Industrial Scale Demonstration of Smart Manufacturing (SM) Achieving Transformational Energy Productivity Gains

DE-EE0005763

AIChE, General Dynamics, Emerson, NCMS, Nimbis Services, NIST, Praxair, Schneider Electric, SMLC, UCLA & University of Texas
September 1, 2013 through November 30, 2016

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

Jim Davis, Co-Principal Investigator
UCLA
Los Angeles, CA

U.S. DOE Advanced Manufacturing Office Peer Review Meeting
Washington, D.C.
June 15, 2016

This presentation does not contain any proprietary, confidential, or otherwise restricted information.
Project Objectives – SM Platform

Develop and demonstrate an open architecture Smart Manufacturing (SM) Platform and Market Place:

- Extensive application of real-time, sensor-driven enterprise data analytics, modeling, optimization and metrics
- Accelerated development, deployment and reuse of smart data-driven, multi-vendor system applications while halving the cost
- Build and demonstrate applicability, interoperability and operational security for two diverse commercial test beds - Praxair and General Dynamics.

- Develop plans to commercialize, sustain, and grow SM technology through SM Open Platform deployment services and application libraries (apps), alignment with provider involvement, and trusted brokering of data and applications in an industry-defined Marketplace aligned with small, medium and large manufacturer requirements.
Demonstrate significant untapped Energy Gains for two diverse test bed operations using Advanced Sensor, Control, Platform and Modeling and deployment facilitated by the SM Platform.
• More efficient/accelerated approach to engineering real-time applications
• Data to many applications strategy
• One data structure to solve many problems
• Highly layered marketplace of product configurations that interoperate
• Marketplace composable and configurability on any cloud platform
Energy Gains with Innovation in Technology Integration & Reusability

Key:
- Proprietary Reusable
- Configuration Reusable
- Environment Reusable

Praxair Data Structure
- Reduced camera platform TRL 5
- Harsh, high temp platform TRL7
- IR camera system TRL9
- Mediation, security TRL7
- Praxair historian TRL9

Praxair furnace contextualized data TRL7
- OSISoft cloud KB TRL 9

Praxair optimizer
- Matlab optimizer config TRL 6-7
- Matlab cloud TRL 9

Praxair furnace tube model
- Ansys Fluent furnace TRL5
- Ansys Fluent TRL9

Tableau burner config TRL7
- Tableau TRL9

Dashboard

Temperature Contextualization

Temperature Field Set-Point

Real-time On-site Sensor Data
- Pre-processing / Outlier Detection

Optimzer

New Valve setting

SM Platform

TRL6-7

ROM Prediction

ROM = Reduced-Order Model

Wireframe TRL6
- Kepler TRL 8
- OSISoft TRL 8
- UCLA HPC TRL 9
- Rackspace TRL 9

Praxair validator
- Matlab validator config TRL 4
- Matlab cloud TRL 9

Praxair furnace tube model
- Ansys Fluent Rxn furnace TRL 4
- Ansys Fluent TRL9

Marketplace TRL4
- User interfaces TRL4
- Data services TRL6
- Security IDM TRL7
Technical Approach - Test Bed Collaboration Model

Productivity gains from radically accelerated application and lowered costs:
(1) Adopting new ruggedized hardware and software sensing systems
(2) Minimizing hardware, development, implementation, maintenance
(3) Increasing degrees of freedom, flexibility
(3) Progressive, gains in trust, managed risk, human involvement, business outcomes
Technical Approach – Measurement/Deployment Progression

First Steam Methane Reformer
Furnace Port Arthur, TX
• 88% efficient
• Distributed sensing
• Distributed actuation (96 burners)
• High fidelity model & reduced order models

10-15% reduction wasted energy
Simple Model
Reduce Cameras
Halve capital cost

HPC Model
Burner Controls
Dynamic energy mgmt
Metrics

On track
25% reduced waste energy
Extend to
20 U.S. SMRs
75-80% efficient

General Dynamics Scranton PA
Integrated line management of part precision, materials/metallurgical properties, dynamic part movement, defect reduction, energy management

Part Tolerances
Part quality
Reduce idle time

Part Properties
3D Radiation
Part quality
Reduce defects destructive tests

Improved gas flow control
Recuperation
Dynamic machine configuration

Predictive Maintenance
Part quality
Reduce defects
Transition and Deployment

Leverage Cyber & Physical Deployment Patterns

Smart Manufacturing Platform Open Infrastructure
- SM Software Marketplace
  - APPs & Toolkits
  - Compose Workflows
  - Cloud Deployment
  - Private/Public IaaS

SM Value Proposition

Private Smart Manufacturing Platform Appliance

Applications
- Context
- Mapping
- Data

Event Data
- Calibration & Maintenance

Time Series
- Production Models
- Sensor Data

Traditional Manufacturing Automation Environment and Software Tools

- Paper
- Steel
- Metals
- Glass
- Food
- Micro electronics
- Industrial gas
- Coatings
- Plastics
- Composites
Significant untapped energy gains in minimizing wasted energy for two diverse test beds through the application of advanced sensing, controls, platforms and modeling

Applied metrics: waste heat minimization, energy efficiency and energy productivity

Accelerated and lowered cost deployment of sensor-based enterprise analytics and optimization systems; shared/scaled platform investment far less costly than sum of individual platform; phased progressive development and deployment

Measure of Success
Project Management & Budget

• Three year project (9/1/2013 – 11/30/2016)

• 8 project tasks and 9 milestones
  - SM Platform Designs-Infrastructure, Security, Software Protocols
  - Test Bed Measurements/Sensors, Data Collection, Math Models
  - Productivity Metrics, Dashboard
  - Commercial Outreach, Marketplace, Website, Workshops, Webinars
  - Market Environmental and Energy Benefit

<table>
<thead>
<tr>
<th></th>
<th>Total Project Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOE Investment</td>
<td>$7,798,383</td>
</tr>
<tr>
<td>Cost Share</td>
<td>$3,437,836</td>
</tr>
<tr>
<td>Project Total</td>
<td>$11,236,219</td>
</tr>
</tbody>
</table>
Results and Accomplishments

**Praxair**
- Praxair Test Bed on track 25% reduced waste energy – unit already 88% efficient
  - Value $1.2 million per year on a 100 MMSCF plant
- Reusable harsh environment sensor system; reusable/flexible model system
- High fidelity modeling new opportunity for further gains
- For more typical 75 - 80% efficient units, impressive gains projected

**General Dynamics**
- Projecting 30% reduction in waste energy - comprehensive management of properties, precision, energy efficiency
- Start with training and testing SM Platform for live data development

**SM Platform and Marketplace**
- Decrease cost of first-of-a-kind system > 25%
- Acceleration 2x
- Decrease replication costs > 50%
- Production prototype

Matlab – multi configurations
- Ansys Fluent – 1 tube, 4 tube, full furnace
- Octave; Tableau; Praxair Metrics; Praxair End-to-End
- Emerson EMS; GD Heat Treatment

Kepler
Cloud Template Standards
Emerson
OSIsoft; OpenStack
Emerson/OSIsoft
UCLA HPC Cluster
Rackspace