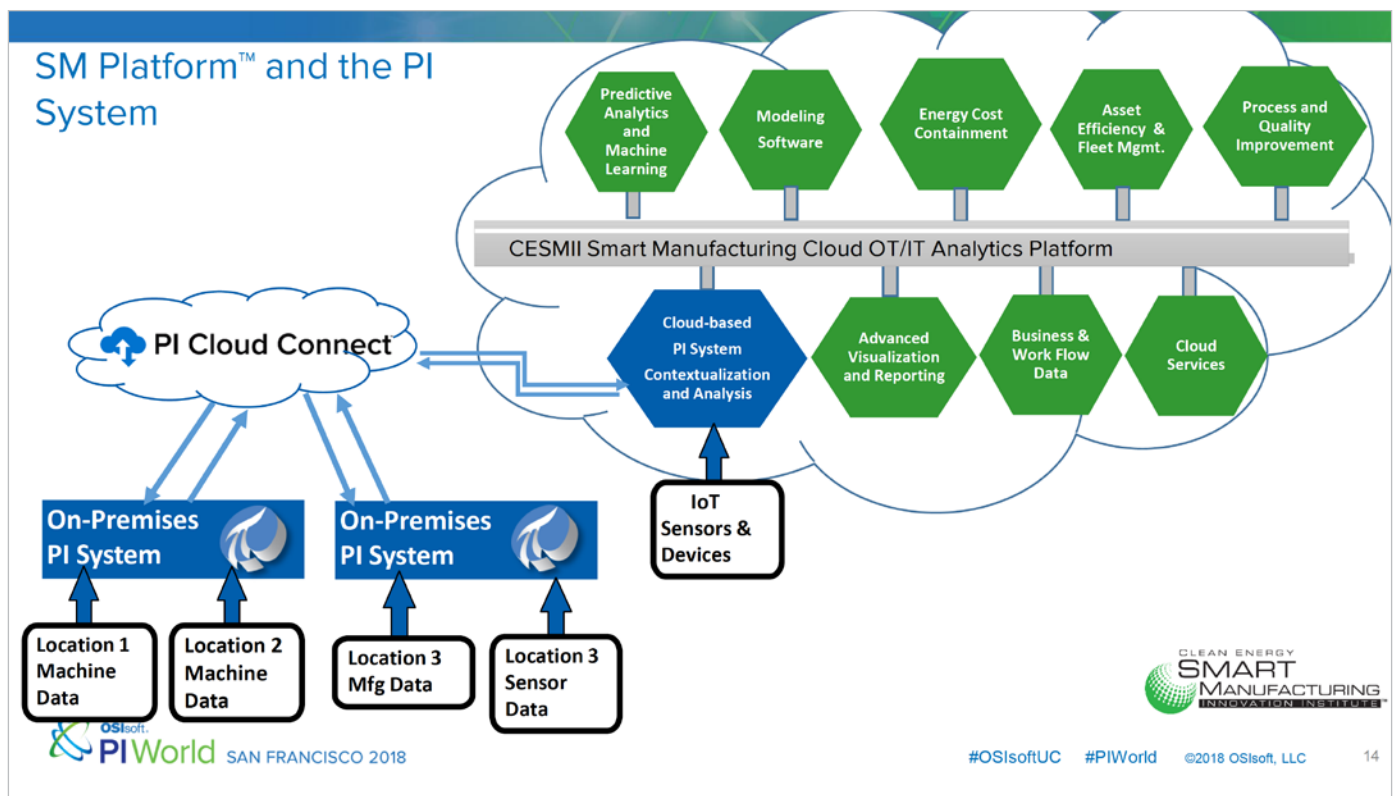


Figure 4



*“The place to start is with small data as opposed to big data – small data that you understand and can do something with. We work from the standpoint of re-usability and interconnectedness and take advantage of approaches that drive toward greater simplicity. The easiest thing to do is to go find a problem that a few sensors could help with. A couple sensors put in a network system can open up tremendous, unexpected value.”*

Jim Davis, Principle CIO Advisor,  
CESMII

## *Conclusion: In a Data State of Mind*

Big returns await those who embrace the changes of the 4th industrial revolution and adopt a data-centric mindset.

Working with economists at the Pacific Northwest National Laboratory (PNNL), a research laboratory for the DOE, CESMII sees initial line of sight productivity improvements in the range of 15-20% with respect to energy usage from the implementation of their Smart Manufacturing platform. Such projections are based on detailed analysis conducted by CESMII and the economists at PNNL concerning potential energy

savings from smart manufacturing practices across multiple energy intensive industries.

CESMII predicts that, even with a conservative market adoption rate of less than 10%, the Smart Manufacturing Platform can add over \$175 billion in revenue and over 1 million jobs to American manufacturing in the next 10 years.

While many of the tools and methodologies of smart manufacturing might seem intimidating at first to those unfamiliar with data-driven approaches, reaping the rewards of smart manufacturing technology doesn't have to be as complicated as one might think. One doesn't need big data or complex advanced analytics to realize the value of smart manufacturing. All a manufacturer really needs is the willingness to get started and a few key tools to collect and get valuable information to the right people. Access to the PI System is a core capability powering CESMII's new Smart Manufacturing Platform. With CESMII's new Smart Manufacturing platform, those tools are now more accessible than ever.

## ABOUT OSISOFT

For over 38 years, OSIsoft has been dedicated to helping people transform their world through data. Our software turns the vast data streams from sensors and other devices into rich, real-time insights for saving money, improving productivity or developing new products. Over 1,000 leading utilities, 95 percent of the largest oil and gas companies and more than 65 percent of the Fortune 500 industrial companies rely on the PI System to get the most out of their businesses. You'll find the PI System in oil refineries, mining sites, wind farms, national labs, pharmaceutical manufacturing facilities, distilleries, data centers and even stadiums helping people save energy, increase productivity and make better decisions. Worldwide, the PI System handles more than 2 billion sensor-based data streams. Founded in 1980, OSIsoft has over 1,300 employees and is headquartered in San Leandro, California. To learn more, please visit [www.osisoft.com](http://www.osisoft.com).

### Corporate Headquarters:

1600 Alvarado Street  
San Leandro, CA 94577, USA



---

## ABOUT CESMII

The Clean Energy Smart Manufacturing Innovation Institute (CESMII), headquartered in Los Angeles, CA, brings over \$140 million in public-private investment from leading universities and manufacturers to focus on innovations that will advance U.S. manufacturing competitiveness, sustainability and innovation. In partnership with the U.S. Department of Energy's Advanced Manufacturing Office, CESMII brings together a consortium of nearly 200 partners from across academia, industry and non-profits—hailing from more than thirty states. CESMII is the 9th Institute of [Manufacturing USA](#), a network of regional institutes, each with a specialized technology focus.

CESMII's is a national network of Regional Manufacturing Centers (RMCs) each focused on local relationships with opportunities for national impact in the areas of technology transfer and workforce development. The power of this network is cross-linking resources, capabilities and expertise across business, workforce and technical focus areas, leveraging each region's unique industrial environments. For more information, visit the CESMII website at [www.cesmii.org](http://www.cesmii.org).



The companies, products, and brands mentioned are trademarks of their respective trademark owners.