EASTMAN

ENERGY STAR AWARD 2017
PARTNER OF THE YEAR
Sustained Excellence

Energy Efficiency – It's Only Natural.

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Agenda

- Energy Efficiency
  - Background
  - Principles and strategy
  - Link with other initiatives
  - Growth
- Water Conservation
- TN Operations Steam Electric Balance Study

2000-2010 Eastman Chemical energy management

- Corporate energy team
- Energy project implementation – ACC energy efficiency awards for 21 consecutive years
- On-site energy training and assessments
- Programs in place at the largest sites to:
  - Improve insulation
  - Improve lighting efficiency
  - Reduce steam leaks
- Capital allocated to improve sub-metering

EASTMAN

A case for change

In 2010, Eastman decided to pursue an aspirational goal to inspire radical improvement and join the DOE Better Buildings, Better Plants program

- The baseline for improvement was 2008, the year Eastman became an ENERGY STAR® Partner
- The existing program would fall short of what was needed to meet this ambitious goal

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U.S. DEPARTMENT OF ENERGY

Background

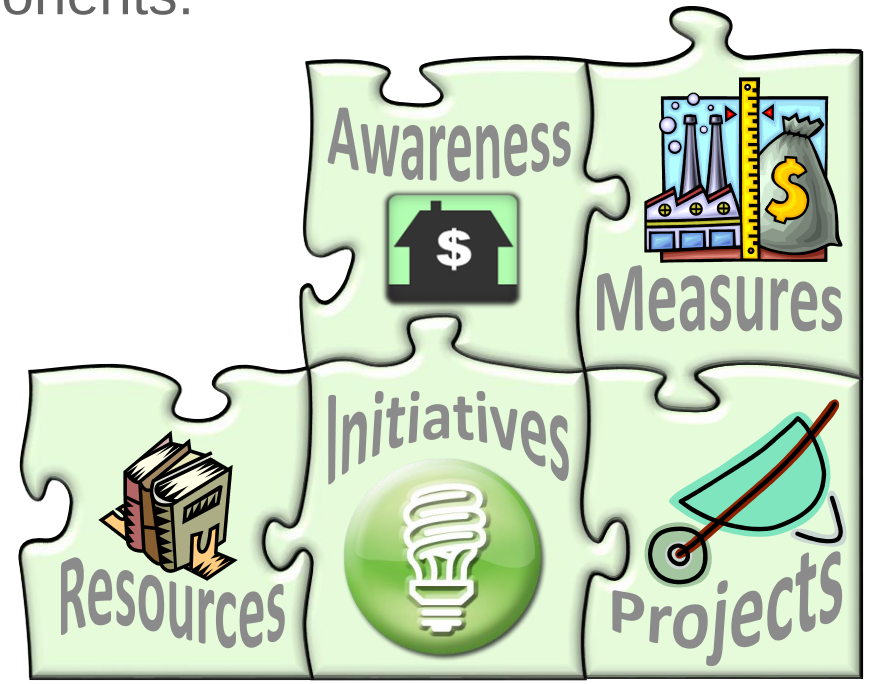
Principles and strategy

Link with other initiatives

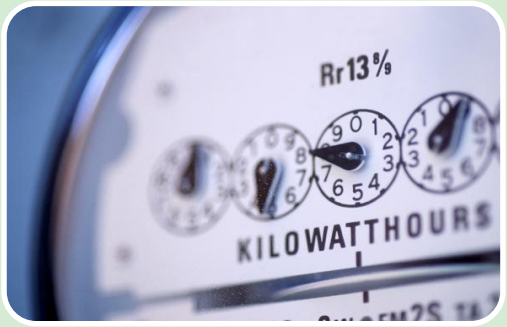
Growth

Principles and strategy

- Three guiding principles were developed as a reference to ensure that decisions made related to the energy program are consistent with the intended direction
- Strategy utilizes five key components:
  - Measures
  - External resources
  - Awareness
  - Initiatives
  - Projects



Guiding principles



Ensure the Accuracy of Utility Information

- Creates a basis for sound business decisions
- Required for accurate reporting and life cycle assessments

Maximize Operating Efficiency

- Reduces energy usage economically
- Typically improves the reliability of equipment

Incorporate Energy Efficiency in Capital Investments

- Improves lifetime equipment costs
- Positively impacts carbon emissions

Principles

Ensure the accuracy of utility information

- Site management at the largest site proactively decided to add meters in strategic locations
- Energy surveys check the accuracy of allocated costs and correct placement of meters
- Modelling efforts have been able to predict energy use on a product level

Manufacturing managers are more than willing to make good energy decisions – they just need the right information to enable them to do so

Principles

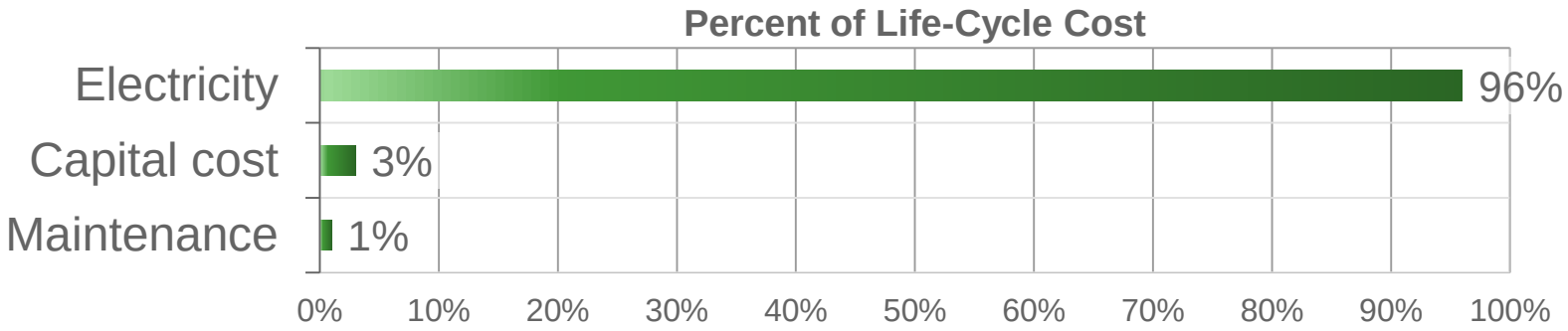
Maximize operating efficiency

- Rotating equipment is tested to ensure that each piece of equipment is operating at the best efficiency point on the operational curve
- Equipment includes turbines, pumps, chillers, and compressors
- Equipment that is not performing as designed is scheduled for maintenance to restore optimum performance

Principles

Incorporate energy efficiency in capital investments

- Most opportunities for energy efficient equipment and processes occur during the design stage versus retrofits
- According to external publications, the total life-cycle cost makeup of an electric motor is:

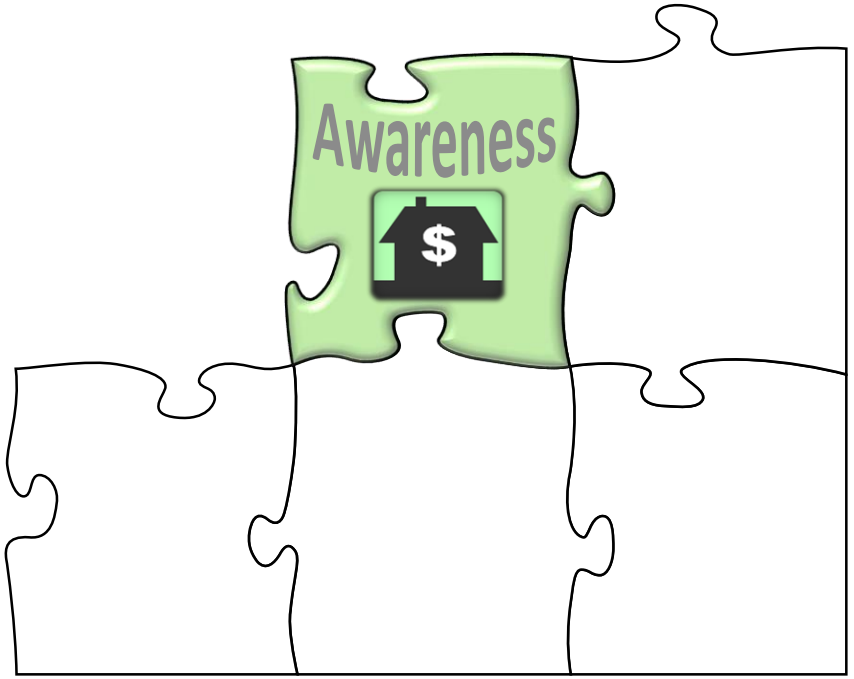


- Energy efficiency considerations can have a large effect on the total ownership costs related to machine drives

Strategy

Employee awareness

- Energy program was originally only project-focused
- ENERGY STAR helped expand the program to include employee engagement and awareness
  - Posters, brochures, children's activity books, and displays are available for ENERGY STAR partners
  - ENERGY STAR is a well-recognized and positively perceived brand
- Energy fairs and office events
  - Held first fair in 2011 after visiting another company's fair
  - Used ENERGY STAR resources
  - Local utilities and retail stores manned booths showcasing energy efficiency products



Strategy

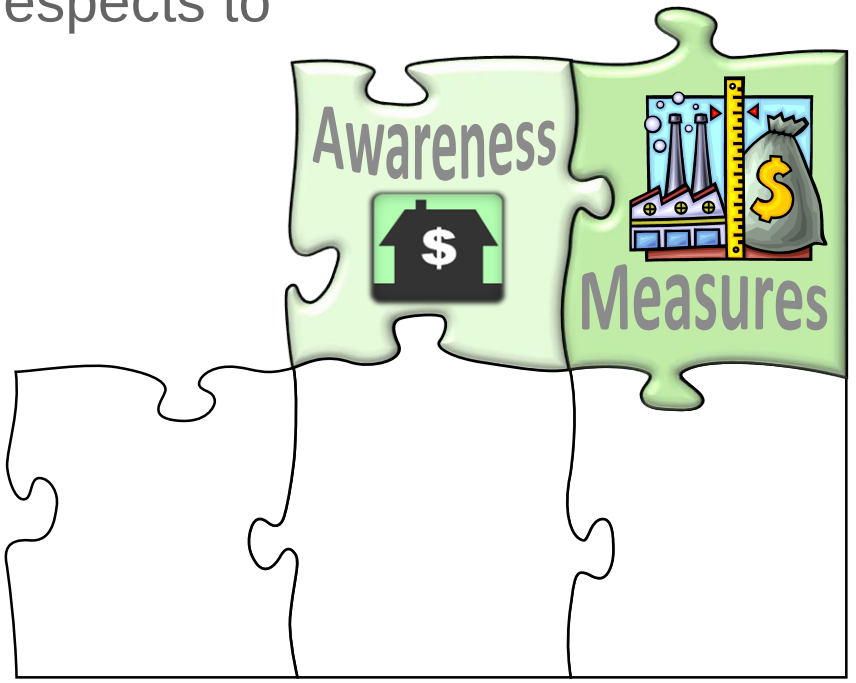
Employee awareness

- Green Teams
  - Geared toward sharing information with employees that have personal interests in preserving the environment
  - ENERGY STAR provides a Green Team Checklist with the needed framework
  - Monthly newsletters with ideas and events
- ENERGY STAR® Building Competitions
  - Internal competitions
  - Reduced energy costs
- ENERGY STAR Portfolio Manager
  - Enables office employees to benchmark building energy use
  - Obtained first ENERGY STAR Certified Building in 2013 after decreasing energy usage in a building by 57%
  - Internal competition between similar buildings increases enthusiasm

Strategy

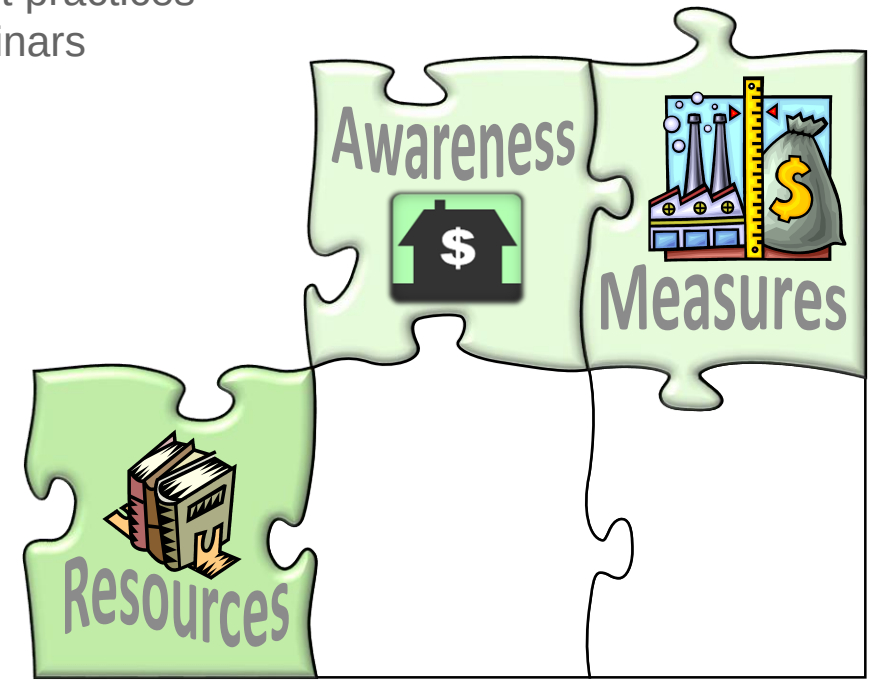
Measures

- Critical to have a well-defined, auditable measure with meaningful goals
- Eastman's existing measure (MMBtu/kkg) had to be improved in several respects to meet this criteria
  - Definition – Standardized and communicated
  - Frequency –Increased from annually to monthly
  - Automation –Reduced the opportunity for human error
  - Auditability – Reported externally in Eastman's Sustainability Report



Strategy
External resources

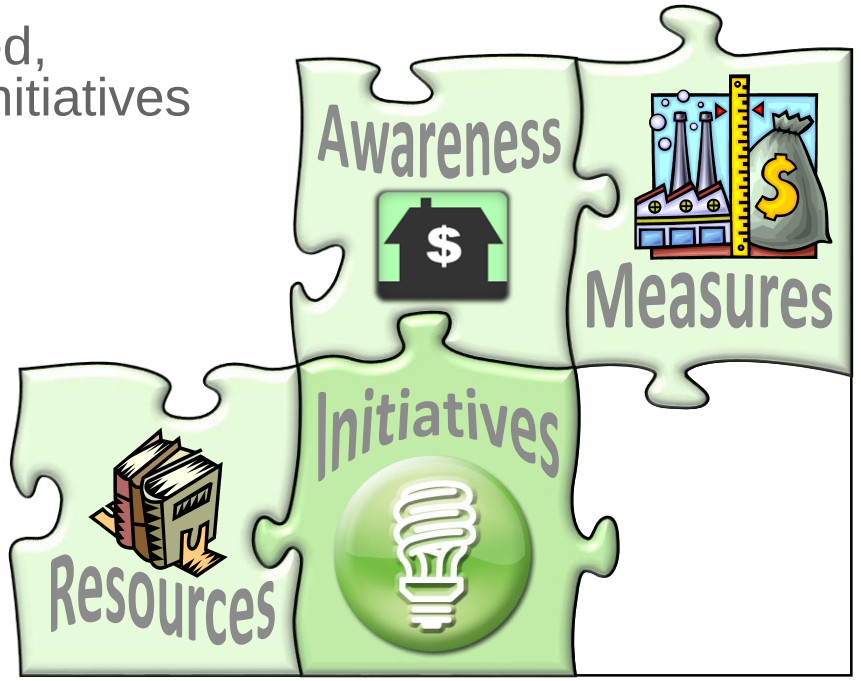
- ENERGY STAR®
  - ENERGY STAR Guidelines for Energy Management used to identify gaps in the existing program
  - ENERGY STAR Partners have the opportunity to benchmark with other companies and share best practices
  - Partner meetings, website, and webinars provide insight
  - Review of the existing corporate energy program by knowledgeable, outside individuals
    - An assigned mentor (an energy manager from another company)
    - Technical Advisor
- Department of Energy Better Plants Program
  - Access to resources
  - National Labs
  - Technical Account Manager (ORNL)



Strategy

Energy initiatives

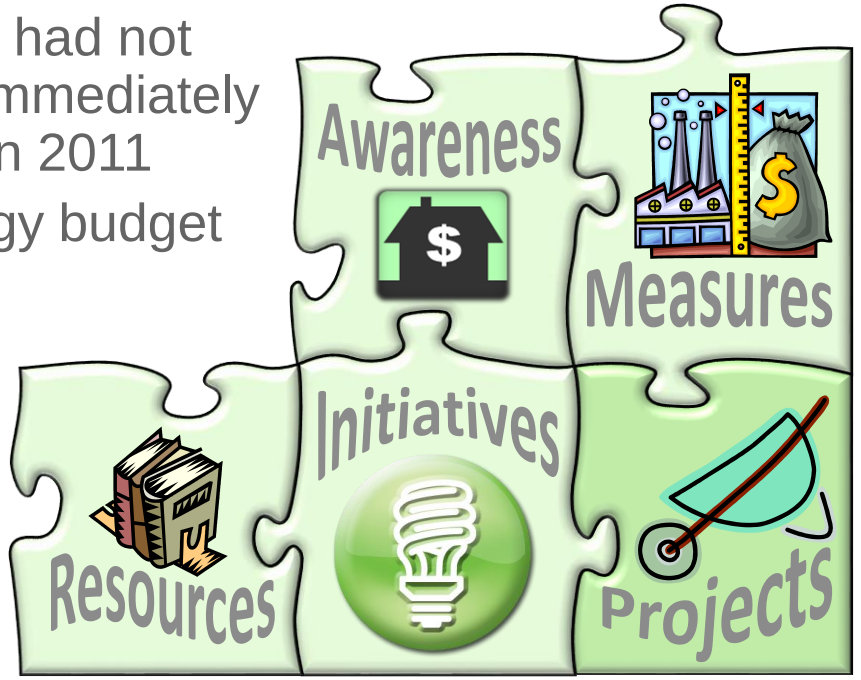
- Sharing of best practices
  - One manufacturing area took a different approach to steam leak repair that led to a 98% reduction in leaks over ten years
  - Their approach has been recognized internally as a best practice and incorporated into the program
- Potential identified for a centralized, standardized approach for other initiatives
  - Steam traps
  - Motors
  - HVAC
- Evaluation
  - Questionnaire to assess the progress of each site in each area
  - Results serve to identify common areas of concern, needs for improvements, and best practices at individual sites for sharing



Strategy

Energy efficiency projects

- In 2010, no capital money was allocated specifically for energy efficiency projects
- Many good energy projects simply fell below the approval level when competing with other projects
- When shown a list of projects that had not been funded, the Steering Team immediately funded $4.2M of energy projects in 2011
- Within two years, the capital energy budget grew to $8M/year
- Led to increased interest in the energy program
  - Manufacturing areas recognized the additional avenue for funding
  - The energy team became a welcomed partner



Strategy

Energy efficiency projects

- Database of potential projects is continually updated
- Best projects are identified
- Typical projects
  - Upgrades to more energy-efficient equipment
  - Heat recovery opportunities
- Project ideas are usually process-specific, but there is some potential to find common opportunity across the company

Strategy
Example Projects

- Running a line from a source of high pressure natural gas to eliminate a compressor used on low pressure natural gas
- Replacement of old equipment with newer more efficient equipment (i.e. boilers, pumps)
- Installing additional piping to allow condensate return
- Fine tuning temperatures of heat exchangers using refrigeration and steam to meet but not exceed requirements
- Installing variable frequency drives to eliminate control valves

Background
Principles and strategy
Link with other initiatives
Growth

Link with other initiatives

Compliment the tangible benefits of energy projects with other corporate initiatives to gain additional support

OutThink | OutExecute

- Safety – More efficient technology can result in:
  - Less lumen degradation → safer working conditions
  - Longer lamp life → employees will be working fewer hours at elevated heights
- Productivity – Group relamping results in more efficient use of labor (and more immediate energy savings)
- Sustainability
  - Sustainability is more closely connected to the businesses while the energy program is more closely tied to manufacturing
  - The sharing of connections and insights has proven valuable
  - The energy program falls under the company's Sustainability Council with executive team members

Background
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Growth

- Eastman's energy program must grow and improve with the company
- Acquisitions
  - Solutia
  - Taminco
- Natural resources
  - Recently expanded to include water conservation
  - Many program elements lend themselves to being more efficient with any natural resource – not just energy

Water conservation

Drivers to address water issues

- Water has become a global macro trend
- Future supply (quantity and quality) concerns
- Customer inquiries
- Sustainability scores (i.e. CDP)
- Closing the gap in our sustainability story
- Public expectations of a large chemical company

Objective

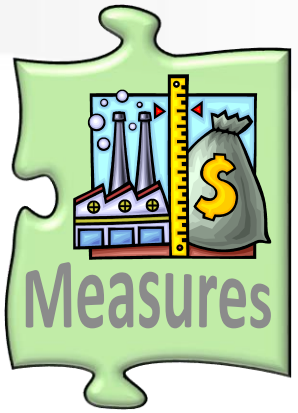
Develop an understanding of water issues and properly identify and manage water risks and opportunities so that Eastman is positioned to respond to manufacturing and customer needs and escalating issues.



Strategy - Water

- Some may have to be convinced that it really is an issue
  - Water is plentiful and cheap in some parts of the world
- Some of the same methods of communication can be used, i.e. Green Team Newsletters
- Employees can be asked to relate issues at home to issues at work
- The same employees who are interested in conserving energy will likely be interested in saving water

Strategy - Water

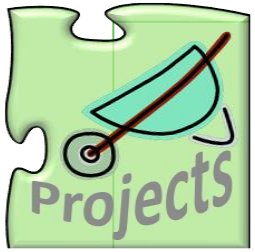


- Measures may be more important for individual sites rather than the entire company
- Measures could be based on amount withdrawn, consumed, or intensity or limited to specific sites
- Quantitative examples:
  - Reduce water consumption by at least 30% at global sites that are located where the renewable freshwater supply is either scarce or stressed as determined by the United Nations analysis of river basins globally. For all other sites, we will hold water consumption flat on an absolute basis through the year 2015, offsetting any increased demand from production volume growth through conservation, reuse and recycle practices.
- Qualitative examples:
  - The goal is focused on water conservation planning and reductions efforts in regions of the world where water resources are limited or excessively extracted (water stressed and hyper stressed).
  - Specific goals developed for sites that are in water stressed areas or have identified potential water savings potential.

Strategy- Water

Initiatives:

- Focus on condensate return improvements.
- This increases energy efficiency and reduces water use.



Projects:

- Capture project ideas in the energy project database for future consideration
- Consider water conservation in design
- Look for opportunities for water reuse (much like heat integration)

Resources:

Increase engagement on water issues in ENERGY STAR and DOE Better Buildings, Better Plants networks

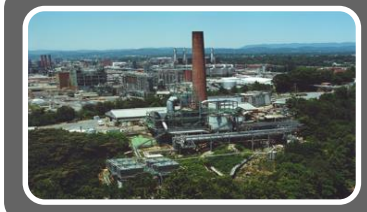
Strategy - Properly Identify and Manage Water Risks and Opportunities

- Preliminary identification of water-stressed sites using commercially available tools - Aqueduct and Global Water Tool is complete
- Pilot effort at one site is complete
- Best practices have been identified and US sites have been assessed against them

Combined Heat and Power at TNO

Self sufficiency mindset

CHP since the 1920's



Incineration complex

Hazardous and non-hazardous landfills

Wastewater treatment

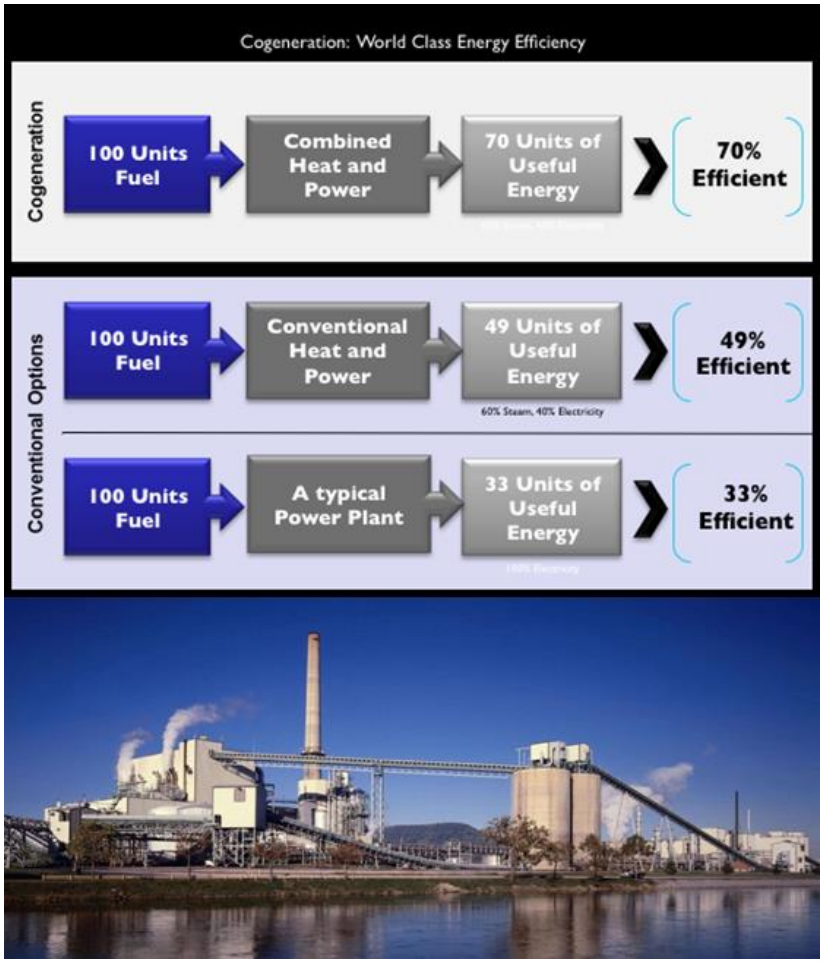
Eastman's first encounter with CHP

Kingsport, Tennessee plant

- Eastman Chemical Company's Tennessee Operations (TNO) is one of the largest chemical manufacturing sites in North America, covering approximately 900 acres
- This facility produces a variety of chemicals, fibers, and plastics and also serves as the worldwide headquarters for Eastman Chemical Company
- The facility began operating its first CHP system in 1920's and has continued adding to the system until its most recent expansion in 1993
- TNO's experience with CHP predates the construction of a reliable electric grid in the Kingsport area
- When it first came online, the CHP system was the only reliable source of electricity for the facility

Benefits of Combined Heat and Power (CHP)

- Dramatically improves Eastman's footprint: ~70% energy captured versus ~40%
- ~90% of the electricity at Eastman comes from CHP technology
- CHP has broad support from environmental groups and the Department of Energy

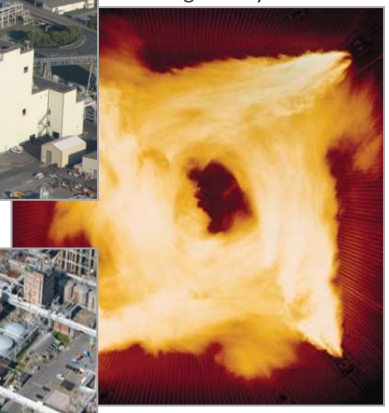


Steam and electricity generation at TNO

- One of the most energy efficient plants in the country
- TNO received ENERGY STAR® Combined Heat and Power (CHP) Award
  (requirement: use at least 10 percent less fuel than *state-of-the-art* separate heat and power generation)
- Total installed cogeneration capacity to a 700 MW power station
- Steam generation
  - 17 boilers
  - Typical steam load: 3.6 million lb/hour
- Electricity generation and distribution
  - Generate 90% of plant's electricity needs
  - Electrical nameplate capacity = 190 MW (enough for a city of ~170,000 homes)
  - 19 turbine-generators
  - ~200 substations

B-325 powerhouse

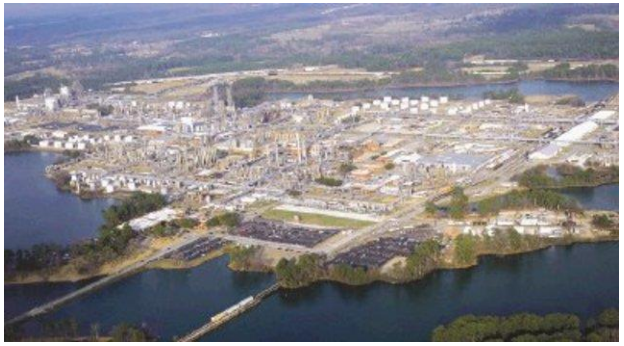
View inside a tangentially-fired boiler



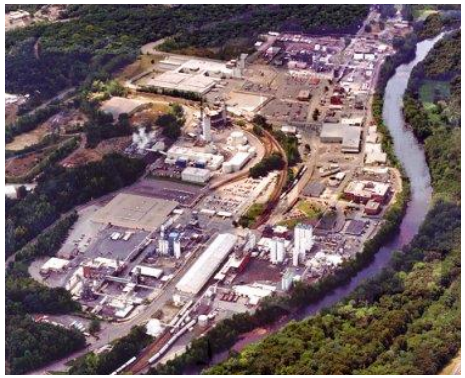
B-83 powerhouse

CHP at Eastman today

- Benefits of CHP at the TNO site:
  - CHP total efficiency: >70%
  - Avoided CO_2 emissions: 358,000 tons/yr (equivalent to emissions from the generation of electricity used by more than 44,000 homes)
  - Yearly savings: $~45M
  - Moreover, by generating electricity on site, the system reduces demands on existing transmission and distribution infrastructure
- Two other Eastman sites currently make use of CHP
  - Longview, Texas
    - Two GE 7241(FA) combustion turbines
    - Two heat recovery steam generators (HRSG)
    - One GE condensing/extraction steam turbine-generator
  - Indian Orchard, MA
- 87% of Eastman's worldwide production occurs at sites with co-generation
- Enables a source energy reduction of several trillion Btu's each year



Longview, TX



Indian Orchard, MA

Improving CHP efficiency at the Kingsport site

TNO cogeneration system evaluation

- Energy is a significant cost to Eastman
- In today's environment, we need to make operations as efficient as possible, including energy efficiency improvements
- A detailed internal study of the system took place in 2016
- Involved Technology, Utilities, and Worldwide Energy Program personnel
- Led to significant learnings

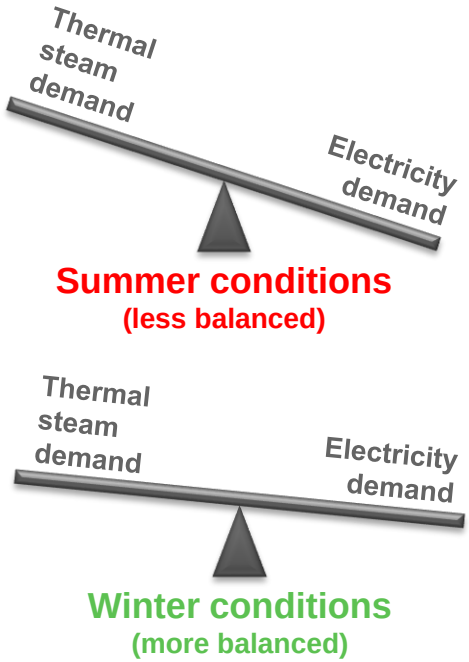
Goal

Determine the proper strategy to maximize profits by improving system efficiency

TNO cogeneration imbalances

- Over time, various changes have led to periods of time when the steam electric system at TNO is unbalanced
- Although the overall efficiency is very high, this imbalance does reduces the ability to operate the power plant as efficiently as possible with current equipment
- Primary factors include:
  - Shift towards specialty chemical company has changed energy demand profile
  - Improved efficiency has reduced thermal steam demand in processes (which reduces electricity cogeneration)
  - Sub optimization of the use of mechanical drives throughout the plant
  - Ambient temperature reduces thermal steam demand in warmer months

Higher ambient temperature exacerbates imbalance



Path forward after evaluation

Ensure users are valuing utility cost savings appropriately

Identify and implement attractive capital projects to bring the system into balance

Educate manufacturing, technology, and engineering on findings and promote involvement

Form the Utilities System Balance Team to review projects and oversee the health of the system

Determine if it is viable to add external customers of 15 & 100 psig steam

Path forward after evaluation

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Focus of DOE Steam System In-Plant Training

Form the Utilities System Balance Team to review projects and oversee the health of the system

Determine if it is viable to add external customers of 15 & 100 psig steam

DOE Steam System In-Plant Training

- Held in August, 2016
- Led by Dr. Greg Harrell
- Focused on identifying options to improve the steam / electric balance at the Kingsport site
- Several potential projects were identified and are in now in various stages of implementation:
  - Absorption chiller operation strategy
  - Backpressure turbine loading strategy
  - Fan drive turbine → motor replacement

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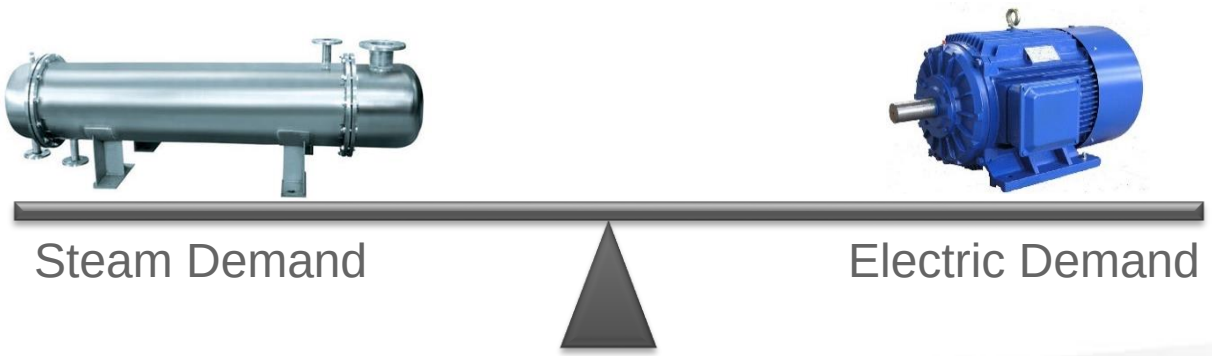
Future improvement strategy

- Some modes of operation are less efficient
- In most cases, these inefficiencies occur due to constraints in our very complex system
- Power Department operations continuously monitors plant needs for steam and electricity and attempts to optimize the system within constraints
- The newly formed **Steam Electric Balance Team** will monitor the system and recommend equipment / operational changes to improve system efficiency
- Over time, these actions are expected to remove current operating constraints for Power Department and effectively eliminate time spent in inefficient operating modes



Summary

- CHP systems are not typically the lowest upfront capital cost approach to supply energy, but they are clear winners when evaluated on a life cycle cost basis
- Over time, the users and configuration of a CHP system may change in a way that impacts overall efficiency
- Operating a CHP system at optimal efficiency requires continual focus to ensure users are not sub-optimizing
- The Department of Energy provides valuable resources to Partners including software, training, and technical support