Making Things Smarter: Smart Manufacturing

Tuesday, May 16
2:00-3:15 pm
Panelists

- Sharon Nolen, Eastman Chemical Corporation
- George Andraos, Ford Motor Company
- Ethan Rogers, ACEEE
- Eli Levine, U.S. Department of Energy (Moderator)
Streamlining corporate energy data analytics

Sharon Nolen, CEM, PE
Eastman Chemical Company
Who we are

- A global specialty chemical company headquartered in Kingsport, Tennessee
- Approximately 14,000 employees and 50 manufacturing sites around the globe
- Serving customers in more than 100 countries
- A company dedicated to environmental stewardship, social responsibility and economic growth
- A Responsible Care® company for more than 25 years
- 2017 ENERGY STAR® Partner of the Year Sustained Excellence
- 2016 revenue of $9 billion
Benefits of energy data analytics

**Gain Insights**
- How energy is purchased and consumed
- What is causing changes in energy use over time
- What factors drive energy use
- How does current use compare to normalized baselines

**Improve Efficiency**
- Increase profit
- Reduce carbon footprint
- Reduce risk
What’s needed?

Method to:

• Gather latest data (potentially many different sources)
• Store the data (potentially many sites and variables)
• Analyze the data
• Provide access to results (static and interactive)

Goal: Streamline this process as much as possible:

• Reduce effort spent on maintaining the measures
• Increase time spent improving efficiency
• Reduce potential for human error
Example #1:
Corporate Energy Measure
Potential tools for corporate data analysis

- EnPI (Energy Performance Indicator)
  - Regression analysis based tool developed by the U.S. Department of Energy
  - Capabilities
    - Store energy use and other related variables
    - Establish a normalized baseline of energy consumption
    - Track annual progress of intensity improvements, energy savings, Superior Energy Performance (SEP) EnPIs, and other EnPIs
    - Account for variations due to weather, production, etc.
    - Can be applied at many different types of facilities

- Eastman’s approach
  - Largely based on EnPI methodology
  - Chose to use a custom set of tools due to challenges presented by two large, integrated chemical plants
Gathering data

- Procurement Data
- Production Rates & Other Variables
- Weather Conditions
- Utility Use (submeter data)

Obtaining and storing this information for many sites over time increases complexity.
Gathering data

- **EnPI**: Enter all data in site/area-specific Excel spreadsheets (these can be rolled-up)

- **Eastman approach to energy data collection**
  - R ([https://www.r-project.org/](https://www.r-project.org/)) is one of the tools used to help automate the data collection process
  - All corporate energy data is stored in SQL Server tables
Analyzing data

- **EnPI**: Site-specific models are developed within each Excel file to calculate normalized energy use.

- Eastman uses R scripts to:
  - Extract relevant raw data from the SQL database.
  - Develop models, calculate normalized use, other analysis.
  - Store calculated results within SQL for later use.

- Alternatives to R: Matlab, Python, SAS, Julia, etc.
Benefits

- Energy users better understand their impact
- Opportunity for engagement at different levels
- More visibility tends to attract better ideas

Sharing results

Once analysis is complete, the results may be

- Summarized in a variety of ways
- Made available to all energy users
Sharing results

- Visualization tools make it much easier to dive into large data sets
- Designed to be interactive - select points, date ranges, areas, etc.
- Available to all employees (with permission) through web browser
Example #2: Cost Center Energy Reports
Gathering data

- Production Rates
- Weather Conditions
- Utility Use (submeter data)

~900 distinct CC & utility combinations

- Finer level of detail leads to additional data
- Quantity of data prohibits manual data entry
Gathering data

- Tools like R enable automatic data collection from multiple sources.
- General process used for cost center data is very similar to the approach used for the corporate energy measure.
- Primary differences:
  - Energy data primarily sourced from utility sub-meters instead of site procurement data.
  - Production must maintain detail by cost center instead of site-level aggregation.
Analyzing data and sharing results

- Models are developed for each cost center utility using variables like production and weather

Results are shared in several ways

- Tableau view that may be accessed & customized on demand
- Custom monthly cost center summary email
- Site-level reports with a high-level breakdown by department
Cost center Tableau visualization

Results include:
- Normalized change in energy use
- Value of change
- Actual versus modeled use by month
- Correlation of a variable to energy demand
Monthly cost center reports

- R is used automatically
  - Generate ~125 custom cost center reports
  - Send the reports by email to cost center managers and other technical staff
- Provides monthly summary information
- Custom Tableau links automatically filter the visualizations for the cost center tied to the report
- Multiple timeframes may be evaluated with a click

### Monthly Energy Report

May, 2017

Cost Center x: Area XYZ

**View Cost Center Report**

Alternate timeframes: vs last month vs last 3 months vs last 12 months year over year

Total normalized improvement in cost center energy: 5%

<table>
<thead>
<tr>
<th>Utility</th>
<th>Current</th>
<th>Improvement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium Pressure Steam</td>
<td>x MMBtu</td>
<td>x%</td>
<td>$k/year</td>
</tr>
<tr>
<td>Low Pressure Steam</td>
<td>x MMBtu</td>
<td>x%</td>
<td>$k/year</td>
</tr>
<tr>
<td>Electric Power</td>
<td>x MMBtu</td>
<td>x%</td>
<td>$k/year</td>
</tr>
<tr>
<td>High Pressure Steam</td>
<td>x MMBtu</td>
<td>x%</td>
<td>$k/year</td>
</tr>
<tr>
<td>River Water</td>
<td>x MMBtu</td>
<td>x%</td>
<td>$k/year</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>x MMBtu</td>
<td>x%</td>
<td>$k/year</td>
</tr>
<tr>
<td>Demineralized Water</td>
<td>x MMBtu</td>
<td>x%</td>
<td>$k/year</td>
</tr>
<tr>
<td>Filtered Water</td>
<td>x MMBtu</td>
<td>x%</td>
<td>$k/year</td>
</tr>
<tr>
<td>Inert Gas</td>
<td>x MMBtu</td>
<td>x%</td>
<td>$k/year</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>x MMBtu</td>
<td>x%</td>
<td>$k/year</td>
</tr>
</tbody>
</table>
Cost center Tableau visualization with options for customization

- Second visualization allows for custom analysis at higher levels
- May be used to rank improvement by area
- Shared monthly with management
- Customization examples:
  - Timeframe comparisons
  - Level of aggregation from cost center to corporation
  - Point and click drill-down to utility detail by cost center
  - Custom exclusion of specific data points
Summary

- Data analytics are a vital part of an energy management program
- Streamline the process from data collection to reporting
- EnPI is a flexible option that’s ready to go
- Eastman uses a combination of SQL Server, R, and Tableau to analyze corporate-level energy data and drive improvement
  - Scalable storage to maintain all corporate energy data in one place
  - Interactive dashboards enable users to do their own ad-hoc analysis
  - Many users may have simultaneous access to the data
INDUSTRIAL IoT: Connected Plants
What exactly is the "INTERNET of THINGS"?

Smart Systems and the Internet of Things are driven by a combination of:

1. SENSORS & ACTUATORS
2. CONNECTIVITY
3. PEOPLE & PROCESSES

* Source: HarbourResearch.com
What is Ford doing about it?

- Connected Plants
- Approved Topologies
- Data Plumbing
- Current Data Standards
- Functional Integration
- Use Cases
Energy Management Operating System (EMOS)

Driving for Energy reduction per unit produced through continuous improvements in processes, designs and culture.

1. Facility Modernization (CIB, Program and Performance Contracting are funding sources)
2. Embed Energy Efficiency in Facility and Process Specifications (100 point and GFF)
3. Engineering, Feasibility Studies & Technology Evaluations

1. Collection & Storage
   • Record & Interval Data
2. Standard Reporting
   • Monthly - Normalized Energy Efficiency Report
   • Weekly - Shutdown Report
   • Daily - Energy Report
3. Analytics and Benchmarking

1. Reliability / Quality
2. Bidding/Contracting Process
3. Risk Management
4. Tariff Intervention

GOAL

Energy Team responsibility is to drive plant performance to Best in World

VOME, PTME, IT, FL Engineering and Energy support Global Plant Energy Team actions
Connected infrastructure

IT Hosted and Supported, Connected Software Platform

IT Hosted and Supported, Connected Software Platform

Manufacturing Systems

Hosted Data Library with tools for Data Sharing and Analysis.

IoT

External Connected Services & Data

New Human Interaction

Mechanical Systems (HVAC)

Electrical Systems (Lighting, Metering)

Security Systems (Cameras, Door Access)

Life Safety Systems (Fire Alarm, Gas Detection)

Data Center Systems (Servers)

Utilities Supply (Elec, Gas, Water, heat, etc)

Connected infrastructure

Ford
approved topologies

Compliant with Ford Information Security Policy (ISP)
Information Security Policy

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Plan for organizing, aggregating and moving building data securely making it usable and accessible by connected systems and devices.

Usable Data from multiple plants and sources
Connecting Data to Behaviors for optimization and process improvements:

Some of Fordland Energy Functional Integrations:
- Building Automation Systems
- Utility Metering Systems
- Compressed Air Systems
- Utility Analysis Tool
- LDAP User Service
- many more in development……
Big Boss: “Is there a problem with my building?”

Manager: “Do I need to call someone?”

Maintenance Manager: “Where is the problem in my system?”

Maintenance Staff/Contractor: “How do I turn off the system or reset it?”

Anyone at any time: “Let’s ask the system what the problem is?”

Ability to only display data needed based on roles when it matters.
Thank You
Better Buildings Summit
Smart Manufacturing Session
May 16, 2017; 2:00 to 3:15pm

Ethan A. Rogers
Program Director, Industry
American Council for an Energy-Efficient Economy
Intelligent Efficiency

Intelligent Efficiency is the system level energy efficiency made possible by the use of information and communications technologies and data analytics.

It is:

• Adaptive
• Anticipatory
• Networked
Typical Energy Measure Savings

- Un-managed building
- Degradation of Savings
- Energy Measure Implemented

Energy Use vs. Time
Intelligent Efficiency Management

- Un-managed building
- Degradation of Savings
- Savings from Learning

Energy Use vs. Time
Typical Savings Trends Over Time

- Un-managed building
- Typical Recommissioning
- Degradation of Savings
Savings with Continual Commissioning

- Un-managed building
- Typical Recommissioning
- Continual Commissioning
Savings with Continual Commissioning

![Graph showing energy use over time with continual commissioning](image)

- **Un-managed building**
- **Savings From Continual Commissioning**
Industrial Internet of Things (IIoT) Connected Devices

Figure 1: IoT Hierarchy

Network devices

Networked devices

Unconnected devices

Source: Derived from IHS-Markit

Internet connectable devices

Internet of Things (IoT)
Investments in IIoT are Increasing

![Graph showing increasing investments in IIoT](image-url)
Standards for Standby Power

Countries with mandatory minimum energy performance standards for relevant appliance groups

Number of mandatory minimum energy performance standards (MEPS) for select appliances

Source: CLASP 2016.
Smart Manufacturing

- Secure I, P and SaaS
- Secure Data Highways
- Data & Device Integration & Orchestration
- Smart Factory Manufacturing
- Smart Enterprise Manufacturing
- Collective Innovation & Practice

- IoT
- Big Data

- Converting Data to Information
- Converting Information to Knowledge
- Converting Knowledge to Wisdom
Digitization of manufacturing control system design and simulation (North, Central, and South America)

Source: Beudert et al. 2015
Countries and Companies are looking to Intelligent Efficiency to Address Many Challenges

Source: Smarter 2030, GeSI 2014.
## Smart Grid and Demand Response

<table>
<thead>
<tr>
<th>Percentage of industrial facilities with AMI</th>
<th>2012</th>
<th>24.5%</th>
<th>2013</th>
<th>35.2%</th>
<th>2014</th>
<th>36.5%</th>
<th><strong>FERC 2014, 2015, 2016</strong></th>
</tr>
</thead>
</table>
Technology Diffusion

Where are we now?
Thank you!

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Visit us on the web at: www.aceee.org
Follow us on Twitter at: @ACEEEEdc

SAVE THE DATE!

ACEEE 2017 Summer Study on Energy Efficiency in Industry
http://aceee.org/conferences/2017/ssi
Related Research & Projects

Rogers, Ethan A., Edward Carley, Sagar Deo, and Frederick Grossberg. 2015. How Information and Communications Technologies Will Change the Evaluation, Measurement, and Verification of Energy Efficiency Programs. [Link](aceee.org/research-report-ie1503)

Rogers, Ethan A. 2014. The Energy Savings of Smart Manufacturing. [Link](aceee.org/research-report-ie1403)


Thank You

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