Sustaining Energy Savings in a Manufacturing Facility

Provided by Advanced Energy
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Who is Advanced Energy?

• Founded in 1980 by the North Carolina Utilities Commission as a nonprofit organization
• Mission: To create economic, environmental and societal benefits through innovative and market-based solutions to energy issues
• ~50 employees
• Funded in part by the NC electric ratepayers

Advanced Energy’s office on North Carolina State University’s Centennial Campus in Raleigh, NC
Our Partners
Topic Outline

• Sustainable Energy Efficiency
• Some Industrial Data
• Energy Prospecting
• Teamwork
• Wrap-Up
Sustainable Energy Efficiency

- **Sustainable**: The capacity to support, maintain, or **endure**
- **Energy**: The ability of one physical system to do work on another physical system causing a **transformation**
- **Efficiency**: The ratio between a specific, useful **output** and the required energy **input**

**Sustainable Energy Efficiency:**
**ENDURING** **TRANSFORMATION** with an ever increasing **OUTPUT** per unit of energy **INPUT**
Sustainable Energy Efficiency

A Good Sustained Trend

Melt Energy Intensity

BTU x 10^6 per TON of Melt

MONTH

Sustainable Energy Efficiency

• **Energy Efficiency (EE)**
  1. The ratio of useful energy output divided by the total energy input for a system and is a percentage less than 100%
  2. Another way to look at this is the \((\text{total energy input} - \text{losses}) / \text{total energy input}\), also as a percentage less than 100%
Sustainable Energy Efficiency

**Energy Intensity (EI)**

1. A measure of the amount of energy needed in terms of kilowatt-hours or BTU’s to create a unit of manufactured product
   e.g. BTU/ton, kWh/linear yard, kWh/pound
2. An indicator of the relative energy use of a process or industry when compared to other energy intensities
   e.g. melting steel has a high process energy intensity compared to drying coatings on textiles

By improving both EE and EI we can produce more product with less energy input!
Some Industrial Data

- Some of the typical UV & EB Industries
  - Adhesives
  - Aerospace & Defense
  - Automotive OEM
  - Collision Repair & Refinish
  - Composites
  - Electronics
  - Metal Finishing
  - Food Packaging
  - Medical Devices
  - Plastics
  - UV Inkjet
  - UV Powder
  - Wood Finishing
  - Building Products
  - Printing & Packaging
  - Fingernail Finishing

UV = Ultraviolet
EB = Electron Beam
Some Industrial Data

Total Annual Primary Energy Usage in Industrial and Other Sectors in USA

End Use Energy Splits

- Residential: 21%
- Commercial: 18%
- Transportation: 29%
- Industrial: 32%
Some Industrial Data

Industrial Facility Electrical Consumption by End Use

- Machine Drive: 51%
- Process Heating & Cooling: 19%
- Electro-Chemical Processes: 7%
- HVAC: 9%
- Lighting: 7%
- Other: 7%

Some Industrial Data

Electrical Energy Usage - Printing and Related Support

- Electric Intensity (kWh/sqft) -- Printing and Related Support

- Total Electric Intensity (kWh/sqft, annual basis): 33.90
- Average Electric Consumption per Establishment (kWh): 1,254,266
- Average Enclosed Floor space per Establishment (sqft): 36,999

Source: EIA energy intensity data from CBECs and MECS, EPRI, and other third party energy use datasets.
Some Industrial Data

Natural Gas Energy Usage: Printing and Related Support

- Process Heating: 40.00%
- HVAC: 33.33%
- Boilers: 13.34%
- Other: 11.11%
- Motors/Machine Drive: 2.22%

Total Gas Intensity (kBtu/sqft, annual basis): 103.93
Average Gas Consumption per Establishment (kBtu): 3,845,306
Average Enclosed Floorspace per Establishment (sqft): 36,999

Source: EIA energy intensity data from CBECs and MECS, EPRI, and other third party energy use datasets.
Some Industrial Data

Energy Intensity in kWh per $ of Product Output
Energy Prospecting

Prospecting for Energy Savings
Combing through the plant, often through basements, side rooms, in utility buildings and in boiler rooms, often on hands and knees looking for signs of wasted BTU’s in the infrastructure.
Energy Prospecting

Understanding Processes

Primary Market → Use → Product → Raw Materials → Process → Transformation → Equipment → Technology

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Energy Prospecting

Understanding Transformation
Energy Prospecting

• For the UV/EB industries the primary transformation process is **CURING**
• Whether it is photons (UV) or a field of electrons (EB), the transformation is basically a chemical reaction
• The Energy Intensity for UV/EB could be tracked in several different ways, depending on the process:
  – kWh per Pound of Coating
  – kWh per Linear Yard of Product
  – kWh per Square Foot of Product, etc.
Energy Prospecting

- Major energy users for a UV/EB process:
  - UV Lamps
  - Electron Beam Field Generators
  - Cooling Equipment
  - Material Handling
  - Temperature and Humidity Control
Energy Prospecting

• The UV/EB process may be only one of many processes required for the product
• There may be many transformation processes involved all over the plant
• There are also many support systems for the transformation processes and for the building
Energy Prospecting

- Potential areas to look for energy savings:
  - Demand Side Management
  - Waste Heat Recovery
  - Compressed Air
  - Motors & Variable Frequency Drives
  - Boilers/Furnaces/Combustion
  - Lighting
Demand Side Management

- Typically, electrical invoices are composed of two major portions:
  - **Energy** charge for actual kilowatt-hours consumed during the billing period
  - **Demand** charge for the level of the single highest kilowatt demand power level for any given interval period over the entire billing cycle
  - This demand charge is based on a peak power level
  - By establishing both procedural controls and possibly automated controls, there is an opportunity to reduce this peak demand and therefore reduce the demand portion of the electrical bill
Energy Prospecting

Demand Side Management

Graph showing energy consumption trends over time with annotations for peaks and background load.
Energy Prospecting

Waste Heat Recovery

• From Heating
• From Combustion
• From Boilers
• From Compression
Energy Prospecting

Some Possible Uses for Waste Heat

- Building Heating
- Steam Production
- Preheating Combustion Air
- Preheating Feed Water for Boilers
- Preheating Water for Pre-Treatment Lines
- Downstream Drying or Curing Processes
- On-Site Electrical Power Generation
Compressed Air

- Compressed air systems have an efficiency of around 15%.
- A 150 hp air compressor, fully loaded for one year at $0.05 per kWhr will cost $50,000 per year for the electricity.
- Typically there is an attitude in the plant that compressed air is free, which can lead to improper uses.
- Compressed air systems always have leaks.
Energy Prospecting

Compressed Air

• Educate Employees on the real COST of compressed air
• Conduct Plant Surveys on END USES – Remove Improper Uses
• Develop and Maintain a strong LEAK Repair Program
• Right Size compressors and base load/trim with VFDs
• Reduce Overall System Pressure to minimum possible
• Evaluate and Update systems controls
• Evaluate Alternatives: Motors, Blowers, Mechanical Actuators, etc.
Energy Prospecting

Motors and Variable Frequency Drives (VFDs)

• Electric motors typically account for around 50% of all the electricity consumed in manufacturing plants
  – Air Compressors, Chillers, HVAC, Fans, Pumps, Hydraulics, Material Handling, etc.

• Effectively managing the motor population in a manufacturing plant can typically save up to 8% in motor energy costs

• VFDs on selected motors can result in dramatic savings
  – Horsepower is proportional to speed (rpm) CUBED
    • HP ~ rpm³
Energy Prospecting

Motors and Variable Frequency Drives (VFDs)

Example: speed reduction to 50%

\[ HP_{0.5} = HP_1 \times (0.5)^3 \]
\[ = HP_1 \times 0.126 \]

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<th>Power</th>
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<tr>
<td>20%</td>
<td>1%</td>
</tr>
<tr>
<td>10%</td>
<td>0.1%</td>
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Energy Prospecting

Motors and Variable Frequency Drives (VFDs)

- On-site training on Motor Management Policy concepts for:
  - Maintenance Staff, Engineers, Purchasing, Operations
- Collect and update motor nameplate data
- Establish motor repair or replace guidelines
- Test and evaluate motors and VFDs
- Use Premium Efficient Motors
- Evaluate Life Cycle Costing
- Right size motors
  - Below 40% load, Efficiency DROPS significantly
Energy Prospecting

Boilers/Furnaces/Combustion

Balance Air and Fuel

Chemical

\[
\text{CH}_4 + \text{O}_2 \rightarrow \text{CO} + \text{H}_2 \text{O}
\]

Concentration in Flue Gas

Efficiency

Highest Efficiency Operating Region

Oxygen

Hydrocarbons

Flue Gas Oxygen (%)

Excess Fuel

Excess Air
Energy Prospecting

Boilers/Furnaces/Combustion

• Understand Losses

• Each 40°F decrease in stack temperature results in a 1% increase in efficiency

• Preheat Combustion Air
Energy Prospecting: Lighting

• Duke Energy in NC
  – LED High Bay replacing a 400 watt Metal Halide High Bay fixture: $225.00/fixture
  – Exterior LED replacing a 400 watt Metal Halide: $200.00/fixture

• Georgia Power in GA
  – Invest in LED (must meet Energy Star requirements): $0.20/watt
  – Install grocery display case LED lighting: $40.00/door
Energy Prospecting

Remember Renewable Energy Opportunities
Energy Prospecting

Other Benefits of Energy Efficiency Projects

• Productivity Improvements
• Quality Improvements
• Ergonomic Improvements
• Better Material Flow
• Labor Savings
• Scrap Reduction
• Water Use Reduction
• Waste Reduction
• Better Floor Space Usage
• Environmental, Health and Safety (EHS) Improvements
Energy Prospecting

Involve Everyone on the Plant Team in Energy Efficiency:

- Product Design
- Purchasing
- Finance
- Operators
- Maintenance
- Plant Engineering
- Energy Teams
- Utility Account Managers
Teamwork

Manufacturing Plants are ENERGY INTENSE

• Your local utility and energy consultant can HELP
  – Assistance with Capital Projects
    • New Equipment Planning
    • Capital Expansions
    • Greenfield Projects
  – Infrastructure
  – Business Continuity
  – Incentive Programs
  – Other Energy Efficiency Programs
Teamwork

Assistance with Capital Projects

• **Consider Electrical Rate Structure Options**
  – Best Rates Analysis
  – Demand Response Programs
  – Energy Efficiency Options
    • Economic Development Discounts for new load and job creation expansions
    • Contact your local utility or account manager **EARLY** in the planning process of your project
Teamwork

Infrastructure

- Take delivery at the primary voltage
- The Utility can bid and turn key install:
  - Substations
  - Transformers
  - Switchgear
  - Main Feeder lines to Furnaces
Teamwork

Business Continuity

• Backup Generation for:
  – Entire plant loads
  – Critical loads only

• The Utility can design, build and install:
  – On-Site Generation
  – Uninterruptible Power Supplies
Teamwork

Incentive Programs

• Typical Areas for Standard Incentives
  – Lighting (including LED’s)
  – Demand Side Management Controllers
  – Variable Speed Drives and Motors
  – Chillers and HVAC Units

• Custom Incentives
  – Plan Ahead. Approval is typically required BEFORE issue of the purchase order for equipment and energy savings typically need to be verified
Teamwork

Other Energy Efficiency Programs

• ISO 50001 – Energy Management System
• Department of Energy, Superior Energy Performance (DOE SEP)
• Government Incentives for Renewable Energy = DSIRE™
• Electrical Power Research Institute
• Environmental Protection Agency (EPA) Energy Star
Find the Best Available Energy Efficient Solution for Your Plant
• Adding Infrared (IR) for a Hybrid Drying System for Textile Coatings
  – *The Challenge*
    • Many woven textile fabrics require a variety of coatings on both the finished side and the back side of the cloth
    • Economically, the speed in linear yards per minute to coat and dry this cloth is the key factor in profit margins on this product
    • Due to the moisture content of the coating materials, the plant had to run all double coated cloth through their natural gas convection drying oven *two* times: one pass for each coated side
    • This required two overtime shifts on Saturday, extra run time for the drying oven and double handling of the cloth

Teamwork: A Success Story

• Adding Infrared (IR) for a Hybrid Drying System for Textile Coatings

  – *The Innovation*

  • Evaluation of possible solutions led to the idea of adding an IR booster oven between the two coating stations
  • This additional IR heat would kick start the drying process of the first coating, before applying the second coating
  • The second coating could then be dried at a higher speed rate through the existing drying oven
  • By adding an infrared (IR) booster oven in-line between the two coating applicators, the cloth could be processed in one pass through the drying oven
  • This will cut the coating drying time in half for all the double coated products
Teamwork: A Success Story

- Adding Infrared (IR) for a Hybrid Drying System for Textile Coatings

  - **The Results**

    - All weekend overtime shifts were eliminated with an estimated annual labor savings of: **$420,000**
    - The run time of the existing drying oven was reduced by: **1,335 hours per year**
    - This reduced existing drying oven run time results in:
      - Electrical Savings: **65,000 kWh per year** ($4,000/yr)
      - Natural Gas Savings: **6,500 Dekatherms per year** ($43,000/yr)
    - Plant energy intensity in terms of kWh per linear yard of cloth was reduced by **12%**
    - Simple payback for this project including the IR oven and installation is: **0.33 years**
Teamwork: A Success Story

- Adding Infrared (IR) for a Hybrid Drying System for Textile Coatings
  - **Non-Energy Benefits**
    - Elimination of double handling of the cloth, reducing the possibility of damage
    - More consistent drying of the coatings for better product quality
    - The addition of the IR oven required minimum floor space and fit into the existing line envelope
    - Increase in plant capacity for processing coated cloth

With the TEAMWORK of the plant, the utility, the vendor, and an energy consultant, the hybrid combination of an electric IR booster oven with a natural gas convection drying oven produced a good solution for this problem.
Wrap Up

Review Our Topics:

• Sustainable Energy Efficiency

  ENDURING TRANSFORMATION with an ever increasing OUTPUT per unit of INPUT

• Some Industrial Data
Wrap Up

Review Our Topics (continued):

• Energy Prospecting – Plant Wide

• Teamwork:
  – Manufacturing + Utilities + Consultants + Vendors = The best energy solution
Sustaining Energy Savings in a Manufacturing Facility

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REMEMBER: Sustaining Energy Efficiency =

ENDURING TRANSFORMATION with an ever increasing OUTPUT per unit of energy INPUT
Sources

• Advanced Energy:
  – www.advancedenergy.org

• Advanced Energy Motors and Drives Horsepower Bulletin:

• Advanced Manufacturing Office – Compressed Air Systems
  – www1.eere.energy.gov/manufacturing/tech_deployment/compressed_air.html

• Advanced Manufacturing Office – Energy Resource Center
  – www1.eere.energy.gov/manufacturing/tech_deployment/echcenter.html

• Dibalog
  – www.dibalog.com

• Duke Energy
Sources

• Duke Energy Smart $aver® Incentive Program
• Energy Footprints by NAICS Codes
• Energy Management Opportunities for Industrial Customers
  – Questline Academy, Mike Carter & Justin Kale
  – www.questline.com
• Energy Star
  – www.energystar.gov/index.cfm?c=business.bus_index
• Electric Power Research Institute (EPRI)
  – www.epri.com
Sources

- Industrial Heating Equipment Association (IHEA)
  - www.ihea.org
- ISO 50001 – Energy Management System
  - www.eere.energy.gov/energymanagement
- Powerit Solutions
  - www.poweritsolutions.com
- Superior Energy Performance Overview
  - www.superiorenergyperformance.net
- Superior Energy Performance Demonstration
  - www.eere.energy.gov/industry/energymanagementdemonstrations/