Energy Efficiency in Industrial Sector

Kat Janowicz, MSME, MBA, LEED GA, CEM
AEE SoCal Monthly Networking Luncheon at Sheraton Cerritos Hotel, February 7, 2013
Famous Last Words

OneWay® Zero harm to people and assets
Zero environmental incidents

“Safety outweighing every other consideration”

“The formal processes were too complicated”

“Uh-oh!”

“It will never happen again”
Agenda

- Energy Review
- Overview of the Industrial Sector
- Energy-Intensive Processes
- Energy in Industrial Applications
- Sustainable Energy-Related Economics
- Examples of WorleyParsons Energy Projects
Primary Energy Consumption by Source and Sector, 2011 (Quadrillion Btu)

- Petroleum: 35.3 (36%)
- Natural Gas: 24.8 (26%)
- Coal: 19.7 (20%)
- Renewable Energy: 9.1 (9%)
- Nuclear Electric Power: 8.3 (8%)

Total: 97.3

- Transportation: 27.0 (28%)
- Industrial: 20.3 (21%)
- Residential & Commercial: 10.7 (11%)
- Electric Power: 39.3 (40%)
## Energy Statistics

### World Energy Consumption, 2008

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid</td>
<td>35%</td>
</tr>
<tr>
<td>Coal</td>
<td>28%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>23%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>5%</td>
</tr>
<tr>
<td>Other</td>
<td>10%</td>
</tr>
</tbody>
</table>

505 quadrillion Btu (by Fuel)

### World Energy Consumption, 2009

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>20%</td>
</tr>
<tr>
<td>China</td>
<td>19%</td>
</tr>
<tr>
<td>Russia</td>
<td>6%</td>
</tr>
<tr>
<td>India</td>
<td>4%</td>
</tr>
<tr>
<td>Japan</td>
<td>4%</td>
</tr>
</tbody>
</table>

483 quadrillion Btu (By Top Five Countries)

### Per Capita Consumption of Selected Countries, 2009

<table>
<thead>
<tr>
<th>Country</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>308 million Btu</td>
</tr>
<tr>
<td>Russia</td>
<td>191 million Btu</td>
</tr>
<tr>
<td>Germany</td>
<td>163 million Btu</td>
</tr>
<tr>
<td>Japan</td>
<td>162 million Btu</td>
</tr>
<tr>
<td>China</td>
<td>68 million Btu</td>
</tr>
</tbody>
</table>

### Energy-Related CO₂ Emissions, 2010

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>26%</td>
</tr>
<tr>
<td>United States</td>
<td>18%</td>
</tr>
<tr>
<td>Europe</td>
<td>14%</td>
</tr>
<tr>
<td>India</td>
<td>5%</td>
</tr>
<tr>
<td>Russia</td>
<td>5%</td>
</tr>
</tbody>
</table>

31,780 million metric tons (By Top Five Emitters)
Industrial Sector Overview

U.S. total energy consumption estimates by end-use sector, 1950-2011

Share of Energy Consumed by Major Sectors of the Economy, 2011

Energy Use by Type of Industry, 2006

Source: U.S. Energy Information Administration, Manufacturing Energy Consumption Survey 2006, Table 1.2.
## US Most Energy-Intensive Industries

<table>
<thead>
<tr>
<th>Industry</th>
<th>Value of Shipments</th>
<th>CAPEX</th>
<th>Energy Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum</td>
<td>$219 billion</td>
<td>$7.3 billion</td>
<td>7.5% of total energy use</td>
</tr>
<tr>
<td>Aluminum</td>
<td>$28.1 billion</td>
<td>$1.2 billion</td>
<td>1% of total energy use</td>
</tr>
<tr>
<td>Chemicals</td>
<td>$438.4 billion</td>
<td>$18.9 billion</td>
<td>6% of total energy use</td>
</tr>
<tr>
<td>Forest Products</td>
<td>$243.1 billion</td>
<td>$9.5 billion</td>
<td>14% of US manufacturing energy use</td>
</tr>
<tr>
<td>Glass</td>
<td>$27.7 billion</td>
<td>$1.83 billion</td>
<td>energy cost 5-7% of shipments</td>
</tr>
<tr>
<td>Metalcasting</td>
<td>$28 billion</td>
<td>$1.5 billion</td>
<td>1% of US manufacturing energy use</td>
</tr>
<tr>
<td>Steel</td>
<td>$60.6 billion</td>
<td>$1.79 billion</td>
<td>1.5% of total energy use</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.7% of US manufacturing energy use</td>
</tr>
</tbody>
</table>
Energy-Management Activities

- Power Factor Correction or Improvement
- Steam Production/System
- Electricity Load Control
- Direct Machine Drive
- Compressed Air Systems
- Special Rate Schedule
- Facilities (Lighting and HVAC)
- CHP (Combined Heat and Power)
- Demand Response
- Energy Storage
- Outage Management
- Human Behaviors and Habits
Energy Audit

► Initiation and Alignment
  - Review processes, equipment, work conditions
  - Review actual and required product specifications to ensure fit-for-purpose
  - Complete plan to identify immediate and sustainable energy savings
  - Identify opportunities due to seasonal operation

► Analysis and Review
  - Examine major users
  - Identify areas for further energy reduction involving CAPEX
  - Identify methods to reduce energy use while maintaining product specifications
  - Simulation against test runs
  - Work with operational staff on proposed strategies
  - Recommend operational changes that can be implemented immediately
  - Identify opportunities to increase throughput

► Deployment In Operations
  - Develop test run procedures and operating procedures with operations
  - Work with applications engineers to automate operations
  - Develop methods for current operation analysis vs. benchmark
  - Summarize recommendations and savings in a report
Driving Energy Stewardship

- Optimizing Energy Usage

- Energy Audit Recommendations
  - Opportunity
  - Issues
  - Current Risk Today
  - Change in Risk
  - Discussion / Comments
  - Solutions
  - Cost / Benefit Analysis
  - Action Items

- Energy-Intensive Processes (EIP)
  - Waste Energy Minimization and Recovery
  - Industrial Reactions and Separations
  - High-Temperature Processing
  - Sustainable Manufacturing
Energy Conservation Program

**Phase I**
Site Survey

**Phase II**
Energy Audits

**Phase III**
Energy Integration

**Phase IV**
EPC

---

**Start of Program**
Overview assessment of energy savings opportunities

**Confirm Potential**
Benchmark ID high potential projects

**Plan Development**
Cost Estimate Energy Savings Process Design Package for approved projects

**Plan Acceptance**
Detailed Engineering Procurement Construction Planning Construction Performance Test

---

**Approval**

---

Energy + CO₂ Emissions Reductions = Cost Savings
Refinery Energy Consumption

► Site Survey Results*

<table>
<thead>
<tr>
<th>REFINERY</th>
<th>CAPACITY</th>
<th>THERMAL ENERGY (1)</th>
<th>ELECTRICAL ENERGY (2)</th>
<th>TOTAL ENERGY AS % OF CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BPSD</td>
<td>FOEBPD MMBTU/HR</td>
<td>FOEBPD MWe %</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>120,000</td>
<td>7,200 1815</td>
<td>1,300 32.8 7.1</td>
<td>7.1</td>
</tr>
<tr>
<td>B</td>
<td>160,080</td>
<td>6,600 1664</td>
<td>1,760 44.4 5.2</td>
<td>5.2</td>
</tr>
<tr>
<td>C</td>
<td>98,080</td>
<td>8,480 2138</td>
<td>1,510 38.1 10.2</td>
<td>10.2</td>
</tr>
<tr>
<td>D</td>
<td>140,000</td>
<td>9,560 2410</td>
<td>1,630 41.1 8</td>
<td>8</td>
</tr>
<tr>
<td>Nominal Average</td>
<td>130,000</td>
<td>8,000 2017</td>
<td>1,550 39.1</td>
<td>100%</td>
</tr>
<tr>
<td>Percent of Total Energy</td>
<td></td>
<td>84% 16%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ELECTRICAL ENERGY (2)

<table>
<thead>
<tr>
<th>FOEBPD</th>
<th>MWe %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,300</td>
<td>32.8</td>
</tr>
<tr>
<td>1,760</td>
<td>44.4</td>
</tr>
<tr>
<td>1,510</td>
<td>38.1</td>
</tr>
<tr>
<td>1,630</td>
<td>41.1</td>
</tr>
<tr>
<td>1,550</td>
<td>39.1</td>
</tr>
</tbody>
</table>

► CO₂ Emissions Resulting from Nominal Refinery Energy Usage*

<table>
<thead>
<tr>
<th>ENERGY CONSUMPTION</th>
<th>CO2 EMISSION FACTORS</th>
<th>CO2 EMISSIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UOM</td>
<td></td>
<td>Metric tons/day</td>
</tr>
<tr>
<td>THERMAL ENERGY</td>
<td>2,017 MMBtu/hr</td>
<td>2,420</td>
</tr>
<tr>
<td>ELECTRICAL ENERGY</td>
<td>39.1 MW</td>
<td>668</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>3,088</td>
</tr>
</tbody>
</table>

A 10% energy reduction = 310 TPD CO₂ emissions reduction

Cost Savings from Electrical Energy Conservation

Total Thermal Cost Savings Potential

Thermal Energy Savings Potential
from $10 MM/year to $60 MM/year
Cost Savings from Electrical Energy Conservation

Electrical Cost Savings Potential

Electrical Energy Savings Potential from $2 MM/year to $10 MM/year
Re-engineering Existing Power Plants

- Carbon Capture & Storage
- Co-powered Solutions
- Flexible Operation
- Integrated Solutions
- Fuel Conversion
- CO2 Reduction & Credits
  - Solar Feed-heating
  - Biomass Co-firing
- Integrated Solutions Pump Storage
- Reliable Capacity Boiler Uprate
- Efficiency Monitoring & Engineered Solutions
- Efficiency & Emissions DryFining
- Water Management
  - CT Blowdown Water Re-Use
- Re-Powering
- Additional Capacity
- Regulatory Compliance Air Quality Control
The Sustainability Imperative

- Sustainable Energy Modernization (SEM)
  - Economic Factors
    - CAPEX
    - OPEX
  - Political Factors
  - Environmental Factors
  - Social Factors

- Profitable sustainability
- Risk management
Drivers, Risks, Monetization

- Climate Change and Energy Security
- Environmental Impact
- Legislation, Guidance, and Goals
- Authorities and Utilities
- Costs and Funding
- Alternatives
- Market Transformation
- Competition
- Energy Use, Demand, Resources, and Generation
- Design, Construction, Operations, and Performance
- Initiatives, Program Implementation, and Evaluation
- Public Outreach and Education
- Stakeholders Involvement
- Workforce Training
- Sustainable and Net Zero Energy Economies
- Human Behavior and Social Dynamics
Apples vs. Oranges vs. Giraffes

Trade-offs

Risk and Value: Cost and Benefit
Energy Economics

- Energy Efficiency Financing
  - DOE and State Energy Programs
  - Utilities, i.e. Demand Response, On-Bill Financing
  - Grant Programs
  - Revenue Bonds Program
  - Low Interest Loans
  - Partnership Programs
  - Business Financing Programs

- Other strategies
  - Changing the Patterns of Energy Use
  - Shifting to Other Sources of Energy
  - Human Behavior and Habits
Laws & Regulations

- Assembly Bill 32 (the Global Warming Solutions Act of 2006)

- California Long Term Energy Efficiency Strategic Plan (Energy Action Plan)
  - SB2(1X) targets: 20% average (2011-2013), 25% by 2016, 33% by 2020
  - 5,900 GWh electricity savings in 2010/11
  - Renewable goals 33% by 2020

- 40 GW of new cost-effective CHP by 2020
  - 50% increase
  - $10 billion a year savings
  - Save 1 quadrillion BTUs (Quad) of energy = 1% of US energy use
  - 150 million tons of CO₂ annually reduced emissions = 25 million cars

- Long-Term Procurement Proceeding
  - Integrate California's long-term procurement policies and consider long-term procurement plans

- Evaluation, Measurement and Verification (EM&V)
The Global Carbon Capture and Storage (CCS) Institute commissioned WorleyParsons, with Schlumberger, Baker & McKenzie and Electric Power Research Institute (EPRI), to complete a strategic analysis of the global status of carbon capture, transport and storage projects and technologies:

- Status of demonstration projects
- Costs of CCS and the impact of the global financial crisis
- Policy and regulatory frameworks
- Research and development efforts
- Commercial and non-commercial gaps to the global deployment of CCS

The six reports are the first step in the global CCS Institute’s objective of beginning broad deployment of carbon capture and storage by 2020.
Whareroa Energy Efficiency Program

Customer: Fonterra
Location: New Zealand
Timeframe: 2003 - 2009
Project Value: $3 million
(Heat Recovery Loop Project)

- Identify and implement energy efficiency projects across Fonterra’s operational sites
- Goal to reduce 15% annual energy use over 5 years
- A site-wide process description was prepared, providing the basis for the pinch analysis
- The key was to rethink the project boundaries and integrate the water, heat and energy systems
- One project installed of a heat recovery loop at the Whareroa site
- The energy savings generated a payback period of less than 2 years on the $3.5 million invested
  - 10% reduction in energy use achieved 2003-2007
  - 15% efficiency target met in 2009 with further improvements to deliver additional energy reductions
Energy Savings Measurement Guide

**Customer:** Department of Resources, Energy and Tourism  
**Location:** Australia  
**Timeframe:** 2007 - 2008  
**Project Value:** $250,000

**Deliverables:**
- Energy Savings Measurement Guide for the Australian Government’s Energy Efficiency Opportunities (EEO) program to evaluate and prioritize energy saving opportunities.

**Outcomes:**
- Guideline to estimate, measure and track energy savings
- Series of interactive workshops to assist with implementations
Collie Power Station
Plant O&M and Improvements

Customer: Verve Energy
Location: Western Australia
Timeframe: 2005 - ongoing
Contract Type: EPCM

► First full third party operation contract for a major Australian Power Plant
  - 330MW steam turbine generator with cooling tower
  - Coal fired sub critical boiler
  - Coal handling plant comprising two 600tph supply conveyors with 20,000t live storage and reclaim
  - Water treatment plant (4000ML per year)
  - Ash and dust handling plant, grounds and buildings

► Facility operations and asset management including maintenance, shutdowns, outages, annual power production requirements, capital improvement projects
  - Maintained reliable base load capacity
  - Top performance global benchmark (RWEEnPower)

► Up-rate from 330MW nameplate to 340MW, address boiler fouling issues affecting reliable capacity above 325MW
  - Additional 10MW capacity
  - Effective 15MW reliable capacity – solved load limitations due to fouling
UCLA Cogeneration Facility

Customer: University of California Los Angeles  
Location: California, USA  
Timeframe: 1993 - ongoing

► 44MW CCGT cogenerating facility consisting of two LM 1600 gas turbines and one steam driven turbine generator
► Facility operates on natural gas blended with methane-based LFG, 20% by volume
► The primary drivers for UCLA outsourcing of the O&M were cost reduction, increased availability, and engineering services
► O&M, repair, production and delivery of thermal energy and electricity to the University
► Customer Benefits
  • Integrated Build-Operate solution
  • Consistent high plant reliability & availability
  • Maintained facility availability at >99% for the past 18 years
  • Optimization of methane fuel blending not to exceed 25% by volume
  • Established commitment to OneWay HSE philosophy
  • Decreased cost in O&M, mobilization, staffing, and training
  • Optimized chilling capacity to accommodate growth and additional load
Customer: University of California San Francisco  
Location: California, USA  
Timeframe: 2011 - ongoing

- UCSF Parnassus Combined Cycle Cogeneration Plant  
- 14MW combined cycle cogenerating facility consisting of two Taurus 60 gas turbines and one steam driven turbine generator  
- Facility operates on natural gas as a primary fuel source with diesel fuel as a secondary emergency source  
- The primary drivers for UCSF outsourcing of the O&M were cost reduction, increased availability, and engineering services  
- O&M and repair to ensure reliable generation and delivery of thermal energy and electricity  
- Customer Benefits
  - Maintained facility availability at >99%  
  - Strong focus on efficient operations reduced water usage by 11 million gallons during the first year of the contract  
  - Established commitment to OneWay HSE philosophy
Customer: Port Authority of New York & New Jersey
Location: Port Jersey Peninsula Jersey City, N.J.
Timeframe: September 2011 - August 2013
Project Value: $1.214 million

- Improve the Greenville Yard to support the Cross Harbor Railroad float bridge operation, enhance rail access and capacity at the yard
  - Improve the movement of goods by rail across the Harbor
  - Accommodate growth of intermodal traffic through the Port
  - Develop a sustainable option for the intermodal freight transport into NYC and Long Island
  - Reduce the volume of truck traffic moving across bridges and through tunnels into the city

- Engineering, Detailed Design, O&M, Decommissioning and Remediation
  - Design of a new rail yard, float bridges, and ancillary facilities
  - Rehabilitation of an existing rail barge and design of a new barge to accommodate rail cars
  - Design of pier fendering and marine structures
  - Rail yard track layout, yard improvements, rail process flow analysis and operations
  - Rail Operational Planning and Process Mapping, Marine Structural and Coastal Engineering, Naval Architecture, Terminal Operational Planning, Freight Capacity Study, Trade Flow Projections
  - Project Management and Sustainability Oversight

- Guidelines developed from several programs
  - LEED®
  - AASHTO center for Environmental Excellence
  - ASLA The Sustainable Sites InitiativeTM
  - NYSDOT GreenLITES
  - Los Angeles World Airports Sustainable Airport Planning

- Credits for Energy Efficiency on Greenville Yard Project
  - Minimize Light Pollution
  - Optimize Energy Performance – reduce min. 10% energy use
  - Utilize Energy End Use Metering
  - Protect Ozone Layer
Greenville Yard pre Hurricane Sandy

The rehabilitation of the Greenville Yard is one of the key elements for the overall PANYNJ capacity expansion and system upgrades.
Greenville Yard
post Hurricane Sandy
Thank you

Kat Janowicz, MSME, MBA, LEED GA, CEM
Project Manager | WorleyParsons
Tel: +1 (626) 599 7497 | Mob: +1 (626) 202 8381
181 West Huntington Dr. | Monrovia | CA | 91016 | USA
Kat.Janowicz-Jimenez@WorleyParsons.com | www.worleyparsons.com