Industrial Scale Demonstration of Smart Manufacturing Achieving Transformational Energy Productivity Gains

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AIChE, General Dynamics, Honeywell, NCMS, Nimbis Services, Praxair, Rockwell Automation, Schneider Electric, UCLA & The University of Texas

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Thomas F. Edgar, Ph.D., Principal Investigator
The University of Texas at Austin
Austin, TX

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Project Objectives

- Develop a prototype open-architecture Smart Manufacturing (SM) Platform that facilitates the extensive application of real-time sensor-driven data analytics, modeling and simulation.
- Validate that the SM Platform reduces the cost of deployment by current methods by 50% and facilitates the application of customized sensor driven modeling, measurement simulation technologies, energy management dashboards and a variety of manufacturing metrics for individual manufacturer requirements.
- Demonstrate SM system ability to interoperate with commercial control and automation systems using two operational test beds at Praxair and General Dynamics. Employ additional sensors and models to extract new intelligence and provide new designs and operating strategies to reduce waste heat.
- Develop plans to commercialize, sustain, and grow SM technology through promotion of the SM platform, its transitions into an Apps store, service and support Marketplace and outreach to small, medium and large manufacturers who might adopt SM.

Technical Approach

- First Test Bed – Modify steam-methane reforming (SMR) unit to install measurements and software so that real-time decisions can reduce energy use and increase productivity in an SMR unit. Use SM Platform to provide high performance computation resources, interface high fidelity modeling with control and automation systems for production, and extend to multiple SMR units at other plants.
- Second Test Bed – Install measurements and software so that real-time decisions can be made to reduce energy use and increase productivity in heat treatment and machining of artillery shell casings and commercial metal parts. Use SM Platform to deploy real-time data and modeling in conjunction with control and automation to optimize heating and forging together with CNC machine operation. Integrate energy and product performance metrics via knowledge transfer for an entire line that also interface with smart grids.
- For both test beds, collect baseline data on key operating variables and develop steady-state and dynamic operating data to i) assess current energy performance, and ii) construct time-dependent mathematical models relating control inputs to key performance indicators that can be computed in real-time in the cloud.
- Involves industry, universities, and NGOs.

Technical Approach

- SM Platform is an innovative web-based infrastructure that facilitates access to actionable real-time networked data and information throughout the business and operation of the manufacturing enterprise.
  - Supports extensive application of network, sensor-driven modeling, computation and comprehensive performance metrics using a common platform that is compatible with leading automation vendors.
  - Uses infrastructure and Apps store similar to Google and iPhone and orchestrates Apps to form 'Functions' that are reusable.
  - Software solutions more easily developed and accessed by many stakeholders; new SM systems deployed at reduced cost.
  - Transformational IT infrastructure demonstration for manufacturing with potential widespread adoption.

Transition and Deployment

- U.S. manufacturers, particularly small and medium sized, must find ways to use information technology to reduce costs, maintain or improve productivity, increase innovation, decrease time to market, and improve value chain interoperability. Thus they can benefit from Project SM.
- Industry community website will be established to include outreach, interaction, input, and co-development; Interface with the communities of interest and manufacturing leaders and users through various roundtables, symposiums, and conferences. A suite of tools to maximize the effectiveness of virtual evaluation and collaboration will be developed. The capabilities of the SM platform demonstrated with the two test beds will be translated and scaled to other manufacturing plants, e.g., Forging Industry Association, other furnace applications including 18 Praxair hydrogen plants.
- Modeling, control, and optimization results developed by UT and UCLA will be publicly available.

Transition and Deployment

- Commercialization of the SM Platform technology is currently viewed as a public-private data, software and resource strategy and can be promoted through Smart Manufacturing Leadership Coalition (SMLC), NNMI hubs, and AMP 2.0.
- Company, Vendor, Open Source and Community IP co-managed and can change with market drivers.
- Orchestration tools, infrastructure and a marketplace will be made available as secure open access for shared use and as reference architecture for industry, e.g., leading automation vendors.
  - Community source and commercial Software Tools, Apps and Apps Functions deployed from a marketplace (cloud-based) by commercial, university and institutional services.
  - IP includes standards and data applications that can be licensed as a reference architecture for commercial platforms (e.g., SMLC members).

Measures of Success

- Demonstrate that the SM Platform:
  - Can be used to deploy Smart systems at 50% of current costs of deploying individual systems requiring new infrastructure.
  - Provides sufficient customization and orchestration flexibility for App and App Function reusability.
- Demonstrate improved productivity and energy reduction of 30% of waste heat at two test plants.
  - Reduction in CO_2 emissions of 30%
- Demonstrate commercialization readiness of the SM Platform orchestration and Marketplace tools and services through industry-driven implementation sites.

Project Management & Budget

- Three year project (9/1/2013 – 11/30/2016)
- Project task and key milestone schedule
  - Eight project tasks and nine milestones will be used to track project progress.

Total Project Budget	
DOE Investment	$7,798,383
Cost Share	$3,408,643
Project Total	$11,207,026

Results and Accomplishments

- Working prototype SM platform has been constructed and demonstrates:
  - Infrastructure, platform and software services across geographical locations.
  - Open architecture orchestration of data, modeling and interface applications through a new 'Workflow as a Service' (WfaaS) capability.
  - Flexible architecture for multiple vendor software applications with computational infrastructure and manages respective IP in a secure web environment.
- Installation of additional temperature sensors and camera at first test bed is complete and development of mathematical models for both test bed furnaces is underway.
  - Platform demonstration use case brings infrared camera data together with computational fluid dynamics modeling.
  - Modelers are using cloud-based computing to parallelize computation – factor of 10 to 100 speedup.
- Future work includes:
  - Control and automation interface Apps, infrared camera data mapping Apps, further WfaaS development and industry review of platform security.
  - Benchmarking of energy usage and increased model sophistication.
- Still issuing some sub awards but most project partners have been working for nine months during contract negotiations and procurement (team was formed in 2012).