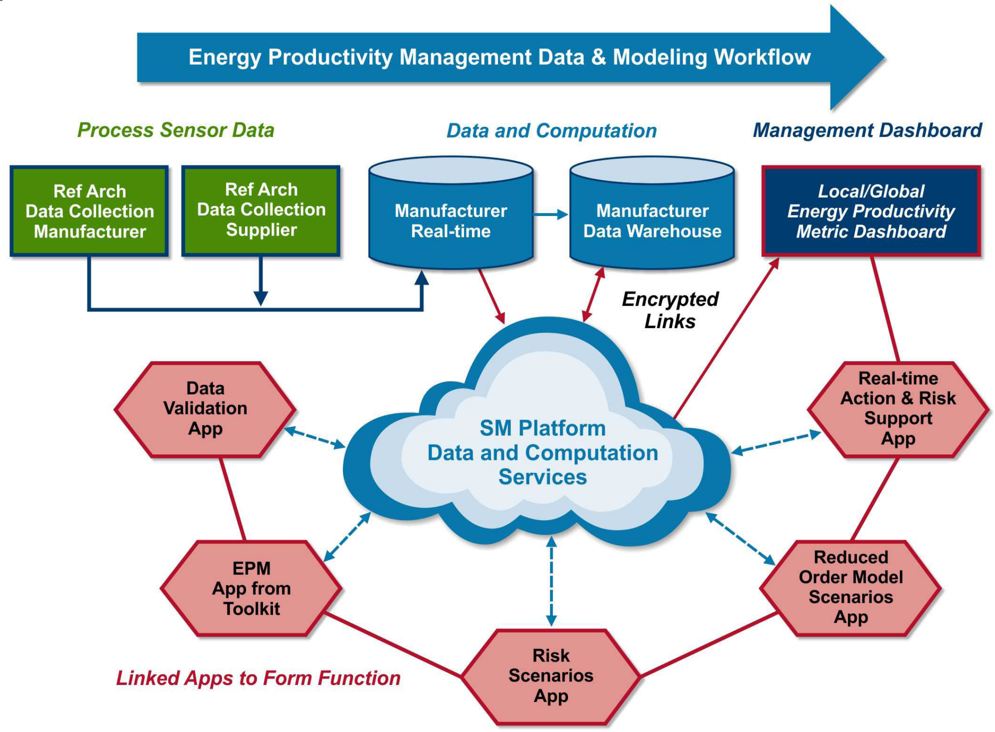
Industrial Scale Demonstration of Smart Manufacturing Achieving Transformational Energy Productivity Gains

Development of an Open Architecture, Widely Applicable Smart Manufacturing Platform



Applying the capability of the SM Platform: energy productivity management data and modeling workflow. *Graphic credit the Smart Manufacturing Leadership Coalition.*

While many U.S. manufacturing operations utilize optimization for individual unit processes, smart manufacturing (SM) systems that integrate manufacturing intelligence in real time across an entire production operation are rare in large companies and virtually nonexistent in smaller organizations. One example of an area where SM systems can be applied is in the management of waste heat. A smart system that not only sought to recover waste heat, but also to generate less heat initially, would be a cost-effective tool optimizing the relationship between energy use and product output together.

The Smart Manufacturing Application and Data Platform (SM Platform) to be developed during this project is an innovative approach that integrates information technology, models, and simulations driven by real-time plant data and performance metrics. This SM Platform will allow manufacturing organizations, regardless of their industry or size, to assemble new management systems at a much lower cost, optimizing process knowledge and improving energy productivity by integrating with existing process control and automation systems. Development of an energy productivity metric—integrated with real-time process information—that provides comparisons for potential, practical, and actual performance, as well as the development of an Energy Dashboard that displays alternatives to optimize energy use within specific business contexts, will help improve energy productivity and reduce emissions in U.S. manufacturing.

Benefits for Our Industry and Our Nation

The project team anticipates that project success, coupled with broad multi-sector adoption of the developed technology, could reduce waste heat generation by an amount equivalent to 1.3% of total U.S. energy use, as well as reduce annual carbon dioxide emissions by 69 million tons. Other potential benefits include reducing process times, solid and liquid wastes, environmental impacts, and water use.

Applications in Our Nation's Industry

Installation of an SM management system could provide energy savings and cost reductions to a wide range of manufacturing industries. The SM Platform framework would be beneficial for large, energy-consuming manufacturing sectors, such as petroleum refining, chemicals, steel, and biofuels. The energy, food, and paper processing industries would also likely realize attractive payback periods by adopting the SM Platform.

Project Description

The overall project objective is to develop an industry-accepted SM Platform that can be scaled to a diverse set of manufacturing operations. Specifically, the project plans to (1) design and demonstrate the application of a prototype SM Platform for two commercial test beds, (2) demonstrate a 30% reduction in waste heat generation at each of the test beds, and (3) work with a group of leading automation vendors to catalyze low-cost commercialization of the technology developed.

Barriers

- Ensuring timely access to high-quality data from test beds.
- Integrating all desired functionalities into the SM Platform.

Pathways

The SM Platform design is based on current manufacturing and IT industry standards. The platform is being used to expedite model and simulation development and deployment in a cloud-based environment using a novel workflow as a service capability. In addition, energy productivity metrics and application toolkits are being defined so that they can be tailored to a specific business situation. The project's two test beds, one in a hydrogen production plant and the other in a forging, heat treatment, and machining operation, utilize sensor- driven modeling, measurement, and simulation systems. This allows energy productivity to be managed in real-time by an energy dashboard throughout the plant and enterprise.

During the first year, the project developed the most highly instrumented steam-methane reformer (SMR) in the U.S. using infrared cameras and thermocouples. Real-time data are streamed to high fidelity and reduced-order models for analysis. A computational fluid dynamics (CFD) model was implemented on the SM Platform cloud environment to take advantage of the cloud's parallel processing advantage, enabling computation times that are 5 to 10 times faster. This is the first time high fidelity, data-driven models have been used to balance natural gas flow to the reformer tubes of a steam reformer for real-time optimization of business productivity. In this hostile environment, infrared cameras outperform thermocouples in coverage, accuracy, reliability, and cost effectiveness.

The forging test bed includes new instrumentation for data capture analysis, modeling, and simulation which will be integrated into SM Platform workflows so that business performance can be managed in real-time. Composable metrics will be developed in the SM Platform to drive improvements in energy productivity, environmental performance, safety, asset management, costs, and overall operations.

Milestones

This three-year project began in 2013.

- Develop operational prototypes of the SM Platform framework and workflow (Completed).
- Use test bed data to model energy efficiency and optimize furnace and reformer performance (Completed).
- Continue test bed operations and develop strategies and integrated energy performance metrics (2015).
- Populate the SM Platform with functionalities and tool kits developed from the test bed work (2016).
- Implement expanded SM Platform framework along with new test bed demonstrations (2016).
- Hold webinars on energy productivity metrics and demonstrate energy dashboard after feedback from user groups (2016).

Commercialization

The commercialization of the SM Platform will require significant cross-industry collaboration. Specific project tasks are dedicated to the commercialization process and include (1) upgrading the industry community website as a portal for accessing and distributing application resources; and (2) analyzing savings from deployment of the SM Platform. SM Platform workshops, webinars, and conferences will target individual industry segments, with a focus on small and medium-sized organizations.

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