Building an Energy Team at a Site

Energy Managers Workshop

Fred C. Schoeneborn

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Questions to ask at a Plant

- What is your Energy Spend?
- What % of your controllable operating cost is energy ?
- Who owns energy consumption?

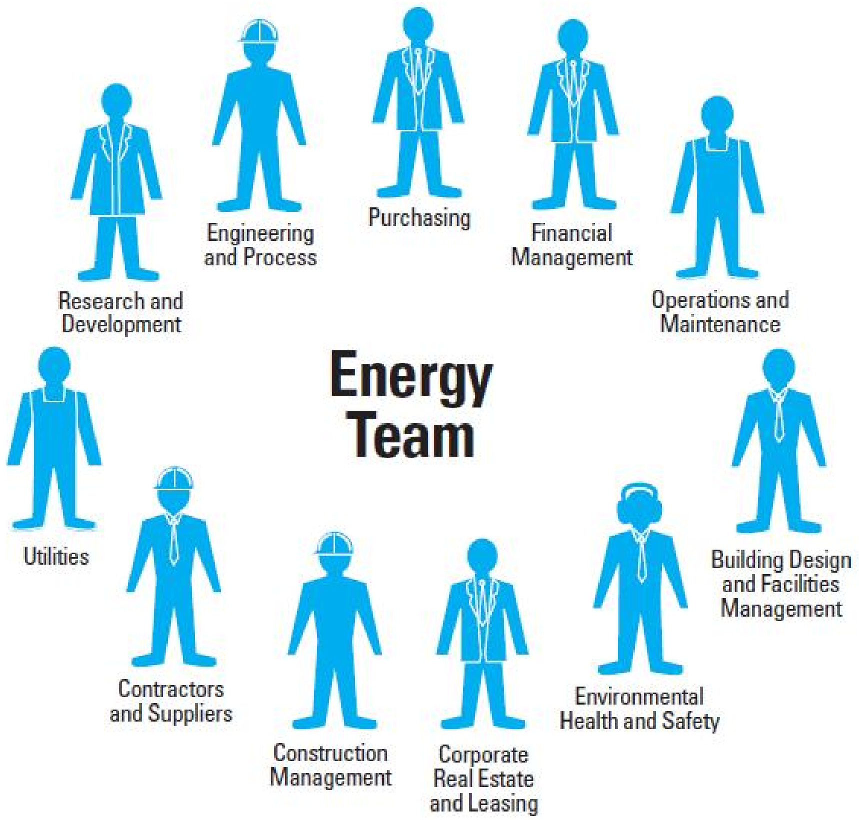
A Mature Plant Energy Program

- Has a dedicated energy manager who owns energy consumption ---
- **NOW WHAT ??**

Why Join the Energy Team ?

- The plant will reduce operating cost = plant competitiveness = job retention.
- Training in a new field.
- Management supports this effort.

Effective teams are multi-functional



Other key players:

- Communications
- Information Technology
- Sales
- Investor Relations

Source: US EPA ENERGY STAR, Teaming-up to Save Energy

SELL -- Give real-world Energy Efficiency Examples

ENERGY STAR

The Importance of Shutdown:

- Each day we park our vehicle, **stop the engine** and commence our work tasks within the plant.

  ----- Similarly as we leave the plant we should continually question the need for lights and equipment that could **be turned off** during our absence.

SELL -- Give real-world Energy Efficiency Examples

Embrace VFD Technology:

- If not – it is similar to placing a concrete block on the car gas pedal and controlling the speed with the brake.

Embrace LED Technology:

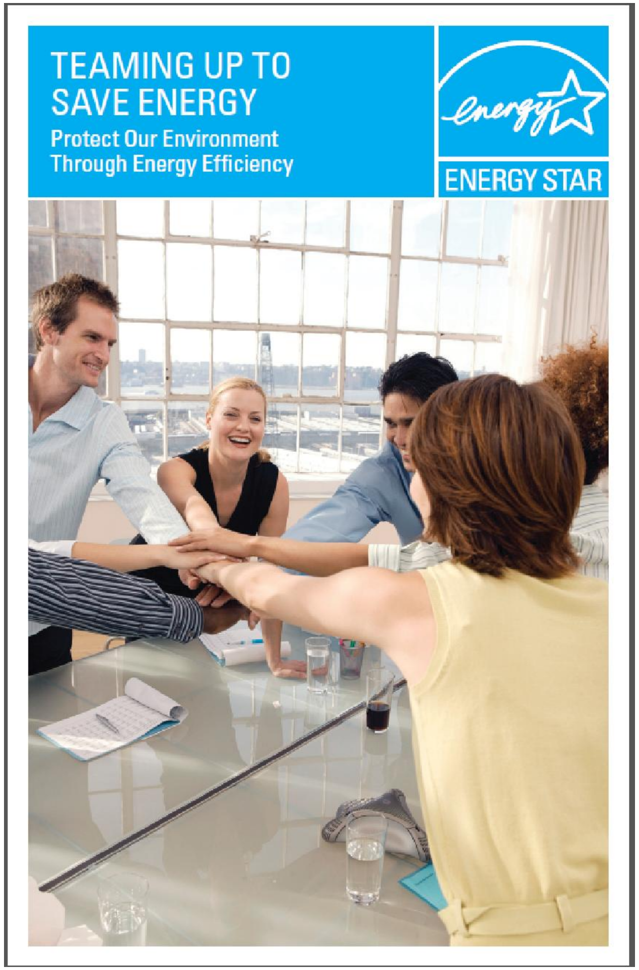
- Many companies are now standardizing on this energy saving lighting approach.

Energy team guidance

- ENERGY STAR offers guidance on building effective energy teams.

- Download at www.energystar.gov/energyteam

ENERGY STAR partner companies gain access to the ENERGY STAR network to learn how other companies build their teams.



Energy Management Strategy

Guidelines for Energy Management

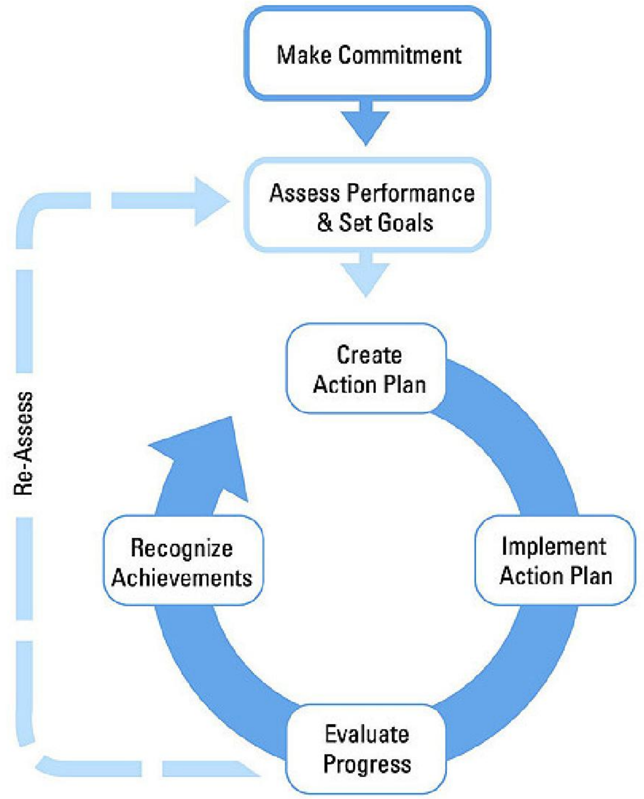
– Provides a framework for how to implement an energy program.

– Outlines key activities and programmatic elements for energy management.

– Consistent with ISO 50001 and other energy management systems / strategic energy management approaches.

– Successfully used by thousands of organizations for over 10 years.

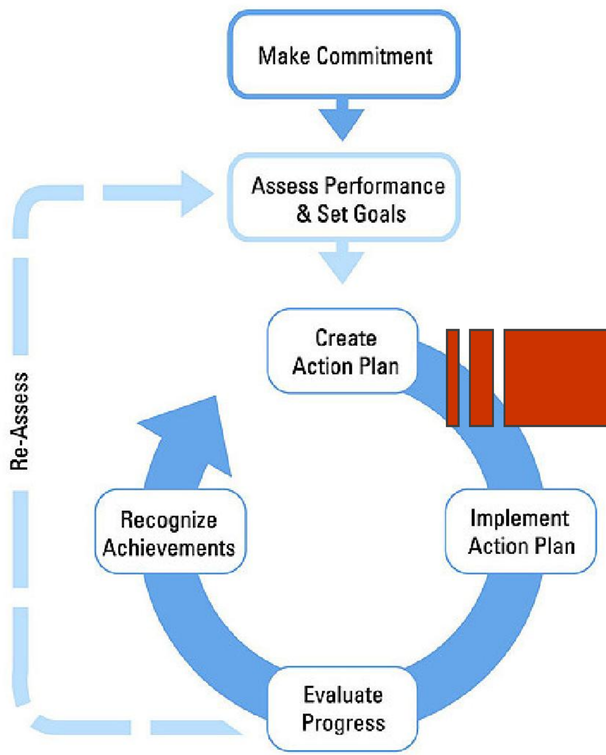
ENERGY STAR Guidelines for Energy Management



www.energystar.gov/guidelines

Benchmark your program

Energy Program & Facility Assessment Matrices



ENERGY STAR® Guidelines for Energy Management Matrix

	Little or no evidence	Some elements/degree	Fully implemented
Normalize	Not addressed	Some unit measures or weather adjustments	All meaningful adjustments for corporate analysis
Establish baselines	No baselines	Various facility-established	Standardized corporate base year and metric established
Benchmark	Not addressed or only same site historical comparisons	Some internal comparisons among company sites	Regular internal & external comparisons & analyses
Analyze	Not addressed	Some attempt to identify and correct spikes	Profiles identifying trends, peaks, valleys & causes
Technical assessments and audits	Not addressed	Internal facility reviews	Reviews by multi-functional team of professionals
t Performance Goals			
etermine scope	No quantifiable goals	Short term facility goals or nominal corporate goals	Short & long term facility and corporate goals
Estimate potential for improvement	No process in place	Specific projects based on limited vendor projections	Facility & corporate defined based on experience
Establish goals	Not addressed	Loosely defined or sporadically applied	Specific & quantifiable at various organizational levels
Create Action Plan			
Define technical steps and targets	Not addressed	Facility-level consideration as opportunities occur	Detailed multi-level targets with timelines to close gaps
Determine roles and resources	Not addressed	Informal interested person competes for funding	Internal/external roles defined & funding identified
Implement Action Plan			
Create a communication plan	Not addressed	Tools targeted for some groups used occasionally	All stakeholders are addressed on regular basis
Raise awareness	No overt effort made	Periodic references to energy initiatives	All levels of organization support energy goals

Evaluate your energy program practices & identify gaps

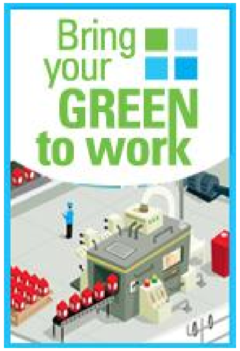
ENERGY STAR offers tools and resources to support energy programs:

Partner Networking Web Conferences

- Bi-monthly series showcasing successful energy management strategies among the partnership.

Employee Engagement Materials

- Information, literature, and other resources to help build energy awareness among employees.



Communication Resources

- Posters, materials and tools to help you drive change.

Raise awareness

- Use posters to raise awareness of plant energy spend, goals, etc.
- Show people how they can make a difference.
- Help people make the connection to saving energy and money at home.
- Use free ENERGY STAR resources.
- **GET PEOPLE INTERESTED!**

Energy bulletin boards

All your sites should have an active energy bulletin board

Goals & performance tracking

- Do your sites have energy performance goals?
- Are employees aware of these goals?
- Are energy performance metrics or energy dashboards visible to employees?

Energy goals and performance metrics can help make energy less abstract.

ENERGY STAR recognition

Recognition from EPA through ENERGY STAR helps energy programs to motivate teams, develop momentum, and build support.

ENERGY STAR offers three forms of recognition for manufacturers:

ENERGY STAR Partner of the Year

Recognizes world-class corporate energy management programs.

ENERGY STAR Plant Certification

Recognizes plants that score in the top 25 percent on the ENERGY STAR energy performance scale based on use of an ENERGY STAR Plant Energy Performance Indicator.

ENERGY STAR Challenge for Industry

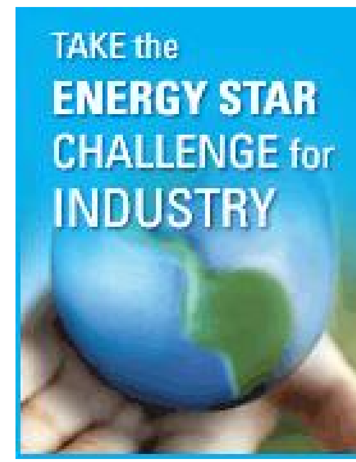
Recognizes sites that reduce their energy intensity by 10%.

ENERGY STAR Challenge for Industry

What does it recognize?

10 % reduction in energy intensity within 5 years or less.

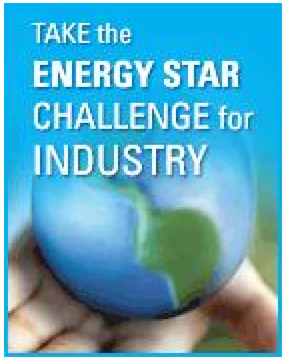
Calculated against an internal baseline at an industrial site.



- Over 900 Challenge takers worldwide
- Over 240 Challenge Achievers
- 20.46% average reduction
- Over 50 Trillion Btu's of energy saved
- Over 10,440,000 metric tons of CO2e prevented

Leverage the Challenge

- Creates an objective for your energy program and sites.
- Reinforces energy management best practices.
- Opportunity to link your energy efforts to ENERGY STAR and a broader campaign.
- Opportunity to leverage the ENERGY STAR brand in communicating your accomplishment.
- Opportunity to gain recognition for your achievements from the U.S. EPA.



Background on ENERGY STAR

ENERGY STAR:

- Voluntary government program
  - Established by EPA in 1992
  - Helps companies achieve their best in energy efficiency

- Works with industry to build strong energy management programs and recognizes successes.

  - Over 750 industrial corporations are partners.
  - Over 28 specialized industrial sectors address their energy management issues with the program.
  - Over 20 years of experience promoting energy management.

- Helps reduce greenhouse gas emissions associated with energy use by encouraging companies to be more energy efficient.

THANK YOU !!

CONTROL BOILER EMISSIONS through Work Practices and Energy Management

James E. Robinson, P.E., P.Eng.
DES Global, LLC

The Boiler MACT regulation provides compliance options that include pollution-abatement equipment, work practices, and energy efficiency improvements. An energy management and reporting system (EMRS) can be a part of a plant's compliance strategy.

Virtually all chemical process industries (CPI) plants in the U.S. are subject to a regulation known as the Boiler MACT rule, *i.e.*, the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters *(1)*. This rule sets numerical emission limits for five hazardous air pollutants (HAPs) — carbon monoxide (CO), hydrogen chloride (HCl), mercury (Hg), and particulate matter (PM) or measured total selected metals (TSM, the combination of arsenic, beryllium, cadmium, chromium, lead, manganese, nickel, and selenium) — based on the application of maximum achievable control technology (MACT).

The specific requirements that a plant must meet depend on the facility's construction status (new or existing), boiler design, fuel burned, and boiler size, as well as whether the facility is a major source — defined as a facility that emits 10 ton/yr or more of any single HAP or 25 ton/yr or more of any combination of HAPs — or an area source (all others). The detailed requirements and the many numerical limits are beyond the scope of this article and are available in the regulation.

Although some facilities should already be in compliance with the rule (for instance, new sources constructed or reconstructed after June 4, 2010, had to comply by Jan. 31, 2013, or upon startup if that was later), existing major sources must comply by Jan. 31, 2016.

To meet the regulatory requirements, some facilities, such as those that burn coal, heavy oil, or biomass, will need to install or upgrade end-of-pipe pollution-control equipment, such as electrostatic precipitators, dry or wet scrubbers, fabric filters, and/or sorbent injection systems. Implementing these controls can have considerable initial capital and annual operating costs. Table 1 presents the U.S. Environmental Protection Agency's (EPA) estimates of the capital and annual operating costs (Ref. 2, Table 5, pp. 7155–7156). Notice the three numbers in red:

• $5.1 billion is the estimated capital to be spent over the next four years

• $94 million/yr is the annualized testing and monitoring cost (excluding the staff costs for recordkeeping and reporting)

• $1.3 billion/yr is the projected net annualized operating cost for MACT equipment operation and work practices. This incorporates a $400-million/yr credit for energy savings *(3)* from new equipment, inspections, and tune-ups that reduce fuel consumption by 47.3 trillion Btu/yr against an unadjusted annual operating cost of $1.7 billion/yr.

Many CPI plants, particularly those that burn natural gas in their boilers, may be able to avoid major capital expenditures by adopting various operating work practices, including advanced energy management and combustion control.

An energy management and reporting system (EMRS) is a real-time, closed-loop, model-predictive control system that manages utility supply (in the powerhouse) and demand (in the process) through the effective management of equipment operation, fuel allocation, and combustion optimization. Managing energy supply and demand effectively is critical to maintaining profitability, so most large facilities employ some type of energy management system. This article outlines an approach to EMRS implementation for work practices, advanced controls, and automated reporting systems that major sources can use to comply with the MACT regulation.

Boiler MACT emission limits and work practices

The rules have different requirements for boilers and process heaters based on their:

• construction date — existing units commenced construction or reconstruction prior to June 4, 2010, new units after that date

• size — large major source boilers and process heaters have a heat input capacity of 10 million Btu/hr or more, small major sources have a capacity less than 10 MMBtu/hr

• fuel — coal, biomass, heavy liquid, light liquid, natural gas or refinery gas (designated Gas 1), or other process gases (Gas 2); liquid-burning units located outside the continental U.S. are regulated under the fuel category of "non-continental liquid."

Table 2 summarizes the applicability of numerical emission limits and work practices based on these distinctions *(4)*. Tables 3 and 4 summarize the emission limits for existing and new sources, respectively (Ref. 2, pp. 7142). The facility owner may choose to manage either filterable PM or TSM to best mitigate the non-Hg metals with the instrumentation and process controls available.

The owner of an existing system must perform a one-time energy assessment to evaluate the operating character-

Table 1. Boiler MACT regulatory cost estimates, assuming all new units will burn natural gas, refinery gas, or biomass.

Source	Subcategory (Fuel Fired)	No. of Affected Units (Estimated or Projected)	Capital Cost, million	Annualized Cost Considering Fuel Savings, million/yr*	Annualized Testing and Monitoring Cost, million/yr*	Capital Cost per Unit	Annualized Cost per Unit
Existing Units	Coal	621	$2,554	$904	$46	$4,113,000	$1,456,000
	Biomass	502	$405	$109	$29	$807,000	$217,000
	Heavy Liquid	319	$761	$221	$5.4	$2,386,000	$693,000
	Light Liquid	615	$712	$166	$4.2	$1,158,000	$270,000
	Non-Continental Liquid†	21	$62	$17	$0.8	$2,952,000	$810,000
	Gas 1 (Natural Gas or Refinery Gas)	11,929	$77	($295)	$0.9	$6,500	($24,700)
	Gas 2 (Other Gases)	129	$138	$58	$2.3	$1,070,000	$450,000
New Units	Coal	0	—	—	—	—	—
	Biomass	82	$381	$99‡	$5.6	$4,646,000	$1,207,000
	Heavy Liquid	0	—	—	—	—	—
	Light Liquid	0	—	—	—	—	—
	Non-Continental Liquid†	0	—	—	—	—	—
	Gas 1 (Natural Gas or Refinery Gas)	1,762	$11	$5.1‡	$0	$6,200	$2,900
	Gas 2 (Other Gases)	0	—	—	—	—	—
Energy Assessments	All	1,700 Facilities	NA	$28	NA	$0	$16,500
Total			$5,101	$1,312	$94		

Notes:
* Annualized costs include testing and monitoring costs, but not recordkeeping and reporting costs.
† A non-continental liquid source is a liquid-burning unit located in Hawaii, the Virgin Islands, Guam, American Samoa, Puerto Rico, or the Northern Mariana Islands.
‡ Total annualized costs for new units do not account for fuel savings, since no fuel savings are estimated in the first year of use.
NA = Not Applicable.

Source: Adapted from Ref. 2, pp. 7155–7156.

istics of the affected boiler or process heater and its energy load (among other things). As an alternative to performing a one-time energy assessment, the facility can implement an energy management program that meets the requirements of ISO 50001 *(5, 6)* for the affected units. EPA recognizes that facilities with such programs, which incorporate energy performance measurements, tracking plans, and periodic reviews, operate under a set of practices and procedures designed to manage energy use on an ongoing basis.

Instrumentation

The energy assessment typically uses the existing instrumentation and data historian to provide the process data needed for the overall evaluation. Additional information required for MACT compliance can be obtained from other data sources, such as fuel usage logs.

The energy assessment is a good opportunity to verify that the process measurements and controls are reliable and available to meet the regulation's continuous compliance requirements. Historian data gaps, bad process readings, controllers in manual operation, and a large number of equipment malfunction alarms are indications of violations to come.

System installation, operation, and maintenance problems that cause malfunctions often result in violations. Under the Boiler MACT startup, shutdown, and malfunction (SSM) provisions, the operator is subject to penalties if emissions during a malfunction exceed the applicable limits, unless the operator can provide what is known as an affirmative defense, which is a demonstration that:

- a reasonable effort was made to avoid the malfunction
- the malfunction was not the result of operator error or abnormal operating practices
- every effort was taken to safely correct the malfunction and return the unit to compliance.

To avoid violations during malfunctions, review process systems and associated work practices to ensure proper continuous operation, and to ensure that any malfunction would be an abnormal occurrence. Evaluate the reliability of the overall process measurement and control system, and correct any deficiencies promptly.

An EMRS that incorporates environmental and operating constraints into an automatic control system can provide consistency across operating shifts and minimize the risk of operator error contributing to a malfunction. Should a malfunction occur, an EMRS can provide the documentation that the facility was operating within process constraints and according to standard operating procedures necessary to establish an affirmative defense.

Instrumentation requirements depend on the type of environmental control equipment installed in the plant and the method used to calculate the allowable emission rate, as discussed in the next section.

Table 2. Summary of Boiler MACT requirements for existing and new major sources.

	Existing or New*	Large or Small†	Tune-Up	Numerical Limits	One-Time Energy Assessment
Gas 1 (Clean Gas)	Existing	Large	Yearly§	None	Yes
		Small	Biennially#	None	Yes
	New	Large	Yearly§	None	No
		Small	Biennially#	None	No
Coal, Biomass, Oil, Gas 2 (Process Gas)	Existing	Large	Yearly§	Hg, CO, HCl, and PM (or TSM) See Table 3	Yes
		Small	Biennially#	None	Yes
	New	Large	Yearly§	Hg, CO, HCl, and PM (or TSM) See Table 4	No
		Small	Biennially#	None	No
Limited Use‡	Existing or New	Large or Small	Every 5 yr	None	No

Notes:
* Existing sources are those that commenced construction or reconstruction on or before June 4, 2010; new sources commenced construction or reconstruction after June 4, 2010.
† Large sources have a heat input capacity ≥10 MMBtu/hr; small sources have a heat input capacity <10 MMBtu/hr.
‡ A limited-use unit is one that has a federally enforceable average annual capacity factor of 10% or less.
§ Boilers and process heaters with a continuous oxygen-trim system perform a tune-up every 5 yr.
\# Boilers and process heaters with a continuous oxygen-trim system, or that have a heat input capacity ≤5 MMBtu/hr and are designed to burn Gas 1, Gas 2, or light liquid, perform a tune-up every 5 yr.

Source: Adapted from Ref. 4, pp. 4–5.

Calculating the allowable emission rate: input basis vs. output basis

The Boiler MACT emission limits for PM, TSM, HCl, CO, and Hg depend on the amount of fuel consumed by the boiler or process heater and have units of pounds per million Btu (lb/MMBtu). The owner must convert the appropriate limit to an allowable emission rate (lb/hr) based on the boiler's firing rate (MMBtu/hr). This rate can be calculated based on heat input, or on steam and electricity output (Figure 1).

Input basis. The input basis is the simplest method for both new and existing units. If the heat entering the boiler or process heater can be measured (Q_{Fuel}, MMBtu/hr), it can be used to calculate the allowable emission rate ($Q_{Emissions}$, lb/hr). The equations for this calculation are given in Ref. 1 (pp. 153–155).

In some cases, fuel delivery reports are sufficient to prove a unit's annual fuel consumption. However, most sources will need fuel measurements and data from a process historian to calculate rolling averages of their emissions.

Output basis. The regulation also provides an alternative output-basis method for calculating the allowable emission rate. The challenge for some facilities that burn multiple fuels with variable heat content, such as biomass or clean secondary sludge, is that it is impractical (or impossible) to measure the fuel's Btu value, and heat inputs are often inferred from the steam output minus any metered co-fired fossil fuel burned in the boiler. Such facilities can determine their allowable emission rate based on steam and/or electrical measurements:

• for boilers or process heaters that provide dedicated process heating, use the amount of process steam produced ($Q_{SteamProcess}$)

Table 3. Emission limits for existing boilers and process heaters with a heat input capacity ≥10 MMBtu/hr.

Subcategory	Particulate Matter (PM) or Total Selected Metals (TSM): Filterable PM, lb/MMBtu of heat input*	Particulate Matter (PM) or Total Selected Metals (TSM): TSM, lb/MMBtu of heat input*	HCl, lb/MMBtu of heat input*	Hg, lb/MMBtu of heat input*	Carbon Monoxide (CO) or CO Limit with CEMS: CO, ppm @3% oxygen*	Carbon Monoxide (CO) or CO Limit with CEMS: CO Limit with CEMS, ppm @3% oxygen†
Coal						
Stoker	0.0400	5.30E–05	0.022	5.70E–06	160	340
Fluidized Bed	0.0400	5.30E–05	0.022	5.70E–06	130	230
Fluidized Bed with FB Heat Exchanger	0.0400	5.30E–05	0.022	5.70E–06	140	150
Burning Pulverized Coal	0.0400	5.30E–05	0.022	5.70E–06	130	320
Biomass						
Wet Stoker/Sloped Grate/Other	0.0370	2.40E–04	0.022	5.70E–06	1,500	720
Kiln-Dried Stoker/Sloped Grate/Other	0.3200	4.00E–03	0.022	5.70E–06	460	ND
Fluidized Bed	0.1100	1.20E–03	0.022	5.70E–06	470	310
Suspension Burner	0.0510	6.50E–03	0.022	5.70E–06	2,400	2,000‡
Dutch Ovens/Pile Burners	0.2800	2.00E–03	0.022	5.70E–06	770	520‡
Fuel Cells	0.0200	5.80E–03	0.022	5.70E–06	1,100	ND
Hybrid Suspension Grate	0.4400	4.50E–04	0.022	5.70E–06	2,800	900
Heavy Liquid	0.0620	2.00E–04	0.0011	2.00E–06	130	ND
Light Liquid	0.0079	6.20E–05	0.0011	2.00E–06	130	ND
Non-Continental Liquid§	0.2700	8.60E–04	0.0011	2.00E–06	130	ND
Gas 1 (Natural Gas, Refinery Gas)	NA	NA	NA	NA	NA	NA
Gas 2 (Other Gases)	0.0067	2.10E–04	0.0017	7.90E–06	130	ND

Notes:
* 3-run average, unless otherwise noted.
† 30-day rolling average, unless otherwise noted.
‡ 10-day rolling average.
§ A liquid-burning unit located in Hawaii, the Virgin Islands, Guam, American Samoa, Puerto Rico, or the Northern Mariana Islands.
NA = Not Applicable; ND = No Data Available.

Source: Adapted from Ref. 2, pp. 7142.

• for boilers or process heaters that provide dedicated steam for electricity generation, use the amount of electricity produced ($Q_{Electricity}$)

• for cogeneration systems in which the affected steam generators provide process steam and electricity, use the amount of steam extracted by the turbine ($Q_{SteamExtraction}$) and the amount of electricity generated.

The equations for these calculations are found in Ref. 1 (pp. 186–188).

The alternative output-basis calculation provides owners of existing affected sources some latitude in complying with Boiler MACT. Existing facilities that use the output-basis method can avoid some or all of the expense of pollution-abatement equipment by taking advantage of efficiency credits and/or emissions averaging (discussed later).

Example: Evaluating compliance options

This example illustrates the steps and calculations involved in determining an existing boiler's compliance status with the particulate matter limits and evaluating its compliance options. The goal is to identify the lowest-cost, highest-reliability solution with some safety margin.

The process for this example is shown in Figure 1. A boiler supplies steam to an extraction-condensing turbine and generator (with an extraction generation coefficient of 28,900 lb/MW) for the production of electricity. The fuel is pulverized coal (PC) with a conversion efficiency of 85%. An existing electrostatic precipitator (ESP) controls PM emissions to 5.0E–02 lb/MMBtu measured at the stack. The boiler has a maximum continuous rated (MCR) capacity of 500,000 lb/hr and operates at 880 psig and 900°F without an economizer feedwater heater. The average process steam

Table 4. Emission limits for new boilers and process heaters with a heat input capacity ≥10 MMBtu/hr.

Subcategory	Particulate Matter (PM) or Total Selected Metals (TSM)		HCl, lb/MMBtu of heat input*	Hg, lb/MMBtu of heat input*	Carbon Monoxide (CO) or CO Limit with CEMS	
	Filterable PM, lb/MMBtu of heat input*	TSM, lb/MMBtu of heat input*			CO, ppm @3% oxygen*	CO Limit with CEMS, ppm @3% oxygen†
Coal						
Stoker	0.0011	2.30E–05	0.022	8.00E–07	130	340
Fluidized Bed	0.0011	2.30E–05	0.022	8.00E–07	130	230
Fluidized Bed with FB Heat Exchanger	0.0011	2.30E–05	0.022	8.00E–07	140	150
Burning Pulverized Coal	0.0011	2.30E–05	0.022	8.00E–07	130	320
Biomass						
Wet Stoker/Sloped Grate/Other	0.0300	2.60E–05	0.022	8.00E–07	620	390
Kiln-Dried Stoker/Sloped Grate/Other	0.0300	4.00E–03	0.022	8.00E–07	460	ND
Fluidized Bed	0.0098	8.30E–05	0.022	8.00E–07	230	310
Suspension Burner	0.0300	6.50E–03	0.022	8.00E–07	2,400	2,000‡
Dutch Ovens/Pile Burners	0.0032	3.90E–05	0.022	8.00E–07	330	520‡
Fuel Cells	0.0200	2.90E–05	0.022	8.00E–07	910	ND
Hybrid Suspension Grate	0.0260	4.40E–04	0.022	8.00E–07	1,100	900
Heavy Liquid	0.0130	7.50E–05	0.00044	4.80E–07	130	ND
Light Liquid	0.0011	2.90E–05	0.00044	4.80E–07	130	ND
Non-Continental Liquid§	0.0230	8.60E–04	0.00044	4.80E–07	130	ND
Gas 1 (Natural Gas, Refinery Gas)	NA	NA	NA	NA	NA	NA
Gas 2 (Other Gases)	0.0067	2.10E–04	0.0017	7.90E–06	130	ND

Notes:
* 3-run average, unless otherwise noted.
† 30-day rolling average, unless otherwise noted.
‡ 10-day rolling average.
§ A liquid-burning unit located in Hawaii, the Virgin Islands, Guam, American Samoa, Puerto Rico, or the Northern Mariana Islands.
NA = Not Applicable; ND = No Data Available.

Source: Adapted from Ref. 2, pp. 7142.

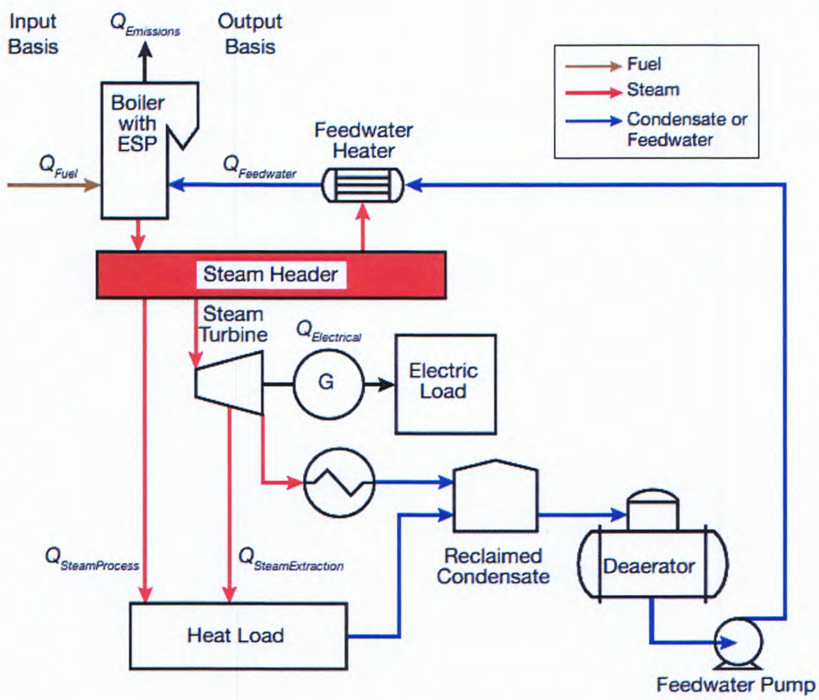


Figure 1. The MACT environmental limit calculations require the boiler firing rate, which can be calculated in two ways: the input-basis method, which uses the fuel input, or the output-basis method, which uses the steam and electric outputs.

demand is 300,000 lb/hr. (For this analysis, sootblower steam, blowdown steam, and steam turbine discretionary condensing are ignored.) Table 5 lists the process data needed for the calculations.

Step 1. Evaluate the boiler's current performance (Case 1) and compare that to the input-basis limit for existing boilers. From Ref. 1 (p. 195, Item 2, Column 3), the PM limit for an existing PC boiler and the input-basis method is $Q_{EmissionsLimit,IBE}$ = 4.0E–02 lb/MMBtu, so the allowable emission rate is:

423 MMBtu/hr × 4.0E–02 lb/MMBtu = 16.9 lb/hr PM

The measured emissions are:

423 MMBtu/hr × 5.0E–02 lb/MMBtu = 21.2 lb/hr PM

Table 5. Process data for Figure 1 example calculation.

Feedwater and Fuel		
	Case 1	Case 2
Temperature	280°F	440°F
$Q_{Feedwater}$	249 Btu/lb	419 Btu/lb
Q_{Fuel}	423 MMBtu/hr	365 MMBtu/hr
Steam		
	Temperature	Pressure
$Q_{SteamProcess}$	900°F	880 psig
$Q_{SteamExtraction}$	—	160 psig

The measured emissions of 21.2 lb/hr exceed the allowable emission rate of 16.9 lb/hr PM, so the boiler is not in compliance. Therefore, it may require combustion air modifications and pollution-abatement equipment, such as upgrading the ESP by combining it with a wet scrubber or other pollution-control equipment. If the cost of these modifications exceeds 50% of the boiler's replacement cost, the unit would be reclassified as a new or rebuilt boiler and subject to stricter emission limits. It would be valuable to know the emission limit for a rebuilt boiler.

Step 2. Evaluate what the emission requirements would be if the facility installs a combustion air and fluegas backend upgrade. From Ref. 1 (p. 191, Item 2, Column 3), the PM limit for a new or rebuilt PC boiler and the input-basis method is $Q_{EmissionsLimit,IBN}$ = 1.1E–03 lb/MMBtu, so the allowable emission rate is:

423 MMBtu/hr × 1.1E–03 lb/MMBtu = 0.47 lb/hr PM

That would require an advanced ESP configuration at a cost of $3 million to $8 million and a 3–5 day service outage *(7)*. Can this expenditure be avoided?

Step 3. Use the output-basis method to calculate the allowable emission rate for an existing boiler, and determine whether this could be met through modified work practices.

Step 3a. According to the definitions in Section 63.7575 of the regulation (Ref. 1, p. 186, Steam Output Definition 2), the total energy output is the sum of the energy content of the steam exiting the turbine and sent to the process in MMBtu/hr and the energy of the electricity generated converted to MMBtu at a rate of 10 MMBtu/MWhr:

$$\begin{aligned}\text{Output} &= Q_{SteamExtraction} + \left(Q_{Electricity}\right)\left(10\ \text{MMBtu/MMhr}\right)\\ &= \left(300{,}000\ \text{lb/hr}\right)\left(1{,}254\ \text{Btu/lb}\right)\\ &\quad + \frac{300{,}000\ \text{lb/hr}}{28{,}900\ \text{lb/MW}}\left(10\ \text{MMBtu/MMhr}\right)\\ &= 480\ \text{MMBtu/hr}\end{aligned}$$

Step 3b. From Ref. 1 (p. 195, Item 2, Column 4), the PM limit for an existing PC boiler and the output-basis method is $Q_{EmissionsLimit,OBE}$ = 4.2E–02 lb/MMBtu, so the allowable emission rate is:

480 MMBtu/hr × 4.2E–02 lb/MMBtu = 20.2 lb/hr PM

The existing emissions of 21.2 lb/hr exceed this limit by only 1.0 lb/hr. Process modifications might be able to reduce emissions by this amount.

Step 4. Evaluate the boiler's performance if the temperature of the feedwater into the boiler is increased to 440°F, which would allow the fuel input to be reduced to 365 MMBtu/hr. Emissions under these conditions would be:

365 MMBtu/hr × 5.0E–02 lb/MMBtu = 18.3 lb/hr PM

This is 1.9 lb/hr below the allowable emission rate of 20.2 lb/hr. The boiler would be in compliance with a 9% margin of safety.

Steps 1, 2, and 3 show that MACT compliance can be difficult to achieve. However, the regulation provides options to help existing boiler owners comply.

Step 4 shows that with a higher feedwater temperature, the amount of coal needed in the boiler can be sufficiently reduced to reduce emissions enough to meet the standard. Furthermore, if the boiler runs 24 hr/day, 320 days/yr, and the facility uses blowdown or waste steam, the plant could realize more than $1–2 million/yr in energy savings.

Efficiency credits

The Boiler MACT standard allows a source to take credit for emission reductions that result from energy conservation projects. Efficiency credits can be obtained if the benefits of the energy conservation measures are realized after Jan. 1, 2008, and if sufficient information is available to determine the appropriate value of credits (*i.e.*, the amount of energy saved and the quantity of emissions avoided as a result of the reduced energy consumption).

Credits are calculated based on the difference between an energy benchmark that is established for each affected boiler and the actual energy demand reductions due to energy conservation measures after Jan. 1, 2008. Section 63.7533 of the regulation (Ref. 1, pp. 161–163) provides the equations to calculate efficiency credits, and Ref. 8 provides further guidance on performing the calculations as well as some examples for complex systems.

The energy benchmark is generally the rate of heat input to the unit during the one-year period before the date that an energy demand reduction occurs. A different time period can be used if the facility can demonstrate that it is more representative of historical operations. To account for process changes, the benchmark can be normalized based on non-energy-related facility and operating data. These provisions establish a fair assessment of the plant's energy usage prior to implementation of the energy savings program.

Emissions averaging

A source that meets certain conditions can demonstrate compliance with the PM (or TSM), HCl, and Hg limits through emissions averaging, as long as the average emissions are not more than 90% of the applicable emissions limit. If a facility's annual stack test emissions are below 75% of the emission limits two years in a row, the performance testing interval can be extended from every year to every three years.

Existing boilers and process heaters in the same solid, liquid, or Gas 2 fuel subcategory that vent to separate stacks are eligible for averaging; new units are not. Averaging across fuels is not permitted (for example, emissions from a unit burning a solid fuel such as coal cannot be averaged with emissions from a unit burning a liquid such as No. 6 oil).

For mercury and HCl, averaging is allowed among units that burn solid fuels regardless of the equipment's design subcategory, among units that burn liquid fuels regardless of design, and among units that burn Gas 2 fuels regardless of design.

For PM (or TSM), averaging is only allowed among units within the same equipment-design subcategory. For example, emissions from a fluidized-bed unit designed to burn biomass cannot be averaged with emissions from a suspension burner designed to burn biomass.

Details on emissions averaging and the applicable equations can be found in Section 63.7522 of the regulation (Ref. 1, pp. 142–147).

Demonstrating compliance

Facilities that are subject to numerical emission limits can demonstrate compliance with the Boiler MACT rule in several ways. Continuous monitoring systems (CMS), such as continuous emission-monitoring systems (CEMS) or continuous parameter-monitoring systems (CPMS), collect a wide range of data (*e.g.*, opacity readings, as well as measurements related to the operation of pollution-abatement equipment) to prove a source's continual compliance.

Facilities can avoid the expense of CMS equipment by conducting stack testing (also called performance testing) and fuel analysis. An initial performance test and fuel analysis is required to establish initial compliance with the numerical limits for Hg, CO, HCl, and TSM or PM and to establish operating limits that must be observed until the next test.

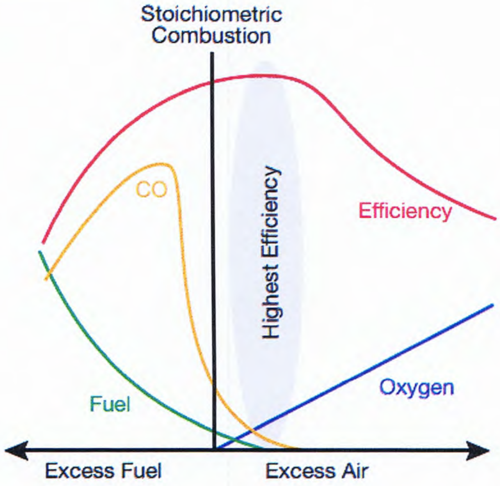
Instead of demonstrating compliance by adhering to operating limits, a plant can perform annual stack testing and monthly fuel analysis. This approach assumes that the emissions limits will be met if the amount of pollutants entering the boiler are kept below specific levels determined during the initial and annual testing. To use fuel analyses to demonstrate compliance, a source must:

- demonstrate that the emissions of Hg, HCl, and TSM are less than the regulation's limits
- conduct a fuel analysis each month for each type of fuel burned, reduce the calculated emissions data to a 12-month rolling average, and maintain the 12-month rolling average at or below the emission limit established during the initial stack test.

If a plant burns more than one type of fuel, it must determine the fuel type or mixture that would result in the maximum emission rates of Hg, HCl, and TSM. Before burning a new type of fuel or mixture, the plant must recalculate the Hg, HCl, and TSM emission rates, which must be less than the applicable emission limits, and perform a stack test within 60 days.

Section 63.7530 of the regulation (Ref. 1, pp. 153–161) discusses fuel testing.

An EMRS is well suited to automating the tasks involved in using the fuel-analysis approach to demonstrate compliance. As combustion parameters change from one moment to the next to satisfy process demands and reliability requirements, the EMRS can calculate, track, and report the expected emissions.



▲ **Figure 2.** Fuel, excess air, CO, and O_2 affect combustion efficiency in a complex way. The vertical axis plots the relative change in CO (in ppm), O_2 (in percent excess air), and efficiency (in percent). The nonlinear nature of CO creation makes it difficult to control CO directly, so O_2 is controlled instead. The highest-efficiency region occurs in a slightly air-rich environment above the point where excess air and excess fuel both equal zero. The preferred operating point occurs when a slightly air-rich environment is reached, indicating that all of the fuel has been consumed. Below that point, an explosive fuel-rich environment would exist, and that is to be avoided.

Process control techniques for CO control

The minimum compliance requirement for major source boilers and process heaters is to perform inspections and tune-ups and to employ rigorous combustion control. A boiler or process heater with a rating of 10 MMBtu/hr or higher that burns a fuel other than natural gas is subject to numerical limits on (among other things) its emissions of carbon monoxide.

Combustion control is designed to minimize excess air for maximum efficiency while managing CO and O_2 concentrations to prevent the release of pollutants. This balancing act is carried out by automated instrumentation and control systems under the watchful eye of a trained process operator. Stricter environmental standards and reductions in operating staffs over the past few decades have made the process control challenge more difficult. The Boiler MACT rule provides additional incentives for plants to install continuous O_2-trim and a combustion-optimization system to manage CO emissions.

Air and fuel are the basic inputs to the boiler or process heater. The combustion reaction oxidizes carbon in the fuel to carbon dioxide according to the following two-step reaction:

$$2C + O_2 \rightarrow 2CO + \text{Heat}$$
$$2CO + O_2 \rightarrow 2CO_2 + \text{Heat}$$

For the complete combustion of carbon to carbon dioxide, every carbon atom must make contact with two oxygen atoms. In large industrial boilers, this is difficult to achieve in practice for several reasons:

- Complete mixing of the free oxygen in air with carbon in the fuel requires sufficient reaction time. Complex multi-fuel boilers require independent control of several layers of combustion air systems to provide the residency time in the furnace needed for complete combustion.
- The boiler firing rate varies constantly with changes in user steam demand to avoid high or low header pressures. This dynamically changes the fuel and air inputs into the boiler, generating HAPs during the transitions.
- The specific amount of carbon in a given volume of fuel may be unknown, so the amount of air required to complete combustion cannot be determined with certainty.

Figure 2 depicts the relationships among fuel input, oxygen consumption, CO production, and boiler efficiency. The nonlinearity of the CO curve illustrates why it is difficult to control CO directly. However, the CO production rate can be used to dynamically determine the minimum excess air required for complete combustion.

Simple systems use a common mechanical jackshaft combustion-control strategy, which consists of mechanical linkages for air and fuel metering mounted on the front of the boiler. An alternative is a small electronic controller on the front of the boiler to set and maintain a minimum O_2 level. While these simple controls may use more fuel and cost more, they do assure that excess air is present and above the CO-formation point.

Larger systems use interconnected air and fuel controllers with O_2 trim to limit the amount of excess air present until CO begins to form. While this is more efficient, it does not respond to changing operating conditions, such as variable-Btu fuels, dynamic process demand changes, or process turndowns.

Complex units with environmental constraints have successfully employed a consumed-air combustion strategy to manage variable-Btu-fuel, multi-fuel boilers. Boilers with changing operating ranges, fuel moisture content, and/or fuel mixes can use adaptive control in addition to consumed-air control to manage CO formation to maximize efficiency.

Consumed-air control

The primary indicator of the completeness of combustion is the amount of oxygen in the fluegas exiting the boiler. Excess oxygen (beyond the stoichiometric amount) is required to complete combustion because the mixing of air and fuel in a boiler is not perfect. If too little excess O_2 is supplied, combustion will be incomplete and the fluegas will contain some amount of carbon monoxide. When more excess O_2 than necessary is provided, the excess air is heated in the furnace, which increases the fluegas temperature and velocity. The increased heat exiting through the stack reduces the boiler's efficiency, and more fuel is needed to meet the steam demand, thereby increasing the environmental impact of the boiler.

The oxygen content of air is relatively fixed, whereas the carbon content of fuel (other than fuels like natural gas or diesel fuel) is variable. The rate of steam generation can be stabilized by setting the air flow based on steam demand and adjusting the fuel rate to achieve the proper amount of O_2 required for combustion.

In the consumed-air strategy, the flow of air into the boiler is initially set at a high enough level to ensure complete combustion. The air flowrate is then trimmed over a short period of time to reduce the excess oxygen to a minimum. Over the long term, the fuel flowrate is varied based on the air-to-fuel ratio calculated dynamically as a function of fuel flow, air flow, and excess O_2.

The minimum O_2 requirement can be found while the boiler is operating by monitoring carbon monoxide as an indication of incomplete combustion in the fluegas. A CO reading of zero indicates that the excess air may be higher than necessary. At the minimum excess O_2 level, the fluegas will contain a small quantity of CO (50–150 ppm).

Adaptive control

Large boilers and process heaters require control systems that can respond to wide variations in process parameters such as:

- steam demand variability and turndown requirements
- ambient air temperature and humidity
- moisture content of the fuel
- inconsistencies in the atomization of the fuel
- fuel quality.

Boiler operators often respond manually to variations in these parameters to minimize fuel usage and environmental impact, and each shift operator has his or her own style of tweaking the boiler. With multiple shifts at a plant, operating variability can cause performance to degrade, resulting in larger economic and environmental impacts.

Example of adaptive control. CO control can be provided by special tools that manipulate controlled variables while maintaining several environmental constraints. Fuzzy logic is one such tool.

In this example, a chemical recovery unit at a paper mill employs a chain of individual, single-variable, priority-constrained fuzzy-logic controllers *(9)* interfaced to other modules in an advanced process control network. One fuzzy logic controller acts as an input boundary limiter (IBL) to incorporate one process input, such as CO level, into a chain of multiple inputs. When these IBLs are linked in a chain, they form a prioritized rule set in which each IBL gives increase and decrease permission to all the rules beneath it. The position of an IBL in the chain, therefore, affects its operation and the final behavior of the controlled variable, which is usually the position of a valve or damper.

This type of control system can manage the behavior of multiple process variables in a very sophisticated manner.

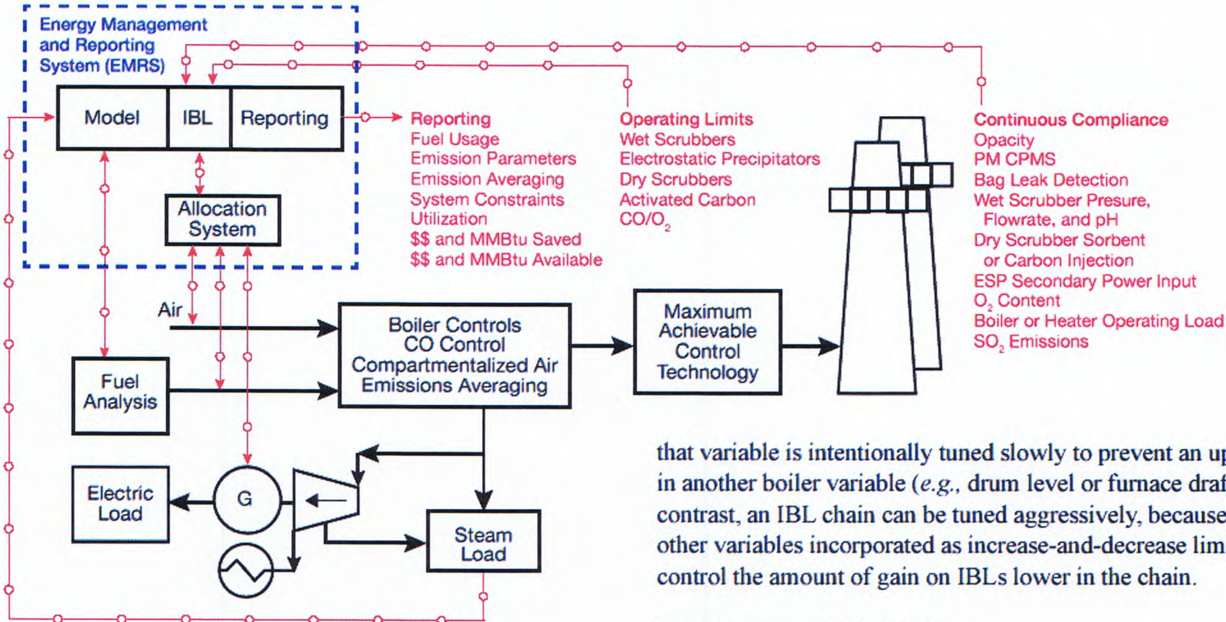
EMRS rules

The EMRS rule sets have always included environmental constraints. This structure can simply be expanded to include the additional Boiler MACT compliance requirements. The constraints are prioritized in order of importance:

1. safety limits
2. physical limits of the equipment
3. environmental limits
4. efficiency.

Notice that control actions aimed at increasing efficiency can be taken only when all physical, safety, and environmental constraints are satisfied. If environmental limits are approached, the control system automatically sacrifices economics and operational demands to keep the boiler in compliance while assuring safe operation.

Velocity rules can be added to prevent the controlled variable from increasing or decreasing too quickly. A typical single-loop controller monitors only one process variable, and



▲ **Figure 3.** The EMRS integrates Boiler MACT compliance requirements with equipment operating limits, continuous compliance instrumentation, and advanced boiler controls.

	Ideal Cost	Actual Cost	Lost Opportunity
Energy Costs ($/Hr)	$5,964	$6,054	$90

	Ideal (KPPH)	Actual (KPPH)	Advice
PB1 Bark	0.0	0.0	PB1 Bark : Perfect
PB1 Coal	371.1	324.1	PB1 Coal : Increase
PB2 Bark	153.2	153.3	PB2 Bark : Perfect
PB2 Coal	159.4	218.6	PB2 Coal : Decrease
Gas Boilers	110.0	105.5	Gas Boilers : Perfect
PB1 Oil	0.0	0.0	PB1 Oil : Perfect
PB2 Oil	0.0	0.0	PB2 Oil : Perfect
RB3 Oil	0.0	0.0	RB3 Oil : Perfect
TG1 Cond	30.3	59.0	TG1 Cond : Decrease
TG2 Cond	72.0	56.1	TG2 Cond : Increase
50# Vent	0.0	0.0	50# Vent : Perfect
Tie-Line	35.5	34.5	Tie-Line : Increase

RTP BUY Price, Now	$44.15	Lost Opp. Today	$470
RTP BUY Price, Next	$44.00	Lost Opp. Yesterday	$870

▲ **Figure 4.** The EMRS is a closed-loop controller and a dynamic model-based advisor. The advisor display gives the operator constant feedback on the current system performance using a process model that adjusts to current constraints. This allows the operator to properly respond to process dynamics with the equipment available. Lost opportunity cost is the gap between the ideal hourly operating cost and the current hourly operating cost. It allows the operator to respond more strategically to reduce costs, and is often an indication of abnormal process or control conditions that should be addressed.

that variable is intentionally tuned slowly to prevent an upset in another boiler variable (*e.g.*, drum level or furnace draft). In contrast, an IBL chain can be tuned aggressively, because the other variables incorporated as increase-and-decrease limiters control the amount of gain on IBLs lower in the chain.

Integrating an EMRS with pollution abatement equipment and work practices

Plants that currently have less-than-ideal energy management may find Boiler MACT compliance particularly challenging. Many facilities have increased their utility demands without increasing the dynamic capabilities of the utility system to meet the higher demands. This presents a challenge if the utility system's environmental permits are based on stack testing under steady-state conditions and require continuous compliance with emission limits that are based on not exceeding 110% of the tested load.

An EMRS can address this challenge by coordinating different combustion control strategies, pressure relief valves (PRVs), turbines, and vents to provide anticipatory control to satisfy facility steam demand across multiple control rooms built on different hardware platforms. This hardware can be incorporated into a modularized yet seamlessly integrated control and reporting solution. An example is predictive header-pressure control *(10, 11)* that manages the powerhouse combustion and steam-distribution systems to reduce variability while satisfying header-pressure requirements.

Figure 3 illustrates a typical EMRS designed for Boiler MACT compliance. The dynamic process advisor model includes fuel characteristics and cost data, which it uses to calculate fuel usage, emissions, savings, and other parameters needed for both regulatory reporting and plant operation and management. Integration of continuous compliance instrumentation with the EMRS permits the implementation of emission averaging. The allocation system uses the plant's projected steam demands to manage the boilers, turbines, PRVs, and vents in order to optimize overall utility management, subject first to emission limits and reliability requirements and then economic goals. The advanced boiler combustion controls are integrated with the pollution abatement equipment's operating limits to manage boiler loading and minimize the risk of malfunctions or unscheduled outages due to operator error.

Environmental parameters have been integrated into powerhouse control EMRS since 1999. This approach has reduced overall steam and fuel costs by 5% to 7% and total facility carbon dioxide equivalent (CO_2e) emissions by 12% *(12)*. Some projects have reported a simple payback of less than three months with savings of $500,000 in the first month of operation *(13)*.

The standard reporting provided by an EMRS satisfies a significant portion of the MACT reporting requirements. Figure 4 shows a typical communications interface with the dynamic process advisor model, which gives the operator constant feedback on the system operation, constraints, and current economics. This is important under Boiler MACT, because the environmental constraint rule set is part of the overall operating strategy.

Closing thoughts

EPA has provided alternatives for sources that are subject to the Boiler MACT regulation. Not all facilities will need to install pollution-abatement equipment. Many will be able to comply with the standard through work practices, fuel switching, and tighter energy management. An EMRS can provide that energy management. By stabilizing dynamic boiler operation and improving safety, an EMRS drives the boiler to higher efficiencies while automatically responding to environmental upsets according to a prioritized, rule-based set of controls. From a financial perspective, an EMRS implementation project has a high rate of return. From a plant management perspective, an EMRS and advanced combustion controls assure compliance at minimal cost, and EMRS reporting charts allow management to view MACT compliance daily. For operators, an EMRS provides the tools and guidance to succeed in a real-time operating environment. CEP

JAMES E. ROBINSON, P.E., P.ENG., CEM, CEP, is Principal Project Engineer at DES Global, LLC (Phone: (484) 868-1901; Email: jrobinson@desglobal.com). He has more than 40 years of experience in the execution of power and control system projects in the industrial and utility sectors, with assignments at Catalytic Engineering and Construction, Honeywell, Babcock and Wilcox, Kvaerner, Gotaverken, and Siemens Westinghouse. He started DES to implement energy management and reporting systems (EMRS) to reduce powerhouse energy usage and environmental emissions while improving overall reliability in heavy industry. He has a BS in engineering from Drexel Univ., is a licensed professional engineer in Pennsylvania (P.E.) and Alberta, Canada (P.Eng.), a Certified Energy Manager (CEM), a Certified Energy Procurement Professional (CEP), an adviser to the Industrial Energy Technology Conference (IETC) at Texas A&M Univ., and a member of the Pennsylvania Smart Energy Initiative (SEI) Board.

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Control Boiler MACT through Work Practices and Energy Management

IETC Energy Managers Workshop

May 2014

Jim Robinson DES Global, LLC

The Significant Impact of Boiler MACT to the Energy/Environmental Engineering?

- Federal Regulation Forces the Convergence of Environmental and Energy
- Weaves Energy into Operations Mantra
  - Control Room Operators Objectives
    - Comply with Environmental Constraints
    - Comply with Equipment Operating Constraints
    - Assure Reliable Powerhouse Operation
    - Assure Reliable Utilities to Process Units
    - Economic Operation
- Requires Consistent Risk Tolerance

What Things are Required?

- Compliance Strategy
- Compliance Permitting
- Performance Testing Programs
- Energy Tune-ups and Assessments
- Continuous Compliance
- Startup, Shutdown, and Malfunction (SSM)
- Facility Changes
  - Air Quality Dispersion Modeling
  - Energy Systems Modeling

Boiler MACT and Energy Assessment Implementation

- Presentation Summary
  - Section 1: Rule Overview, Status, and Impact
  - Section 2: MACT Compliance through Work Practices
  - Section 3: Conclusion, References, and Questions

ITEMS DISCUSSED

Why did the EPA implement MACT?

What is the timeline?

What is it going to cost?

How does it work and what does it look like from the energy side?

Is it ready?

SECTION 1: RULE OVERVIEW

Why did EPA implement Boiler MACT?

- The Courts mandated Hazardous Air Pollutants (HAP) Regulation
  - Furans and Dioxins
  - Mercury
  - Hydrogen Chloride (HCL)
  - Total Selected Metals (TSM)

    or
  - Particulate Matter (PM)
  - Carbon Monoxide (CO)

What is the Major Source Timeline?

- Major sources have notification due

  May 31, 2013

- New or Reconstructed Source Compliance

  January 31, 2013 or Startup

  Whichever is later

- Existing Source Compliance

  January 31, 2016

What does Boiler MACT cost?

Table 1. Boiler MACT regulatory cost estimates, assuming all new units will burn natural gas, refinery gas, or biomass.

Source	Subcategory (Fuel Fired)	No. of Affected Units (Estimated or Projected)	Capital Cost, million	Annualized Cost Considering Fuel Savings, million/yr*	Annualized Testing and Monitoring Cost, million/yr*	Capital Cost per Unit	Annualized Cost per Unit
Existing Units	Coal	621	$2,554	$904	$46	$4,113,000	$1,456,000
	Biomass	502	$405	$109	$29	$807,000	$217,000
	Heavy Liquid	319	$761	$221	$5.4	$2,386,000	$693,000
	Light Liquid	615	$712	$166	$4.2	$1,158,000	$270,000
	Non-Continental Liquid†	21	$62	$17	$0.8	$2,952,000	$810,000
	Gas 1 (Natural Gas or Refinery Gas)	11,929	$77	($295)	$0.9	$6,500	($24,700)
	Gas 2 (Other Gases)	129	$138	$58	$2.3	$1,070,000	$450,000
New Units	Coal	0	—	—	—	—	—
	Biomass	82	$381	$99‡	$5.6	$4,646,000	$1,207,000
	Heavy Liquid	0	—	—	—	—	—
	Light Liquid	0	—	—	—	—	—
	Non-Continental Liquid†	0	—	—	—	—	—
	Gas 1 (Natural Gas or Refinery Gas)	1,762	$11	$5.1‡	$0	$6,200	$2,900
	Gas 2 (Other Gases)	0	—	—	—	—	—
Energy Assessments	All	1,700 Facilities	NA	$28	NA	$0	$16,500
Total			$5,101	$1,312	$94		

Notes:
* Annualized costs include testing and monitoring costs, but not recordkeeping and reporting costs.
† A non-continental liquid source is a liquid-burning unit located in Hawaii, the Virgin Islands, Guam, American Samoa, Puerto Rico, or the Northern Mariana Islands.
‡ Total annualized costs for new units do not account for fuel savings, since no fuel savings are estimated in the first year of use.
NA = Not Applicable.

Source: Adapted from Ref. 2, pp. 7155–7156.

Federal Register Volume 78 No. 21 January 31, 2013 40 CFR Part 63 EPA-HQ-OAR-2002-0058; FRL-9676-8 Summary, Table 5 - Summary of Total Capital and Annual Costs for the New and Existing Sources for the Final Amended Rule. Page 7155

How do Boiler MACT Rules work?

- Work Practices
  - Energy Assessments and Energy Credits
  - Combustion Inspection and Tune Up
  - Fuel Switching and Fuel Testing
- Maximum Achievable Control Technologies
- Monitoring and Control

Work Practices

Table 2. Summary of Boiler MACT requirements for existing and new major sources.

	Existing or New*	Large or Small†	Tune-Up	Numerical Limits	One-Time Energy Assessment
Gas 1 (Clean Gas)	Existing	Large	Yearly§	None	Yes
		Small	Biennially#	None	Yes
	New	Large	Yearly§	None	No
		Small	Biennially#	None	No
Coal, Biomass, Oil, Gas 2 (Process Gas)	Existing	Large	Yearly§	Hg, CO, HCl, and PM (or TSM) See Table 3	Yes
		Small	Biennially#	None	Yes
	New	Large	Yearly§	Hg, CO, HCl, and PM (or TSM) See Table 4	No
		Small	Biennially#	None	No
Limited Use‡	Existing or New	Large or Small	Every 5 yr	None	No

Notes:
* Existing sources are those that commenced construction or reconstruction on or before June 4, 2010; new sources commenced construction or reconstruction after June 4, 2010.
† Large sources have a heat input capacity ≥10 MMBtu/hr; small sources have a heat input capacity <10 MMBtu/hr.
‡ A limited-use unit is one that has a federally enforceable average annual capacity factor of 10% or less.
§ Boilers and process heaters with a continuous oxygen-trim system perform a tune-up every 5 yr.
# Boilers and process heaters with a continuous oxygen-trim system, or that have a heat input capacity ≤5 MMBtu/hr and are designed to burn Gas 1, Gas 2, or light liquid, perform a tune-up every 5 yr.

Source: Adapted from Ref. 4, pp. 4–5.

Boiler MACT Existing Boilers

Table 3. Emission limits for existing boilers and process heaters with a heat input capacity ≥10 MMBtu/hr.

Subcategory	Particulate Matter (PM) or Total Selected Metals (TSM)		HCl, lb/MMBtu of heat input*	Hg, lb/MMBtu of heat input*	Carbon Monoxide (CO) or CO Limit with CEMS	
	Filterable PM, lb/MMBtu of heat input*	TSM, lb/MMBtu of heat input*			CO, ppm @3% oxygen*	CO Limit with CEMS, ppm @3% oxygen†
Coal						
Stoker	0.0400	5.30E–05	0.022	5.70E–06	160	340
Fluidized Bed	0.0400	5.30E–05	0.022	5.70E–06	130	230
Fluidized Bed with FB Heat Exchanger	0.0400	5.30E–05	0.022	5.70E–06	140	150
Burning Pulverized Coal	0.0400	5.30E–05	0.022	5.70E–06	130	320
Biomass						
Wet Stoker/Sloped Grate/Other	0.0370	2.40E–04	0.022	5.70E–06	1,500	720
Kiln-Dried Stoker/Sloped Grate/Other	0.3200	4.00E–03	0.022	5.70E–06	460	ND
Fluidized Bed	0.1100	1.20E–03	0.022	5.70E–06	470	310
Suspension Burner	0.0510	6.50E–03	0.022	5.70E–06	2,400	2,000‡
Dutch Ovens/Pile Burners	0.2800	2.00E–03	0.022	5.70E–06	770	520‡
Fuel Cells	0.0200	5.80E–03	0.022	5.70E–06	1,100	ND
Hybrid Suspension Grate	0.4400	4.50E–04	0.022	5.70E–06	2,800	900
Heavy Liquid	0.0620	2.00E–04	0.0011	2.00E–06	130	ND
Light Liquid	0.0079	6.20E–05	0.0011	2.00E–06	130	ND
Non-Continental Liquid§	0.2700	8.60E–04	0.0011	2.00E–06	130	ND
Gas 1 (Natural Gas, Refinery Gas)	NA	NA	NA	NA	NA	NA
Gas 2 (Other Gases)	0.0067	2.10E–04	0.0017	7.90E–06	130	ND

Notes:
* 3-run average, unless otherwise noted.
† 30-day rolling average, unless otherwise noted.
‡ 10-day rolling average.
§ A liquid-burning unit located in Hawaii, the Virgin Islands, Guam, American Samoa, Puerto Rico, or the Northern Mariana Islands.
NA = Not Applicable; ND = No Data Available.

Source: Adapted from Ref. 2, pp. 7142.

ITEMS DISCUSSED

How do you comply with Boiler MACT?

How does Boiler MACT Energy Assessments and the existing Energy Assessment Structure fit?

SECTION 2: MACT COMPLIANCE

How do you comply with Boiler MACT ?

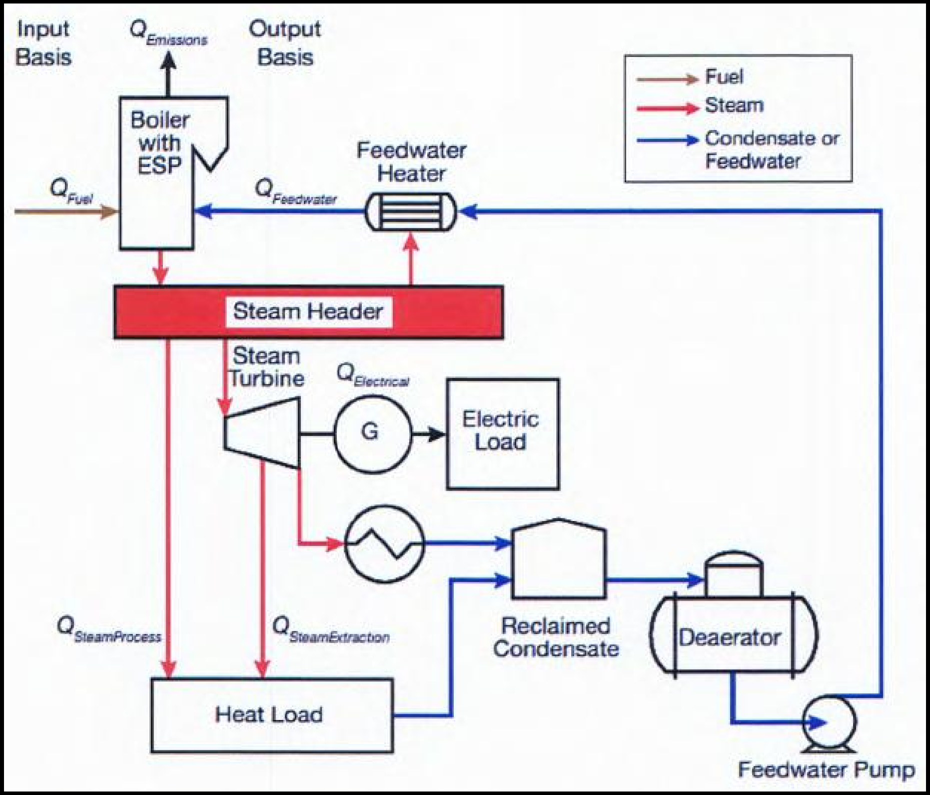
	Hazardous Air Pollutant (HAP) and Work Practice	Energy Assessments	Efficiency Credits [a]	Tune-ups	Fuel Testing	Pollution Abatement Equipment
Hazardous Air Pollutant (HAP)						
	Furans and Dioxins			X		
	Mercury		X		X	X
	Hydrogen Chloride (HCL)		X		X	X
	Total Selected Metals (TSM)		X		X	X
	Particulate Matter (PM)		X			X
	Carbon Monoxide (CO)			X		
Work Practices						
	Energy Assessment	X				
	Efficiency Credits		X			
	Tune-ups and Inspections			X		
	Fuel Testing				X	
	Initial Compliance	X	X	X	X	X
	Continual Compliance		X	X	X	X
	Emission Averaging				X	X
	Startup, Shutdown, and Malfunction (SSM)					X
Notes						
a	Applicable for existing affected units using the Output-Basis Method .					

Past Energy Assessments have Value!

- Past Energy Assessments can be upgraded to MACT
  - Energy project savings as early as 1/1/2008 can be used for energy credits.
  - Benchmark begins 1 year prior to assessment, can be as early as 1/1/2007.
  - Efficiency Credits can mitigate emission limits.
  - Equipment shutdown through efficiency projects must be in the strategic plan for credit.
- Past Energy Assessments have Value
  - Build an inventory of past assessments
  - Find a favorable baseline

Boiler MACT
Work Practice Compliance & Energy Assessment

1. MACT Energy Assessments
2. Powerhouse Energy Assessment expanded to:
    1. Include powerhouse auxiliaries
    2. Include catalog of energy users
    3. Add mill identified energy projects
    4. Establish Benchmark
    5. Include strategic plan
    6. Identify energy projects with ROI
    7. Or ISO 50001
3. Prepare process for MACT metrics and reporting requirements.
4. Prepare for the required instrumentation.

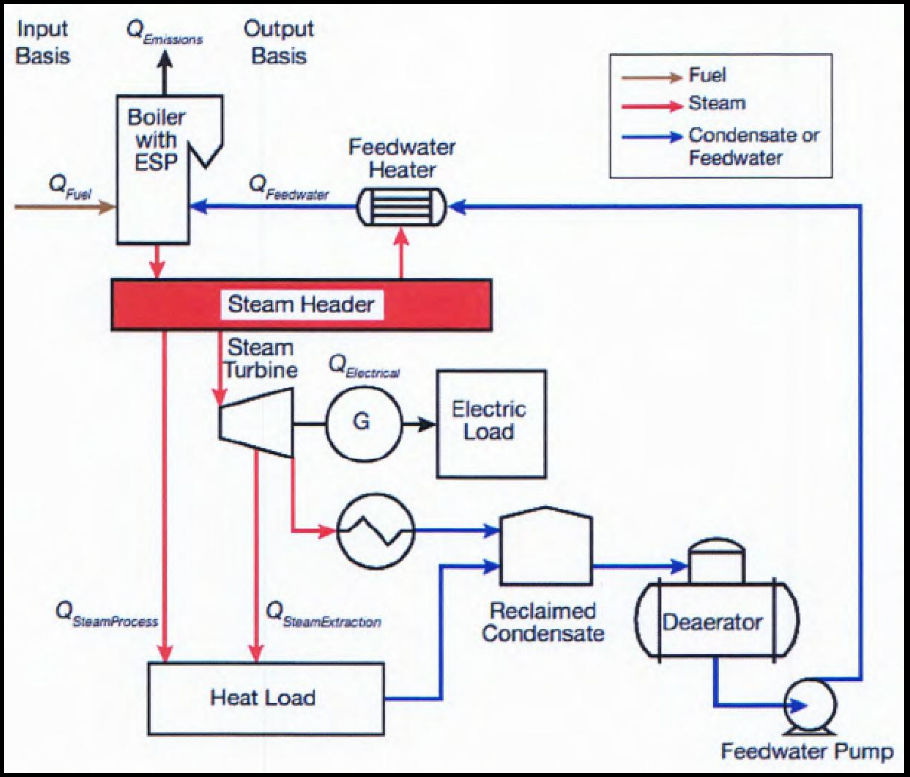


Input-Basis versus Output-Basis
Begin With the End In Mind

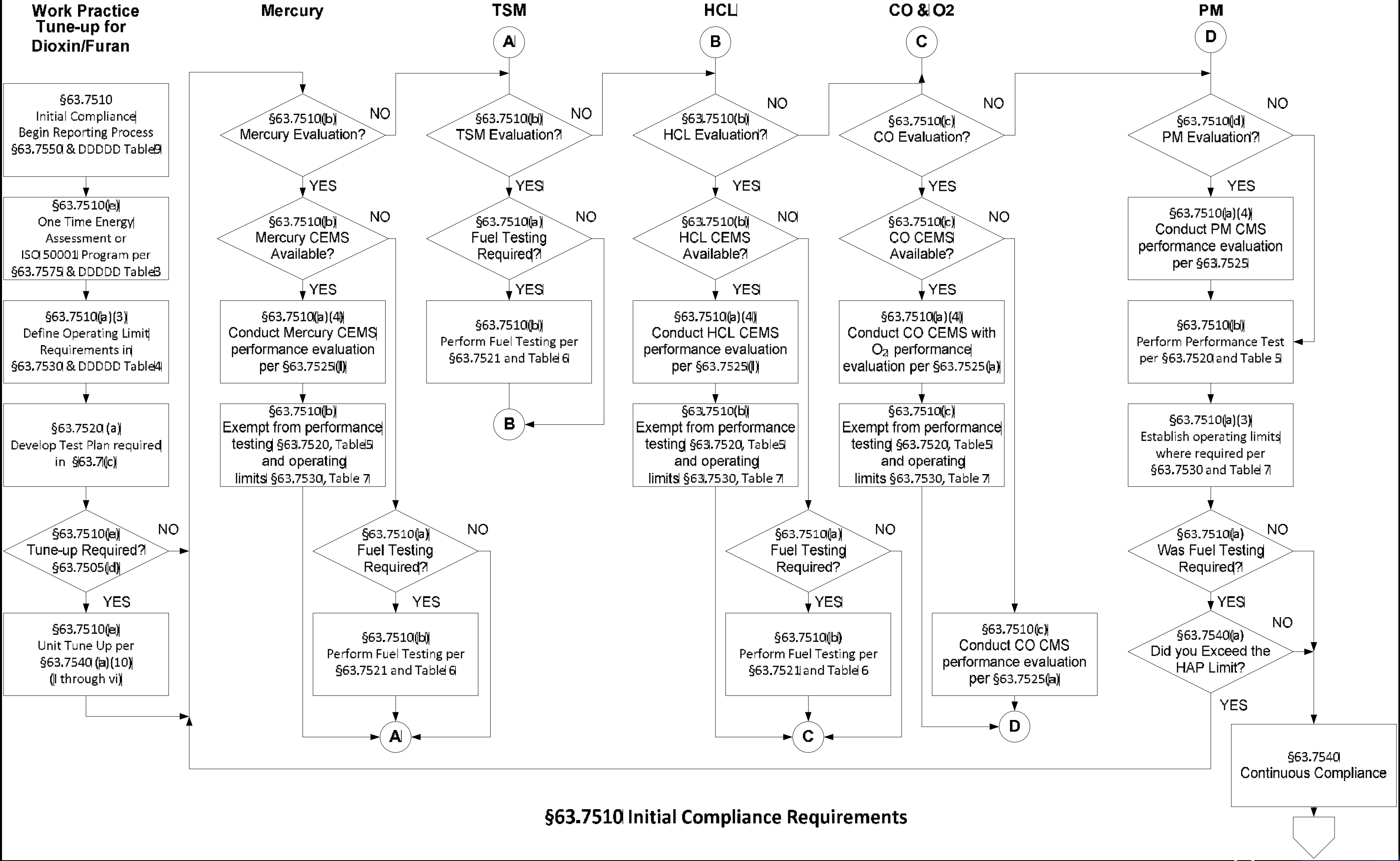
- There are four methods for emission limit calculation
  - Input-Basis
    - MMBtu/hr Input
  - Output-Basis
    - MMBtu/h Output Steam
    - MWh Output Electricity
    - Cogeneration

      MMBtu/h Extraction +

      MWh X 10MMBtu/MWh
- Output-Basis allows
  - Efficiency Credits on existing units
  - Emission Averaging for existing sources can be used across multiple units.



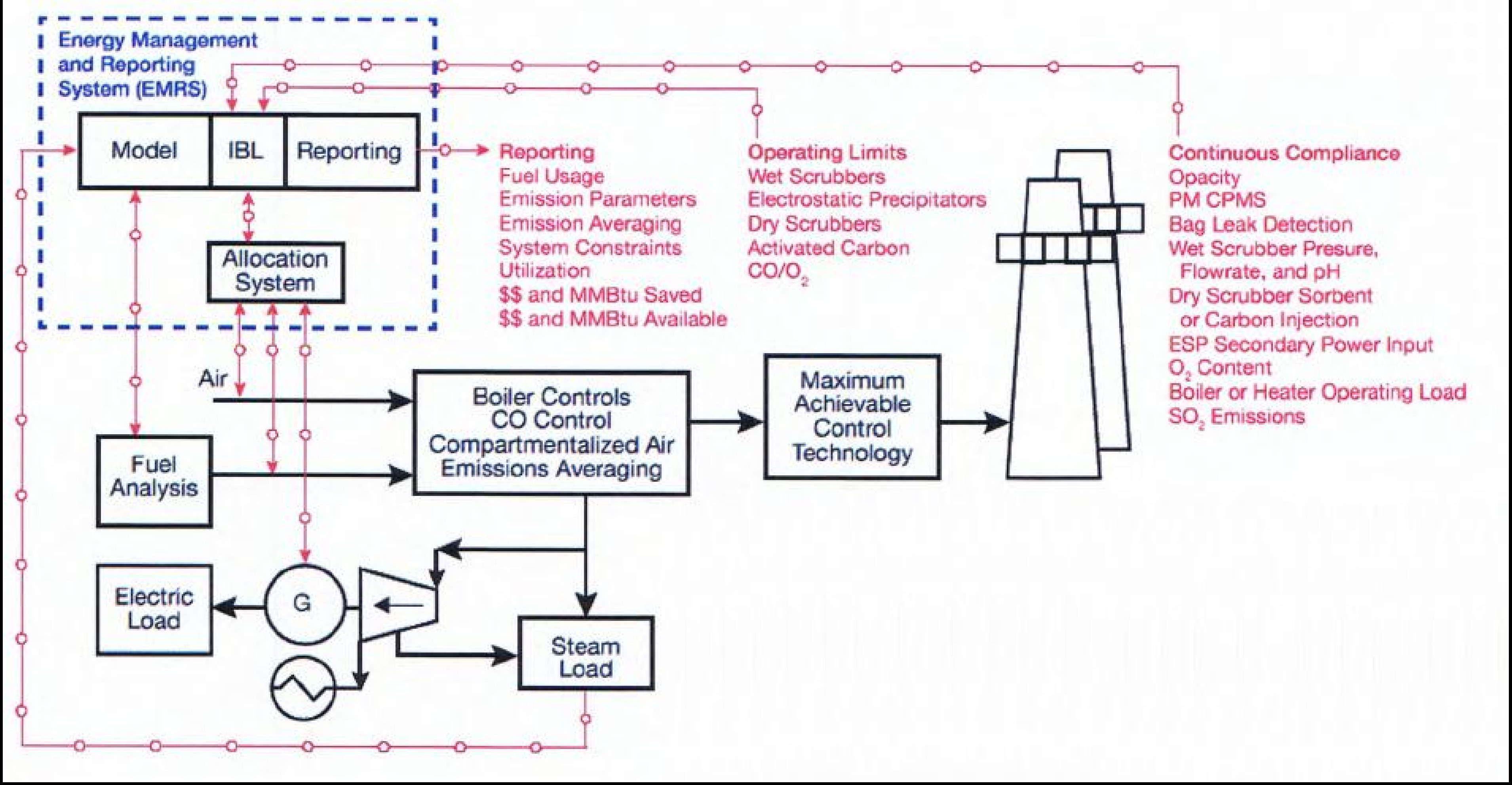
Compliance Process



§63.7510 Initial Compliance Requirements

DES LLC

Find Innovative Control Solutions…



ITEMS DISCUSSED

Innovative solutions?

SECTION 3 CONCLUSION

How Do We Get Through This?

- Begin with the end in mind.
- MACT isn’t done, industry needs to be creative to plug the holes.
- Resources are available to help.
  - EPA Resources
  - DOE Clean Energy Assessment Centers
  - Industrial Assessment Centers
- Use past work and automate where possible.

Conclusion

- We’re on the clock – 40% of the schedule is gone.
- Be smart, don’t think you can always throw pig iron at this to be successful or that pollution abatement is the only alternative.
- Boiler MACT needs to be integrated into other facility projects or pieces will be missed.

Questions & References

- Best References
  - Small Entity Compliance Guide for Major Source Boilers and Process Heaters

    http://www.epa.gov/ttn/atw/boiler/imptools/20130312compliancequide.pdf
  - EPA Industrial/Commercial/Institutional Boilers and Process Heaters
    - http://www.epa.gov/airtoxics/boiler/boilerpg.html

Energy Data Capture and Reporting Driving Strategic Decisions

Case Study from a Major Manufacturer

Energy Managers' Workshop

Industrial Energy Technology Conference
May 20th, 2014 New Orleans, Louisiana

Global Energy Management *Headline Goals*

- Energy Productivity
  - *Increase of 20 to 30% relative to 2006 levels within 7 years*
  - *Further 15% improvement by 2020*
- Greenhouse Gas Emissions
  - *Long term vision to achieve an 83% reduction in GHG intensity by 2050 relative to 2006 levels*

How to Measure Corporate Energy Productivity?

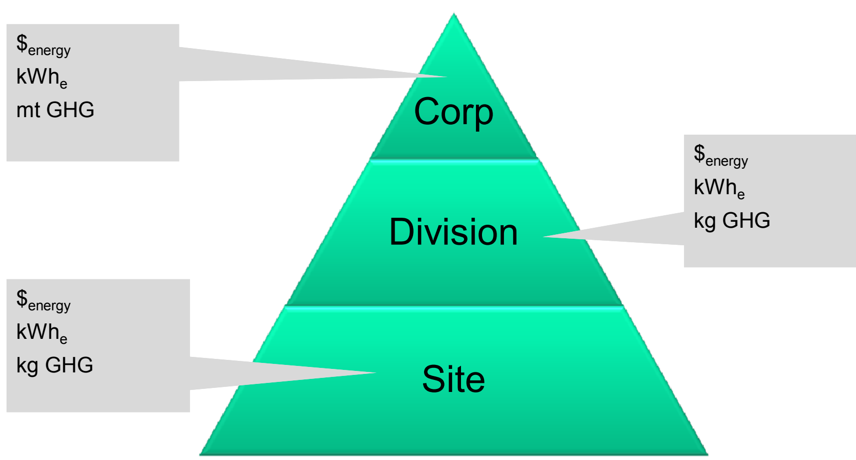
Energy Management Data Tools
Overall Objectives

Overall Goal

To provided readily available relevant energy data to support Corporate performance targets

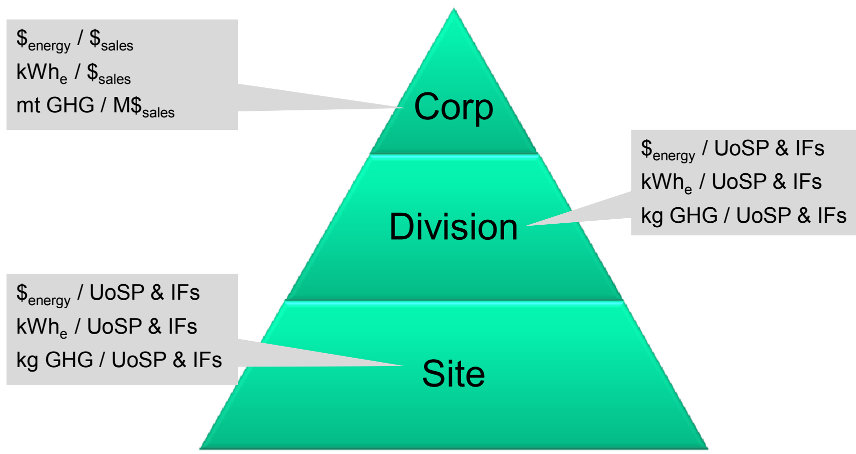
- Summaries that drive behavior at all levels
- Minimum manual intervention
- Visibility of targets and performance
- High data integrity
- Simple process to minimize errors
- Routinely available for Division and Site Energy Managers
- Visibility of targets and performance
- Relevant to site level planning and actions

Performance Reporting
Totals – Usage, Cost, GHG-Emissions



Basic Information – Reliable and Timely Availability

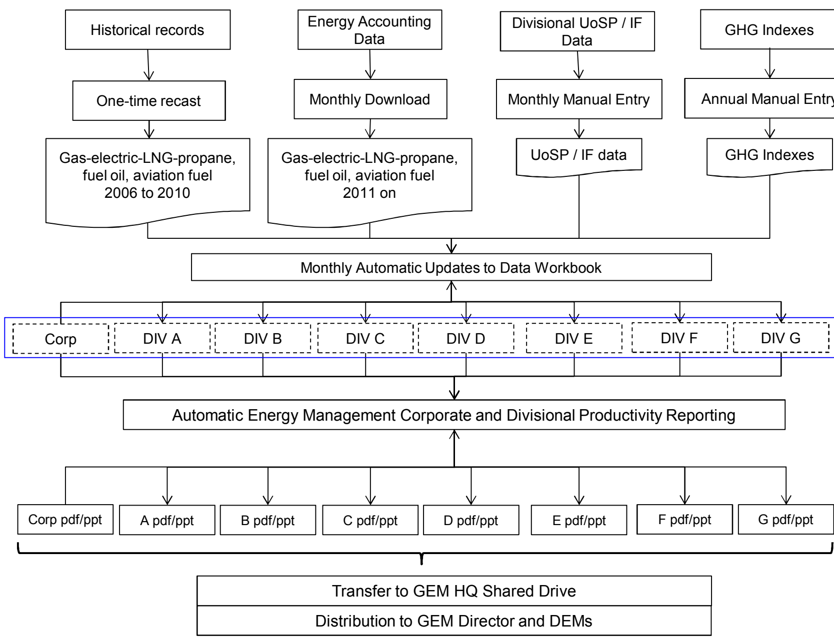
Performance Reporting
Performance Indexes – Usage, Cost and GHG



Align on Common Indexing Parameters

Data Tools
Overview

- Single Corporate / Division Tool
- Multiple Division / Site Tools
- Consolidated history data from 2006 to 2010
- One data source for all global sites from 2011 continually updated with current invoices
- Automatic import / export of energy data with tests for completeness, credibility and validity
- Multiple indexes possible – Site/Div/Corp
- Standardized & tailored reports
- Self-correcting structure ensures any data disturbance is corrected with next data import



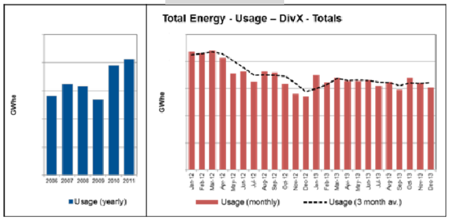
Corporate-Division Tool: Monthly Process Flow

Corporate / Division Data Tool
Overview

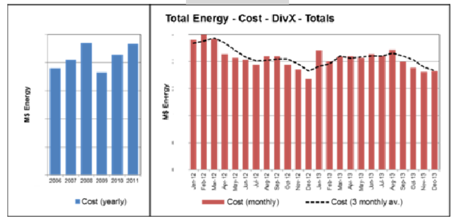
- Import function for global data from Energy Accounting Data
- Evaluation macros for Corporate and Divisions as indexed and total values
- Selection options for
  - *Corporate and divisions*
  - *Commodity*
  - *Cost / Usage / Emissions*
  - *Baseline year*
  - *Reporting Periods*
  - *Target display (on/off)*
- Available Graphs
  - *Yearly, monthly and combined bar graphs*
  - *Line graphs showing cost or usage and indexing factors*
- Selectable reporting formats
  - *Pdf Print (various options)*
  - *Export to PowerPoint as pre-defined Standard Report*
  - *Export to PowerPoint with flexible Reporting option*
- Export function to feed Division /Site Tools

Example of Division Monthly Report

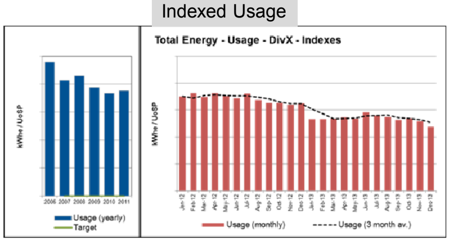
Total Usage



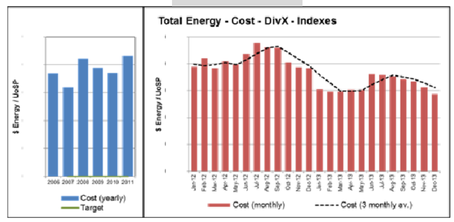
Total Cost



Indexed Usage



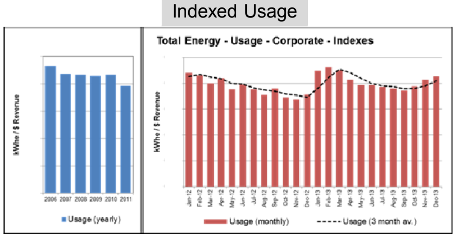
Indexed Cost



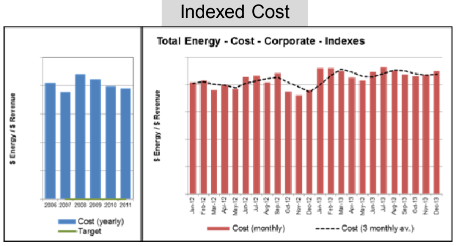
Each Division has Unique Indexing Measure

Example of Corporate Energy Performance
Indexed against Revenue

Indexed Usage

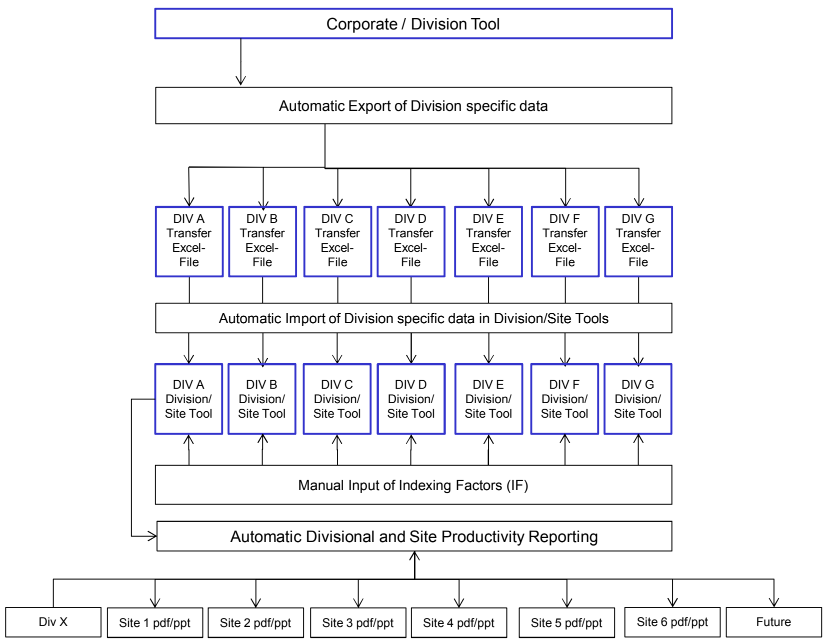


Indexed Cost



- Revenue or total costs commonly used as corporate indexing function
- Limited value as overall measure of efficiency or productivity gains
  - *Distorted by many external factors*
  - *Disguises divisional or site contributions*
  - *Divisional financial data often not released or available to operational teams*
- Weighted indexing assessed as more representative approach

Need a Better Way to “Add Apples and Oranges”

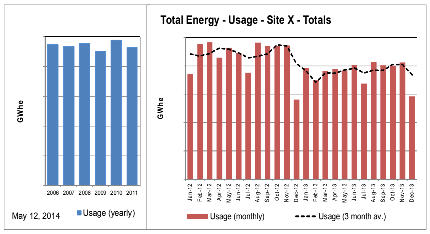


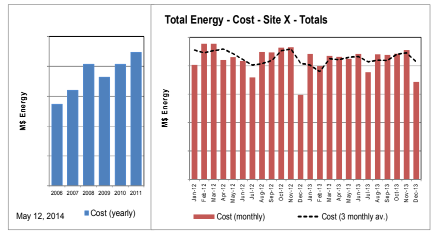
Division-Standard Site Tool: Monthly Process Flow

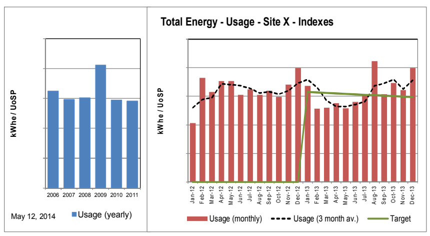
Division / Site Data Tool
Overview

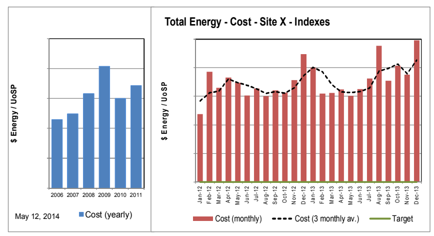
- Import function for data from CD Tool
- Evaluation macros for division and their sites as total and indexed values
- Selection options for
  - *Total division and sites*
  - *Commodity*
  - *Cost / Usage / Emissions*
  - *Baseline year*
  - *Reporting Periods*
  - *Target display (on/off)*
- Available Graphs
  - *Yearly, Monthly and combined bar graphs*
  - *Line graphs for comparison of indexes for selected sites and division average*
- Selectable reporting formats
  - *Pdf Print (various options)*
  - *Export to PowerPoint as pre-defined Standard Report*
  - *Export to PowerPoint with flexible Reporting option*

Example of Site Monthly Report

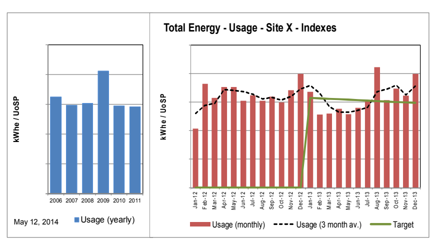


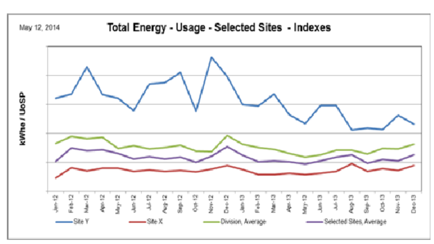






Example of Site Energy Intensity Report
Compare Similar Site and Division Average





Summary of Benefits

- Credible validated data and data history
- Major reduction in report preparation and distribution time
- Consistent formats for all corporate entities
- Flexible graphic design of reports
- Simple checks on data flow
- Automatic refresh of historical data
- Standardized Tools allow management level assessment down to individual site performance

Corporate Productivity
Overall Energy Performance Gain

- Background
  - *Divisions have very different products*
  - *Need for Corporate Performance Indexes based on overall manufacturing activity of all divisions*
  - *Each Division's gains weighted by its energy use as a share of the corporate total energy use*
  - *Corporate performance gain is total of all divisions' weighted improvements*
- *Implementation*
  - *Three Indexes - Efficiency; Productivity; Emissions*
  - *Selectable time period*
  - *Immediately available using current data*

Energy Data must be Credible - Reliable - Timely

Corporate Energy Productivity*
Adding up Apples and Oranges?

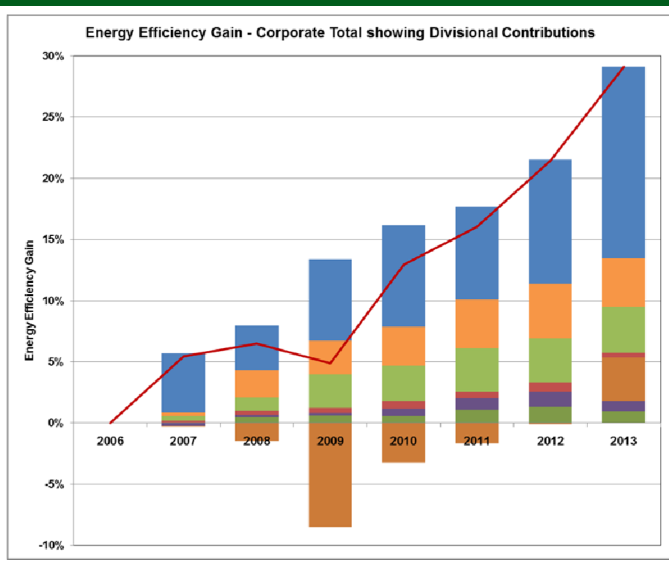
- Consumer Price Index answers the question

"If costs (expenditures) are going up, is it because of increased prices or increased consumption/purchases?"

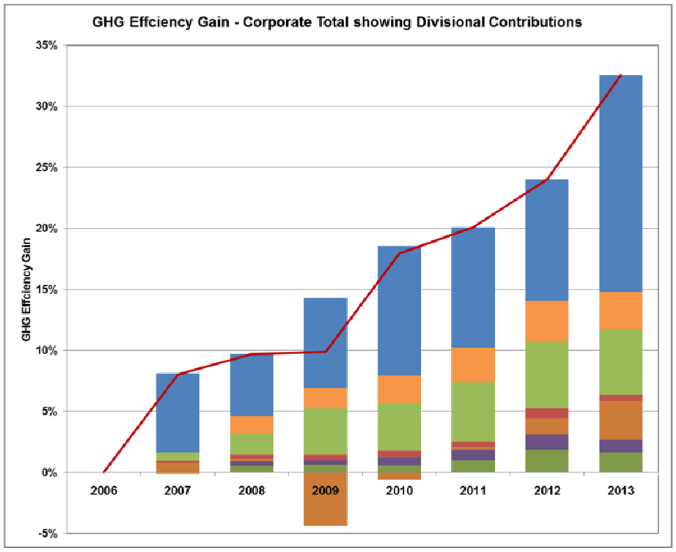
- This is analogous to energy use, except that energy intensity plays the roles of prices
  - *Intensity = Energy Use / unit of Product*
  - *Price = Total $ spent / unit of Product*
- CPI index is simple
  - *Take "basket" of goods purchased/produced and fix it in a point in time.*
  - *Apply the new prices to the fixed basket*
  - *Compare the level of expenses*
- The products in a price index can range from apples to oranges (to gasoline and rent)
- Use same data logic and formulas from CPI to the "energy question"

**Adapted from presentation by G Boyd, Duke University, May 2014*

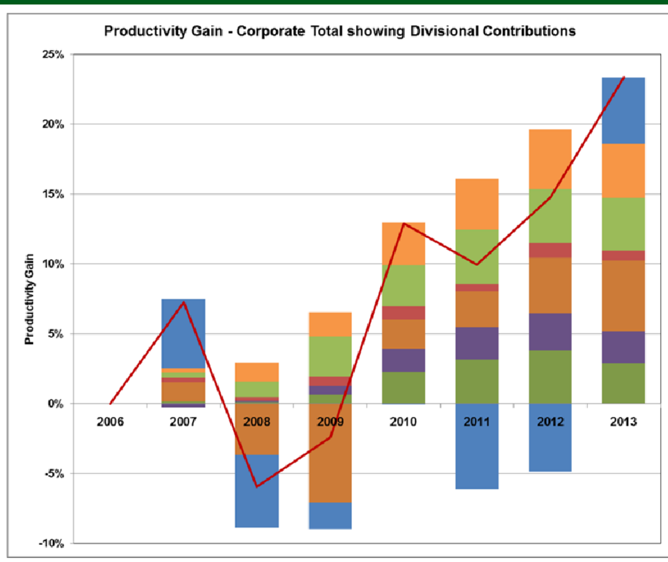
Corporate Energy Performance
Efficiency Gain



Corporate Energy Performance
GHG Intensity Reduction



Corporate Energy Performance
Productivity Gain



Corporate Energy Performance
Clear Benefits from Weighted Indexing

- Corporate energy performance tracking
- Valuable communication tool
- Compare performance between divisions
- Prioritizing ongoing programmes
  - *Scale and potential impact*
  - *Historical performance*
  - *Cost / Efficiency / Emissions*
- Could also use to track Division performance over many sites
  - *Different production processes*
  - *Different products*
  - *Production and non-production locations*
- Good starting point for future risk assessment

Thank You

Peter Garforth
Garforth International llc
peter@garforthint.com
+1 (419) 578 9613 - Office
+1 (419) 320 0664 - Mobile

Identifying and Quantifying Energy Opportunities

IETC May 2014

Walter Brockway Alcoa, inc

Topics

Building blocks for indentifying opportunity

Importance of management commitment

Techniques for reviewing a plant

Tools for quantifying

How to get started (get invited to a plant)

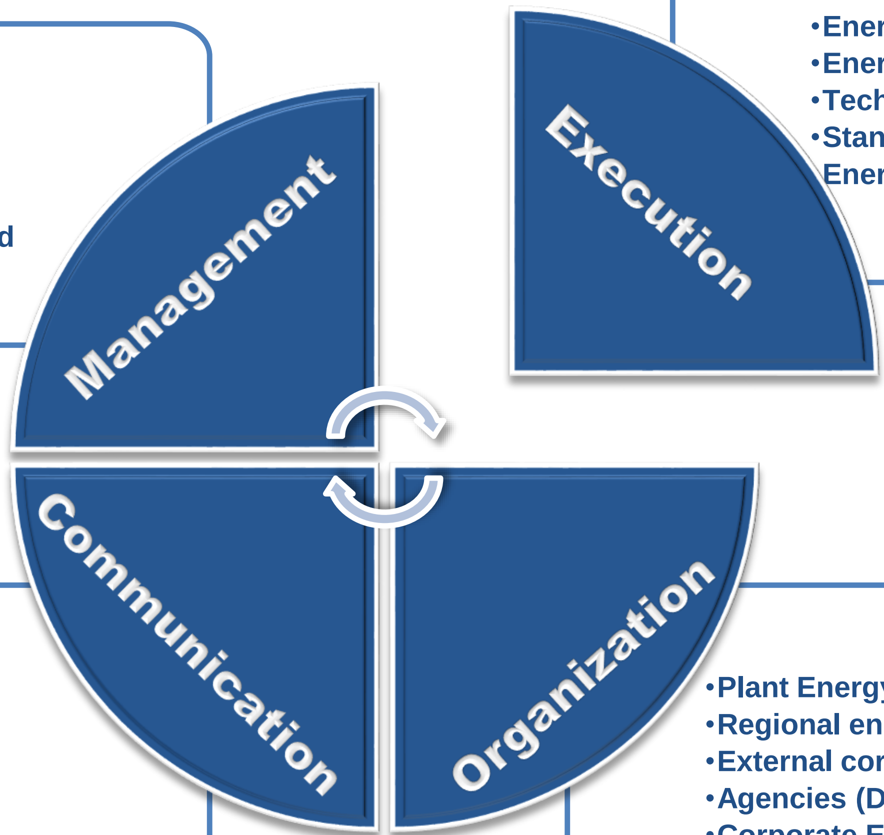
Building Blocks to identifying real opportunities

1. Management commitment
2. Be invited to the facility (go where you are loved)
3. Bring expertise that will gel with the plant
4. Draw (heavily) on plant personnel experience
5. No ideas are bad BUT focus on the few that can be accomplished
6. Quantify the value and the cost before you leave
7. Do a wrap up with management led by plant personnel
8. Follow up with technical or other guidance

Energy Efficiency Program

- Top level commitment
- Goal setting
- Reporting
- Recognition
- Energy management standard practice

- Energy assessments
- Energy Kaizens
- Technical assistance
- Standard practices
- Energy projects



- Training
- Webinars
- Global & regional meetings
- Workshops
- Case studies

- Plant Energy SPAs
- Regional energy organizations
- External corporations
- Agencies (DOE, ABRACE, ETC.)
- Corporate Energy Team

Top Level Commitment

MANAGEMENT

- Dedicated energy team and energy efficiency staff.
- Each business sets annual energy reduction goals.
- Businesses and business units designate energy champions (SPAs).
- Each business establishes an energy cost reduction goal and strategy.
- Executive compensation linked to an energy reduction goal.

Goal Setting & Reporting

- Set long term reduction goals
  - Global Primary Products (Mining, refining and smelting)
    - *10% reduction in energy intensity between 2005 - 2020*
    - *15% reduction by 2030*
  - Downstream businesses (GRP and EPS)
    - *20% reduction in energy intensity between 2005 – 2020 (2010 for EPS)*
    - *30% reduction by2030*
- Progress is reported in the Alcoa sustainability report each year

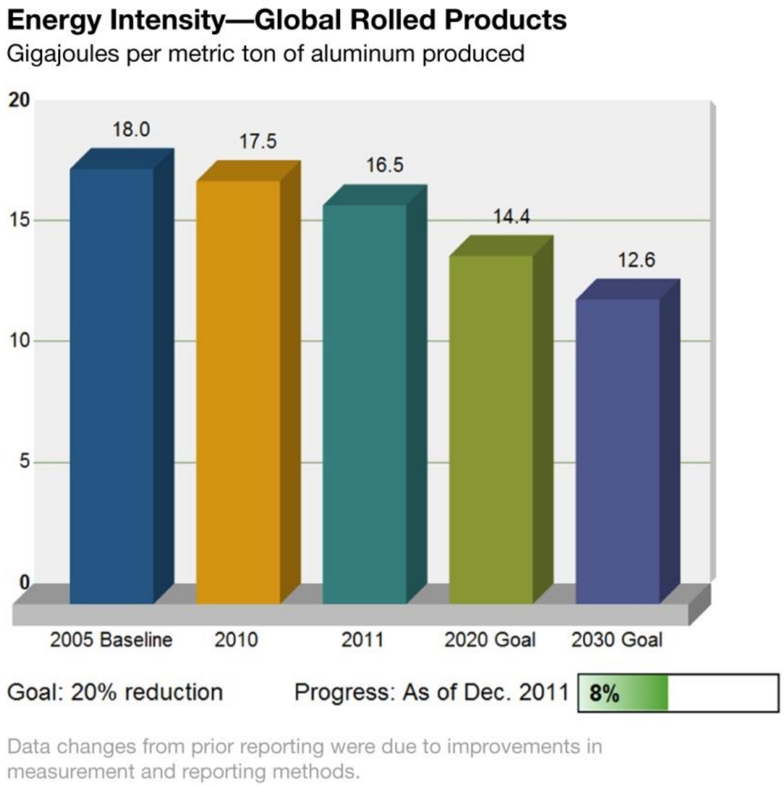


Chart from the Alcoa *2011 Sustainability at a Glance Report*

Where energy opportunities are initiated…

No cost, low cost, and high return.

No Cost / Low Cost Energy Actions Items

Low Cost and High Return Energy Actions Items

Capital Investment Energy Actions Items

Productivity Actions Items

Opportunities Identified

Tools

- Technical Assessments
- Energy Kaizens
- Technical assistance
- Standard Practices
- Vendor and utility programs

Resources

Internal Staff

Plant resources

Agencies

DOE

EPA

State resources

Consultants

Vendors

Data Gathering

- Data gathering is done before the Kaizen or Assessment so that during the event teams can focus on “floor time” identifying opportunity
- A set of excel templates are provided to identify significant energy users, annual cost / consumption, and plant operating parameters
- Additional information such as project lists and major upgrades that will affect the plant energy profile should be included
  - Plant energy profile – meter or utility data
  - Lighting count
  - Proposals for upgrades / projects
  - Existing projects / upgrades
  - Previous energy assessments
  - Utility rate structure / contracts

Most often a pre assessment visit is arranged with EE staff

Information needs

Energy invoice data	Plant details	Largest energy users
Contact person (SPA)	What does the plant want to investigate	What metering is available

Tools - Alcoa Energy Efficiency Suitcase

HOBO U12 Data Logger + 600 AMP Split Core Current Transformer

HOBO H22 Energy Logger – Multi Channel Multi Transducer Data Logger

HOBO U12-014 Logger – 0 to 1800 degree thermocouple

Testo 540 Light Meter

Kill-A-Watt 120VAC outlet energy meter

Dickson Pressure Logger

Fluke 345 – Clamp Meter (Power Factor / Energy Logging)

UE Ultrasonic Leak Detector

Activities and Timing

2 months	1 month	1 week	Event
Request for activity Establish contact person Assure management support Arrange a pre-visit Target a date Identify consultants if needed Consider inviting other plants or neighbors Utility participation? Will there be training? Will others be invited? Internal consultants Define any cost share	Complete pre – visit Send invitations if applicable Develop an agenda Gather energy use data Deploy measuring devices Determine plant participants are on board – guides, safety, EHS, etc Arrange logistics with plant Rooms Directions Electronics	Re affirm plant participants Send equipment Review logistics and agenda Confirm plant management participation Assure no changes are made prior to event	Be there and be fully committed to the event Engage plant management Capture all ideas quantify them Leave plant with summary and value of opportunities

Energy Assessment

EXECUTION

Five day program reviews all aspects of energy use.

- Technical investigation of specific energy users.
- All opportunities (capital and non-capital) identified and quantified.
- Involves both internal and external experts.
- Full report of findings prepared.

Kofem Assessment Report

Recommended Action	Estimated Cost ($)	Estimated Annual Savings ($)	Simple Payback (Years)	Classification
Compressed Air Distribution				
Extrusion Area Conpressed Air Induction Nozzle Use	$0	$1,880	0.00	Maintenance/Process Improvement
Subtotal	$0	$1,880	0.00	
Fans & Blowers				
Reduce Cooling Air Requirements for FRP Mill Motor During Downtime	$8,000	$13,000	0.62	Maintenance/Process Improvement
Subtotal	$8,000	$13,000	0.62	
Furnaces				
Birlec Homogenizing Furnace Combustion Air Preheater	$90,000	$39,120	2.30	Capital Project
Elhaus Billet Heating Furnace Combustion Air Preheater	$0	$58,680	0.00	Maintenance/Process Improvement
Fancia Homogenizing Furnace Combustio air Preheater	$35,000	$15,648	2.24	Capital Project
Gautschi Homogenizing Furnace Combustion Air Preheater	$150,000	$58,680	2.56	Capital Project
Scrap Furnace Logistics Optimization	$0	$352,078	0.00	Maintenance/Process Improvement
Subtotal	$275,000	$524,205	0.52	
General & NEC				
Adjust Smelter Air Demand Tariff	$0	$120,000	0.00	Maintenance/Process Improvement
Combined Heat and Power for Anodizing	$470,000	$213,000	2.21	Capital Project
Combined Heat and Power for the Hot Mill Emulsion System	$150,000	$65,000	2.31	Capital Project
Subtotal	$620,000	$398,000	1.56	
Steam Distribution				
#75 Boiler Feedwater Economizer	$20,000	$12,675	1.58	Capital Project
Incinerator Feedwater Preheater	$13,000	$7,335	1.77	Capital Project
Steam Generation Pressure Reduction	$0	$5,379	0.00	Maintenance/Process Improvement
Steam Line Insulation	$5,000	$4,890	1.02	Maintenance/Process Improvement
Subtotal	$38,000	$30,279	1.26	
Total	**$941,000**	**$967,364**	**0.97**	

Energy Kaizen

A three day, plant-wide activity focused on:

- Low cost and no cost actions to reduce energy consumption.
- Learning ways to **continuously** improve and reduce energy consumption.
- Cross-functional teams of Alcoans brainstorm ways to reduce energy use throughout the plant.
- Teams identify, analyze, and evaluate energy savings opportunities by observing daily operations.
- Opportunities for reduction are quantified using a standard methodology and calculation.

Alcoa employees implement the kaizen process.

Quantify

- Assessments
  - Internal and external experts to develop estimates during the event
- Kaizens
  - Detail estimating calculators have been developed (Toyota Treasure Hunt)

Energy cost Data

Electric		CO$_2$	
Avg Electric Cost [/kWh]	£0.09	CO$_2$ Rate [lb/kWh]	1.082 lb/kWh
		NG CO$_2$ Emission Rate [lb/MMBtu]	119.5 lb/MMBtu

Misc		Water	
Gas Cost [£/MMBtu]	£ 7.84 /MMBtu	Water Cost [£/kGal]	£ 7.260 /kGal
Compressed Air Cost [£/kcf]	£ 0.169 /kcf	CHW Cost [£/kTon]	
Steam Cost [£/klb]	£ 10.000 /klb	WWT Cost [£/kGal]	£ 29.440 /kGal
Altitude (Above MSL) [ft]	23 /ft	POTW Cost [£/kGal]	
Sub Resources			
Type	Compressed Air (kscf)	Steam (klb)	Chilled Water (kTon)
Electricty [kWh/unit]	1.69 kWh/kscf		
Gas [MMBtu/unit]			
Water [kGal/unit]			
Other [$/unit]			

Compressed Air Leaks							
Input	User Defined			Value	Details		
Electric Cost [$/kWh]				£ 0.086 /kWh			
Compressor Power Qualifier	20.00 kW/100scfm	Rotary Screw (Lubricant-Injected)		20.00 kW/100scfm	*Typically 15 - 25*	*Estimated Air Cost*	*\$ 0.287 \$/10³sft³*	*\$ 10.123 \$/10³Nm³*
Compressor Control Qualifier	50%	User Defined		50%	*Typically 20%- 90%*	*Captured Air Cost*	*\$ 0.143 \$/10³sft³*	*\$ 5.062 \$/10³Nm³*
Captured Compressed Air Cost Fraction of Full Compressed Air Cost							
It is common for the Captured Compressed Air Savings to be much less than the Full Compressed Air Cost calculated above. This results from the compressor control strategy.							
Discharge Coefficient	0.35	Sharp Edged		0.60			
Operating Period [hr/yr]	8,760.00 hr/yr						
Compressed Air Temp [°F]	80. °F						
Compressed Air Pressure [psig]	95. /psig						
Atmospheric Pressure [psia]	14.7 /psia						

Calculation sheet

Kaizen Info

Kaizen Title:	EDM Extraction - Small EDM Area	Plant:	Exeter
		Business Unit:	APP
Process / Equipment:	FEX1014 and FEX1013	Originator:	Samuel Hollis
		Date:	4/14/2013 Set to Today

Resources

☑ Electricty ☐ Natural Gas ☐ Compressed Air ☐ CA Leak Survey ☐ Steam ☐ Chilled Water ☐ Water ☐ WWT ☐ POTW ☐ Other

Kaizen Description

Description: Small EDM extraction left running 24hrs/7days. Not required to run all weekend - Operator to turn off extraction over weekend. Motors = 5.5kW each, used single figures of total 11kW for option 3 calculations.

Current Situation (Before Kaizen)				Projected Situation (After Kaizen)			
Production Hours		Non-Production hours		Production Hours		Non-Production hours	
24	Hrs/Day	24	Hrs/Day	24	Hrs/Day	9	Hrs/Day
22	Days/Mo. Winter/Gas	22	Days/Mo. Winter/Gas	22	Days/Mo. Winter/Gas	4	Days/Mo. Winter/Gas
12	Months ___ Mo.	12	Months ___ Mo.	12	Months ___ Mo.	12	Months ___ Mo.
1	# of units	1	# of units	1	# of units	1	# of units

Energy Use

Energy units			Energy Use Before Kaizen (Energy units/yr)	Energy Use After Kaizen (Energy Units/yr)	Energy Savings (Energy Units/yr)	CO2
Electricity (kWh)	Non-prod	N	115,597.6	61,739.6	53,858.0	26.4
Gas (MMBtu)			-	-	-	0.0
Compressed Air (kWh)			-	-	-	0.0
Compressed Air Leak (kWh)			-		-	0.0
Steam (kLB)			-	-	-	
Chilled Water (kTon)			-	-	-	
Water (kGal)			-	-	-	
WWT (kGal)			-	-	-	
POTW (kGal)			-	-	-	
Other: Explain					-	
					Total CO2 Savings/yr	26.4

Cost / Savings

Implementation Cost	
Engineering Services:	
Material:	
labor: Contract	
labor: In House	
Other:	
Other:	
Other:	
Other:	
Other:	
Total:	£0.00

£/unit	Projected Annual Savings		
£ 0.09	Electricity (kWh)	£	-
£ 7.84	Gas (MMBtu)	£	-
£ 0.09	Compressed Air (kWh)	£	-
£ 0.09	Comp Air Leak (kWh)	£	-
£ 10.0	Steam (kLB)	£	-
£ -	Chilled Water (kTon)	£	-
£ 7.26	Water	£	-
######	WWT (kGal)	£	-
£ -	POTW (kGal)	£	-
	Other: Explain	£	-
	Total:	£	4,631.78
	Simple Payback Period (yrs):		0.00

Energy Kaizen Example

EXECUTION

Plant Air Pressure Reduction

Reduce North and South plant compressed air pressure from 115 psi to 85 psi.

Savings: $13,000
Installation: $1,200
Payback period: 0.1 years

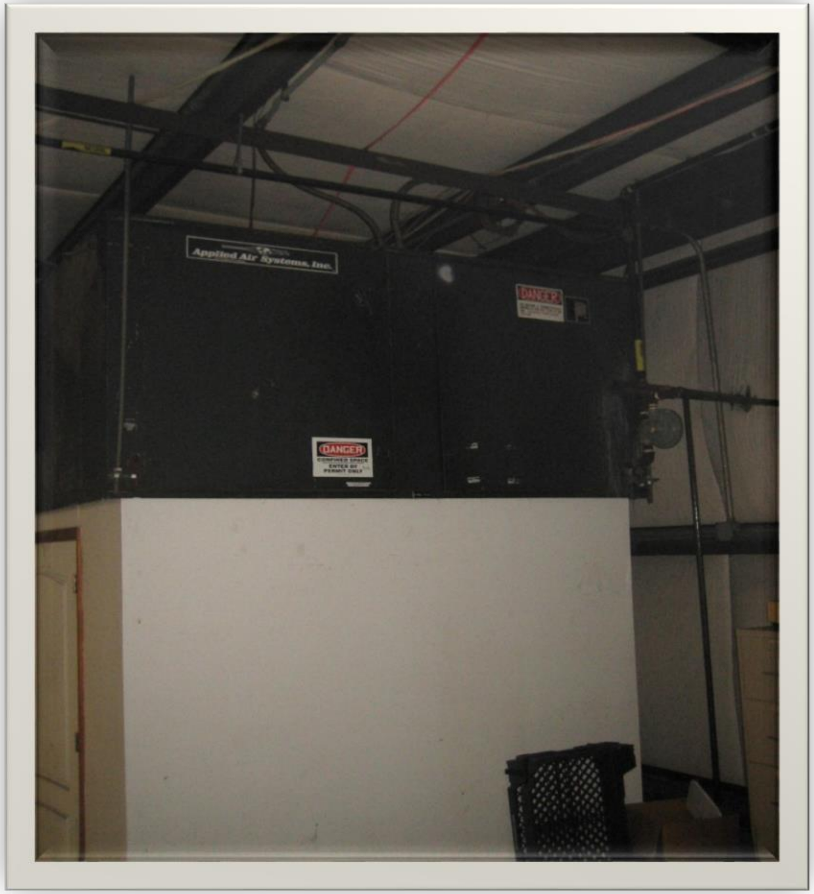
Reducing Light Usage

Turn off 36 of the 400W high bay lights where not needed.

Examples include storage and other areas lit when not used.

Savings: $7,000
Installation: $1,000
Payback period: 0.14 years

Isolate Unnecessary MAUs



Turn off gas supply for six make-up air.

Savings: $49,000
Installation: $0
Payback period: Immediate

So…. How do I get invited to a plant?

Technical Assistance

By phone

By email

In person

The Corporate Energy Team is available to help with questions, problems, issues, and ideas.

SPAs also a good source for phone or email assistance.


Win the energy challenge with
ISO 50001
ISO 50001
energy management
ISO

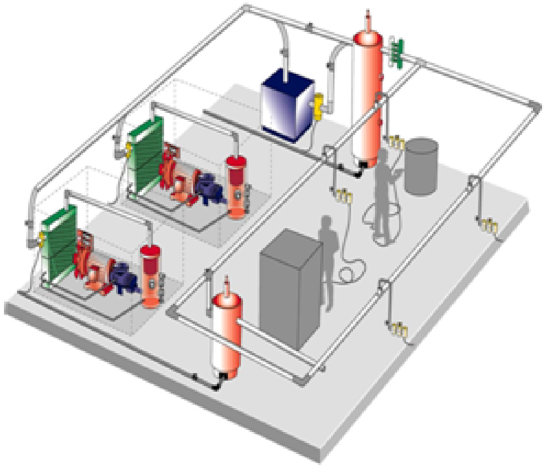
Compressed Air - Best Practices

Introduction

Best practice ELEMENTS for compressed air are listed below.

ELEMENTS:

Section 1	Compressed Air End Use Utilization
Section 2	Compressed Air Generation / Operation
Section 3	Maintenance
Section 4	Metrics



From Compressed Air Challenge

The structure of the Best Practices for each element is as follows:

Key Aspect	A description of the major areas of importance of this component of Compressed Air System.
Intent	Why each Key Aspect is important and what is its primary goal.
Essential Elements	Describes the two or three main features of each Key Aspect.
Measures	A list of common metrics associated with each Key Aspect.
Minimum Standard	A description of the minimum recommended levels of performance in each Key Aspect.
Best Practice	The minimum requirements plus the best practices observed in each Key Aspect.

Also included is an appendix and reference list.

Document last updated 31 May 2011

Measurement, Management & Verification - Best Practice

Introduction

Best practice ELEMENTS for MM and V are listed below.

ELEMENTS:

Section 1 Measurement – Plant Utility Consumption (Metering)

Section 2 Management

Section 3 Verification

Section 4 Metrics

The structure of the Best Practices for each element is as follows:

Key Aspect	A description of the major areas of importance of this component of measurement and verification.
Intent	Why each Key Aspect is important and what is its primary goal.
Essential Elements	Describes the two or three main features of each Key Aspect.
Measures	A list of common metrics associated with each Key Aspect.
Minimum Standard	A description of the minimum recommended levels of performance in each Key Aspect.
Best Practice	The minimum requirements plus the best practices observed in each Key Aspect.

Also included is an appendix and reference list.

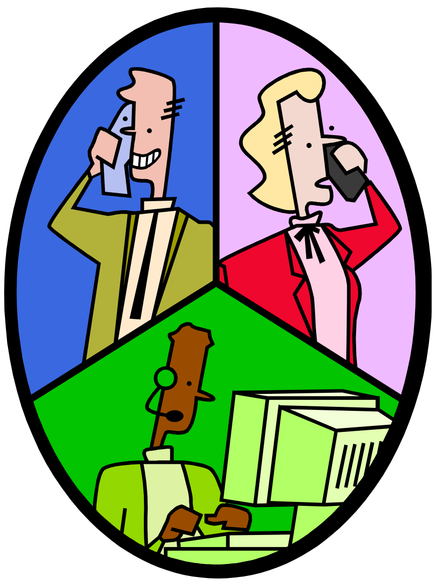
Document last updated 13 January 2011

Standard Practices help encourage

Evaluation Date	[redacted]										
Target Area											Average
1.1 Compressed air supply and end-use pressure evaluation	2.6	2.0	2.0	2.4	0.4	1.0	1.3	2.0	1.2	0.0	1.5
1.2 End-Use Evaluation	2.5	2.0	2.0	1.0	0.0	1.0	1.0	2.0	0.0	0.0	1.2
1.3 CSA (Customer Satisfaction Analysis)	2.5	1.0	1.0	2.0	0.5	1.0	1.0	2.0	1.5	0.0	1.3
1.4 Process Change Log (Compressed Air Champion)	3.0	1.0	1.0	2.3	0.7	1.0	2.3	1.0	0.0	1.0	1.3
2.1 Compressor Control (multi-compressor control strategy)	3.0	3.0	2.5	2.5	0.5	0.0	2.5	2.0	1.5	0.0	1.8
2.2 Primary Storage and Pressure-Flow Control	3.0	3.0	2.5	2.7	0.0	1.0	1.0	2.0	2.0	1.0	1.8
2.3 Air Quality Evaluation	2.5	2.0	2.0	2.3	0.3	0.0	1.5	1.0	0.5	0.0	1.2
2.4 Air Dryer Operation	2.0	2.0	2.0	2.7	0.0	1.0	1.0	2.0	2.0	0.0	1.5
2.5 Liquid Removal Evaluation	2.5	2.0	2.0	2.5	0.5	2.0	2.0	1.5	1.0	0.0	1.6
2.6 Compressor Thermal Energy Recovery Evaluation	1.7	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	2.0	0.5
2.7 SOP - Standard Operational Procedure	3.0	1.0	2.5	2.5	0.0	0.0	2.3	2.0	2.3	2.0	1.8
3.1 Compressed Air Leak Management	2.7	1.0	2.0	1.3	0.3	2.0	0.7	2.5	0.0	0.0	1.3
3.2 Compressed Air Supply Reliability	2.9	2.0	2.0	3.0	0.0	1.0	2.0	2.0	0.0	2.0	1.7
3.3 Compressor Maintenance Effectiveness and Expenditures	3.0	2.0	2.5	2.5	0.5	2.0	1.5	1.5	1.5	1.0	1.8
4.1 Compressor Power Monitoring	2.3	2.0	1.5	2.0	0.0	1.0	0.7	2.0	0.0	0.0	1.2
4.2 Compressed Air Flow (Generation)	2.8	2.0	1.5	2.0	0.0	0.0	1.5	1.0	1.0	0.0	1.2
AVERAGE=>	2.6	1.8	1.8	2.1	0.2	0.9	1.4	1.8	0.9	0.6	1.4

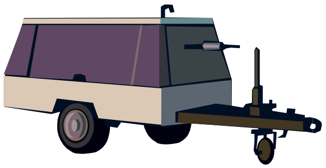
Energy Assessment Tools in Use

Webinars



Lighting Systems

Metering Systems



Compressed Air

Reporting and Tracking

Global Energy Summit

Global & Regional Meetings

COMMUNICATION

Global phone conferences – monthly

Regional conferences – Europe, Latin America, Refining, Canada, LAC

Business unit conferences – BCS, APP, EPS, GRP

Workshops

Two-day workshop helps businesses and locations develop an energy reduction program. Topics covered include:

Getting started

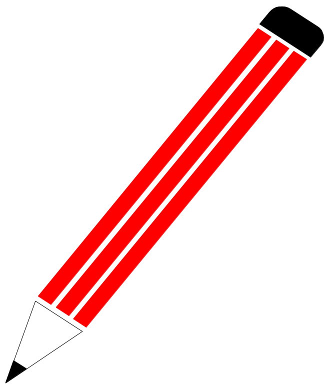
Information sharing

Performing an assessment

Scheduling a Kaizen

Needed actions for energy efficiency

Next steps



Each workshop individualized to the needs of the plant.

Sharing Case Studies

COMMUNICATION

Global Energy Efficiency

2011 No. 8 Case Study

Compressed Air Best Practice

Alcoa São Luis

Background

The Alcoa São Luis, Brazil smelter is one of the largest aluminum smelters in the Alcoa system. As such, it has one of the largest compressed air systems of all Alcoa plants. In 2010 Alcoa São Luis operated all twelve of the sites air compressors continuously. Without backup compressors, any compressor outage impacted site operations and discouraged routine maintenance. The purchase and installation of a new compressor to provide sufficient reserve capacity was estimated to cost about $400,000. By implementing strategies from the Compressed Air Best Practice, São Luis was able to improve compressor availability, avoid the expense of a new compressor, significantly reduce energy consumption and increase system reliability.

Summary

In 2010 a compressed air assessment identified several opportunities to improve system operation. The systematic approach of applying the **Compressed Air Best Practice** provided a framework to achieve savings identified by the site compressed air team. The site was able to reduce their compressed air demand to less than two thirds of its previous value with only eight of the twelve compressors now satisfying the demand. By shutting down four compressors, the $400,000 investment was avoided, routine compressor maintenance did not adversely impact site operations, and annual electricity purchases were reduced by $900,000.

Best Practice-Compressed

The strategies applied to achieve taking four compressors offline are below:

- Reducing compressed air system pressure to match end-use needs
- Enhancing compressor control
- Minimizing compressed air use:
  - Air-slide applications
  - Infrared thermometer cooling
  - Rotary valves in alumina reactors
  - Dust collectors
  - Open blowing applications
- Eliminating air leaks

Alcoa Global Energy Efficiency

2012 No. 4 Case Study

Non Capital Approach to Retrofitting Lighting

Kawneer Springdale, AR

Background

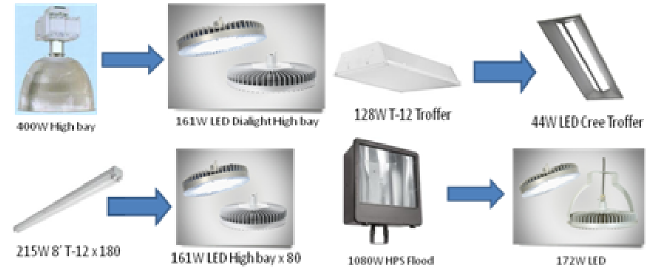
Lighting projects frequently have payback periods between 2-4 years at Alcoa facilities. Justifying capital for lighting projects can be difficult when competing projects typically have a 1-2 year payback. There are a handful of strategies that can be successful in getting new lighting into your facility. Kawneer Springdale of Alcoa's BCS business unit has taken a comprehensive approach to applying these strategies while avoiding capital spending.

Summary

- Replace old fixtures with new fixtures as they fail
- Capture and incorporate maintenance costs into payback of new fixtures
- Incorporate energy intensity reduction goals into justification
- Track energy savings per fixture in DI system
- Rollup less attractive payback areas with the comprehensive facility payback

Case Study Example:

The high initial cost of LED lighting can be offset by taking this approach. Kawneer Springdale is retrofitting with LED technology. LED lighting is becoming more widely available for a number of applications. Below are the retrofit specifications for Springdale:



Sharing Case Studies

COMMUNICATION

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

INDUSTRIAL TECHNOLOGIES PROGRAM

Alcoa: C-Suite Participation in Energy Efficiency Increases Accountability and Staff Engagement Throughout the Organization

Jeff Walker (ITP's former Partnership Development & Deployment Supervisor) and Rick Bowen (Alcoa's President of Energy) at the Alcoa LEADER signing event.

Alcoa's corporate leadership recognizes the benefits of working with the U.S. Department of Energy through the *Save Energy Now* LEADER initiative to advance the company's industrial energy efficiency initiatives.

Alcoa is the largest manufacturer of aluminum and aluminum products in the United States, and one of the largest consumers of electricity on the North American continent. Accordingly, energy consumption at Alcoa's U.S. facilities represents a significant expenditure for the company. Energy consumption by all sources accounts for approximately 26% of the company's total alumina refining production costs, while electric power alone accounts for approximately 27% of the company's primary aluminum production costs. Due in large part to rising energy prices, Alcoa has placed—and maintained—great emphasis on energy management as a cost control measure.[1]

Committing to Energy Efficiency

Alcoa began to focus its attention on reducing the energy intensity of its refining and smelting processes in 1990, in addition to decreasing their associated carbon emissions. This energy and environmental focus was incorporated into the company's first set of sustainability goals in 1993.[2] Since that time, Alcoa has revised its goals on several occasions. The company's newest goals—established in 2009—are to reduce the energy intensity of its primary operations 10% by 2020 (from a 2005 base year) and 15% by 2030. Further, Alcoa aims to reduce the energy intensity of all its other businesses 20% by 2020 and 30% by 2030.[3]

To help achieve these goals, the company developed a number of supporting programs. For example, in 2002 Alcoa's Chief Executive Officer (CEO) and management team established a program called the Energy Efficiency Network. The program's mission is to identify energy efficiency improvement opportunities within the company's operations. To identify these types of opportunities, the network conducts energy efficiency surveys at each of Alcoa's operating locations. After a plant has been surveyed, it is up to the facility's manager and energy team to decide whether to implement the resulting energy efficiency recommendations. To date, Alcoa's Energy Efficiency Network has identified more than $100 million in potential savings opportunities.[4]

Alcoa has a long history of working closely with the U.S. Department of Energy (DOE), benefiting from its unique set of tools and resources as well as access to other experts in the field. One recent partnership opportunity occured in 2009 when Alcoa worked with the DOE to conduct an energy assessment on the combustion systems at one of its U.S.-based smelter facilities. Using DOE's Process Heating Assessment and Survey Tool, Alcoa identified nearly $500,000 in energy savings opportunities for that plant that required no capital investment.

Corporate Energy Management at Alcoa

Alcoa views energy management as a continuous priority for which many people throughout the organization are responsible. In fact, beginning in 2010, Alcoa linked leadership performance pay directly to the company's energy performance.[5] On a day-to-day basis, Alcoa's President of Energy, Rick Bowen, develops the company's corporate-wide energy strategy, in addition to leading the energy team's efficiency efforts.[6] Mr. Bowen reports directly to the company's Chairman and CEO, Klaus Kleinfeld. The Vice President of Energy Services, Richard Notte, reports to Rick.

continued >

Global Energy Efficiency

ALCOA

2012 No. 2 Case Study

Continuous Energy Improvement: Employee Suggestion Program

Kawneer Bloomsburg, Pa

Background

Employee engagement is one of the most effective ways to realize savings from energy management opportunities. Implementing an energy suggestion program at a facility leverages internal knowledge and expertise from the people who are familiar with the process as it applies to a particular location. A change in process or equipment coming from within a facility has "buy-in" because the idea is generated by those who will be affected most by the decision. Energy management standards such as Alcoa's **Energy Management Best Practice** and **ISO50001** specifically require an employee suggestion program to promote cultural awareness and provide continuous energy improvement through internal feedback.

Summary

In June 2012, Alcoa's Kawneer plant in Bloomsburg, Pa, rolled out an employee suggestion program to encourage employees to recognize areas where they can conserve or eliminate wasted energy. The Bloomsburg facility has an active energy team, and the suggestion program opened the doors for all of the employees to participate. The suggestion system helps provide cultural awareness and employee recognition, both important elements in a successful energy management program.

Case Study Example:

Bloomsburg Employee Suggestion Program

1 Provide employees with a system to submit ideas
  - ⇒ Bloomsburg utilized the existing IFE program as a template for getting ideas submitted
  - ⇒ Modifications to the standard IFE form and submittal process provided a familiar framework for employees to work with.
  - ⇒ View their suggestion form to see details on how submissions are handled:

Continuous Energy Improvement ...

2 Create awareness of the initiative
  - ⇒ The program was rolled out at the facility's monthly employee communication meetings.
  - ⇒ They also use this forum to keep employees updated on the status of the program and the winners of the awards for suggestions

3 Incentivize participation "What's in it for me?"
  - ⇒ Energy suggestions get credit for IFE quotas just like a safety observation
  - ⇒ $5 gifts are awarded if an idea is used, $25 gifts are given to the top 3 ideas

Getting Started

Deploy the ISO 50001 Energy Management Standard Practice.

Utilize an Energy Kaizen.

Consider an assessment.

Don’t forget, we are here to help. Contact the Corporate Energy Team for assistance, answers to questions, locating resources.

Questions

This is not just about this year or next…

…energy efficiency is our future.

	$0 to <$10K Usually an expense or operating cost
Low Cost and High Return Energy Actions Items	$5K to <$20K Capital less than 1 year simple pay back
	Capital greater than 1 year simple pay back
	Added production capacity, scrap reduction, etc.

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Industrial Opportunities from Federal GHG Emissions Regulations

Presented to the IETC Energy Managers Workshop

May 20 2014

R. Neal Elliott, Ph.D., P.E.

Associate Director for Research

ACEEE

The American Council for an Energy-Efficient Economy (ACEEE)

- ACEEE is a nonprofit 501(c)(3) that acts as a catalyst to advance energy efficiency policies, programs, technologies, investments & behaviors.
- Nearly 50 staff based in Washington, D.C.
- Focus on end-use efficiency in industry, buildings, utilities & transportation
- Other research in economic analysis; behavior; national, state & local policy.
- Funding:
  - Foundation Grants (52%)
  - Contract Work & Gov. Grants (20%)
  - Conferences and Publications (20%)
  - Contributions and Other (8%)

www.aceee.org

ACEEE American Council for an Energy-Efficient Economy

ACEEE Intelligent Efficiency Conference

November 16 - 18, 2014 • Hyatt Regency • San Francisco, CA

Who Should Attend:

- Energy efficiency program developers and administrators
- Service providers
- Investors
- Entrepreneurs
- Hardware and software developers
- ICT solution providers
- Building automation providers
- Smart manufacturing and smart transportation leaders

#ACEEEIE

ACEEE Summer Study on Energy Efficiency in Industry

August 4 - 6, 2015 • Hyatt Buffalo • Buffalo, NY

Who Should Attend:

- Industrial energy decision-makers and program implementers
- Equipment manufacturers
- Policymakers
- Local, state, and federal agency personnel
- Utility staff
- Consultants
- Leading industrial energy researchers
- NGOs
- Academics

#ACEEESSI

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www.aceee.org/conferences

Federal Regulation of Power Plant GHG Emissions

- May 2007: The Supreme Court Ruled that EPA, under the *Clean Air Act* may regulate GHGs if they are determined to be a danger to human health
- December 2009: EPA issued its "Endangerment Finding," which found that GHGs threaten health & human welfare.
- May 2010: *Tailoring Rule* requires that new or modified sources that subject to New Source Review for other pollutants also meet requirements for GHG. Smaller sources excluded.
- March 2012: *New Source Performance Standards* rule for new utility sources proposed.

Existing Power Plant Rule

EPA proposing to regulate carbon emissions from existing power plants under section 111(d) of the *Clean Air Act*.

- September 2013: EPA requested stakeholder input on how this rule should be implemented
- June 2014: EPA will propose draft rule. Public has 90 day period to comment.
- June 2015: EPA's rule will be finalized rule
- ~June 2016: States file implementation plans

Anticipated that EPA will allow energy efficiency outside power plant fence to count toward state compliance.

Implementation Possibilities

- Up to each state whether or not to include efficiency as a compliance method.
- Two possible approaches:
    - Mass-based (cap in #tons/year)
    - Rate-based (#tons/MWh)
- Will only affect power plants (for now)
- EPA has indicated petroleum refining could be next rule but no schedule anounced

Energy Efficiency for Carbon Credits in 111(d) World—Opportunity for Industry

If states allow energy efficiency gains by customers to be used as a compliance mechanism by the utilities to meet state implementation plans, utilities could pay industrial customers for electricity savings that result in power plant CO_2 reductions.

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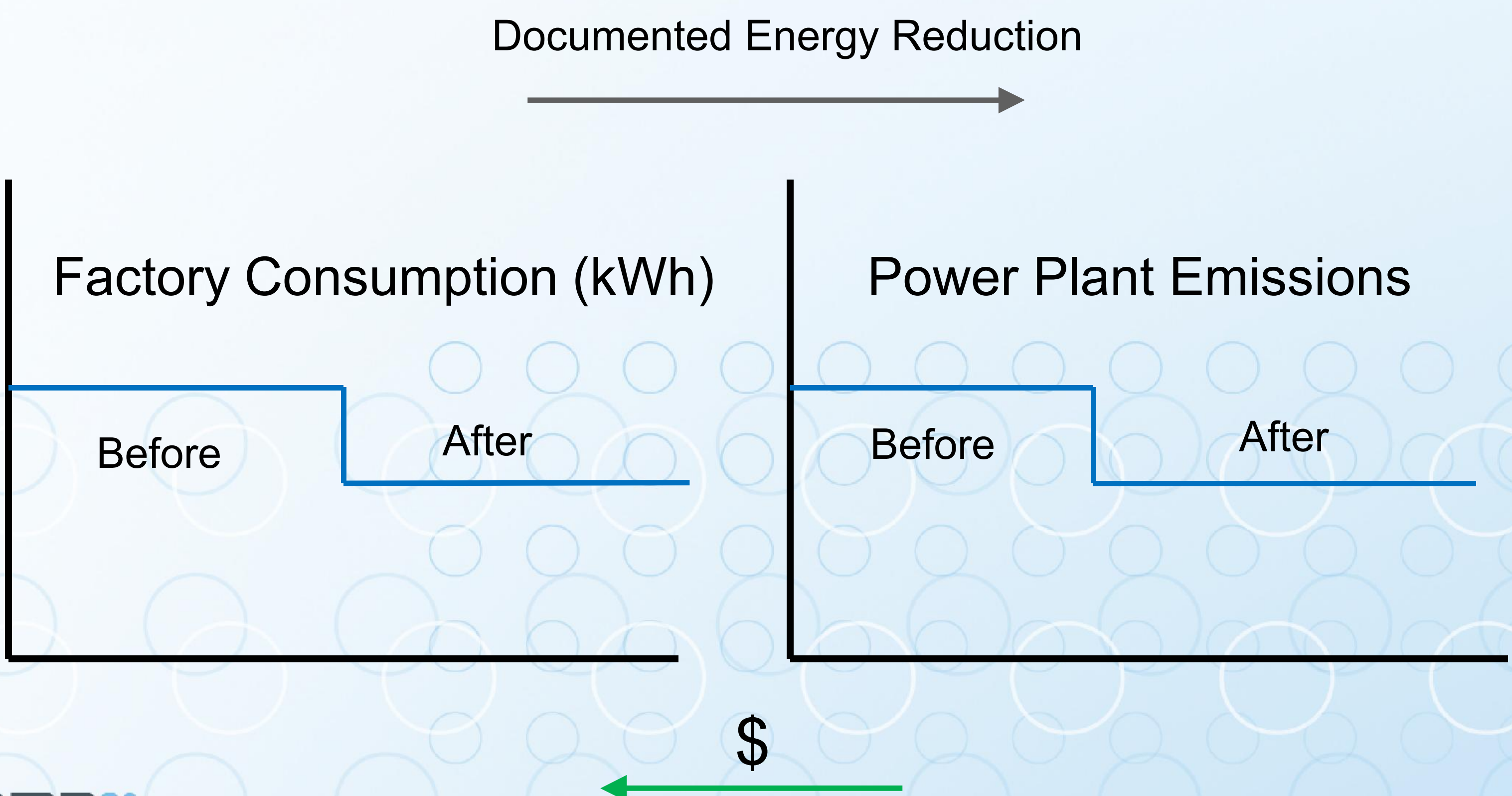
EE as Emission Reduction

How it might work

Electricity only



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What this might mean

- Vendors selling more electricity efficient solutions: can build a CO_2-credits revenue stream into value proposition
- Manufacturers: more efficient plants will have lower energy costs
- Utilities: can still use combustion technologies to provide power

Hot off the presses!
ACEEE 50 State Study

- ACEEE undertook an analysis of how much energy efficiency could contribute GHG reductions nationally and for all 50 states.
- Estimated what the cost and benefits would be to implement energy efficiency.

How Big is Efficiency Opportunity?

ACEEE prepared a top-down policy analysis of EE potential in all 50 states from:

- Energy savings target of 1.5% annually
- Residential & commercial building codes
- Combined heat & power
- State appliance standards for 5 products

To find out:

- Electricity savings available from proven, in-practice technologies and policies
- Cost, economic impact, jobs and pollution

Energy Savings Target

- Essentially an EERS
- Responsible for 75% of all savings
- Picked 1.5% because critical mass of states are already proving it to be possible, and;
  - Research indicates more is possible
  - Several states are already achieving more
- Gradual ramp up of .25% per year – policy not fully achieved until after 2020
- Cost tiers – 17 cents/32 cents (first year)

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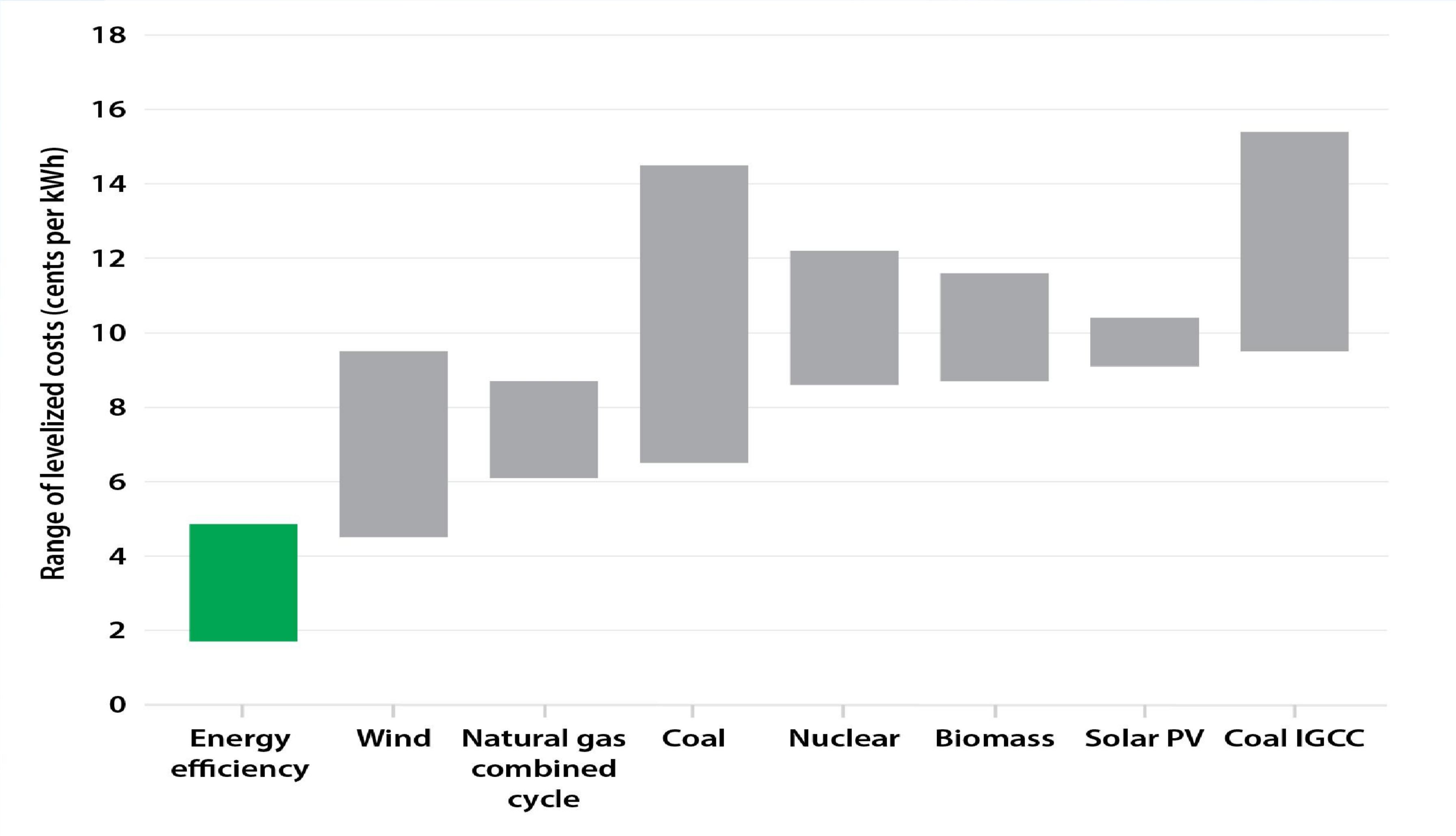
Levelized electricity resource costs



Source: Energy efficiency data represent the results from Molina 2014 for utility program costs (range of four-year averages for 2009-2012); supply costs are from Lazard 2013.

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The Other Three Policies

Building Codes

- Assumes latest codes adopted in 2016 and one more upgrade before 2030
- Eventually reflects savings of 50% relative to 2006 codes

Combined Heat and Power

- Deployment of cost-effective CHP with short payback
- Results in 20 GW of new capacity by 2030

Appliance Standards

- Assumed for 5 products not otherwise regulated: certain halogen lamps, faucets, hot-food holding cabinets, portable electric spas, and certain water dispensers.
- Could be more products

Results - Electricity savings

- 925 million MWh in 2030
  - Note: this is not all EE possible, but is based on what is tested and proven in states
- Savings in 2030 are a 25% reduction relative to 2012 consumption
- 247 GW of avoided capacity
  - nearly 500 power plants

Percentage of electricity savings relative to 2012 consumption, by census region

Region	Total (all four policies)
New England	30%
Middle Atlantic	28%
South Atlantic	24%
East South Central	23%
West South Central	24%
East North Central	22%
West North Central	22%
Mountain	30%
Pacific	27%

Jobs & Economic Analysis

Dynamic **E**nergy **E**fficiency **P**olicy **E**valuation **R**outine, or **DEEPER** model: Input-output model

- National and state-by-state net jobs impact
- National and state GDP/GSP impacts

- The model has a 20-year history of use and development,
  - 15-sector input-output (I/O) model
  - Core data based on IMPLAN
  - Energy consumption and cost data from AEO
  - Labor and employment data from the Bureau of Labor Statistics

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Results – Costs and Economic Impacts

EE scenario costs less than generation

- Efficiency investments required to generate 2030 savings: $47 billion
- Retail price of avoided electricity: $95 billion
- Net savings of $48 billion

Economic impacts

- 17.2 billion increase in GDP in 2030
- 611,000 jobs in 2030

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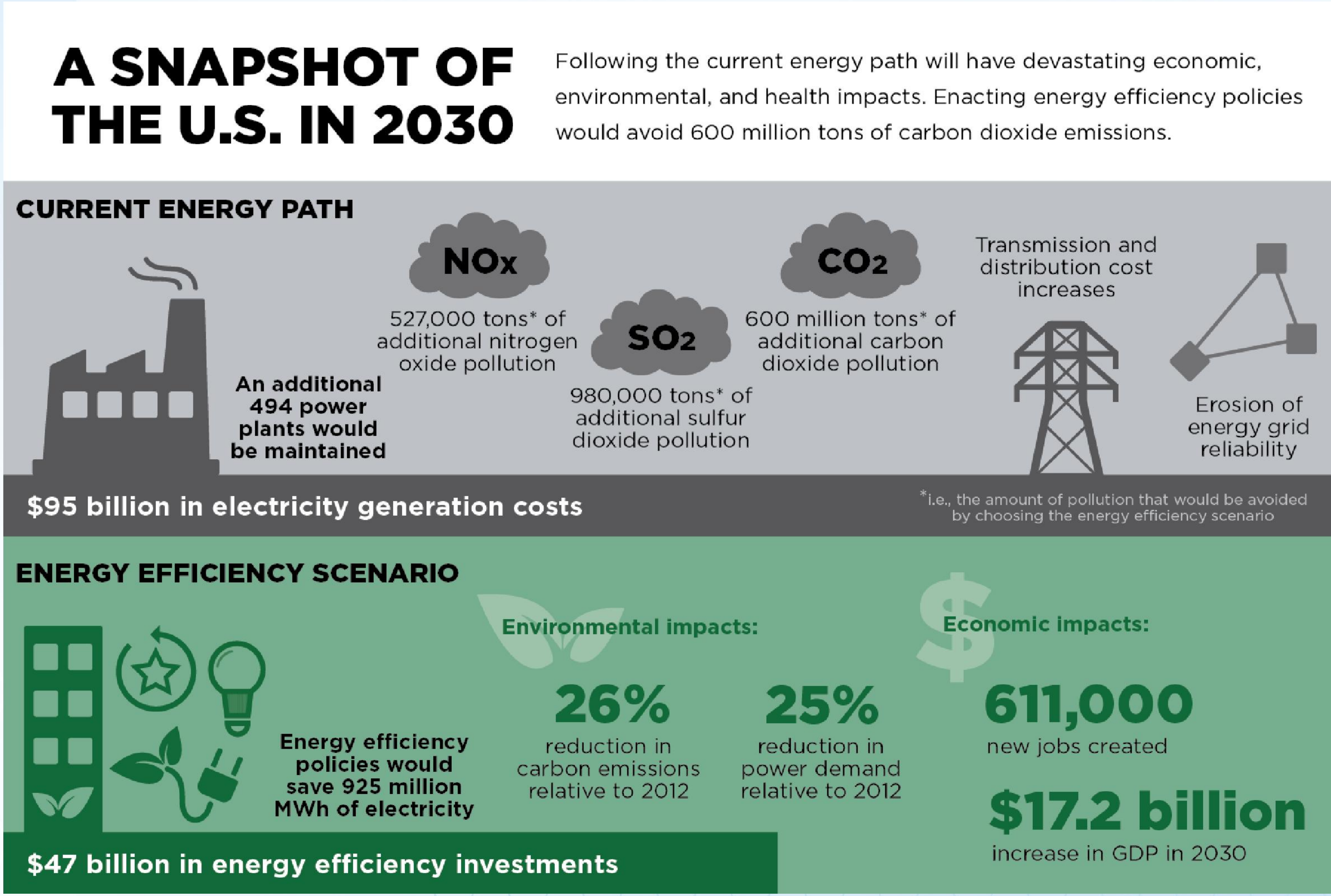

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Key Findings

EE policies and programs already in use could reduce 2030 electricity demand by 25% or more

- States can begin implementing immediately, and many are already doing many of these things
- Policies aren't a guarantee (Indiana, Ohio) and even states that have taken action could benefit from a "back stop"

The economic and employment impacts of this amount of EE would be positive in all states.

- Note: There are market barriers to EE and if the standard isn't aggressive enough states could fall back to more expensive compliance options (as they have done in NAAQS SIPs)

What Next?

We are optimistic that EPA will allow EE to be used as a compliance mechanism AND set the standard based on what could be achieved.

What does this mean for businesses?

- Increased state and utility investment in EE
  - States with EERSs & other EE policies less likely to roll back
  - States that are on the fence might adopt more EE
- Possible opportunity to earn “credits”

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Concluding Thoughts

- Large corporations are including carbon footprints into their public documents
- EPA will try to limit carbon emissions from the utility sector, they will be sued, they will eventually enact new rules
- States will submit plans
- Some will include energy efficiency as a compliance mechanism for pollution
- Large energy users should factor this into their energy plans—represents a strategic opportunity for the firms

Resources

Download the ACEEE's report here: http://aceee.org/research-report/e1401

Template for crediting EE: http://aceee.org/files/pdf/sip-template-0314.pdf

"3N" Preamble: http://naseo.org/Data/Sites/1/media/suggested-emv-preamble-language_4-22-14.pdf

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Thank you!

Neal Elliott, ACEEE

rnelliott@aceee.org
202-507-4009

ACEEE
American Council for an Energy-Efficient Economy

"Industrial Site Energy Master Planning"

Key to Breakthrough Energy Performance

Energy Managers' Workshop

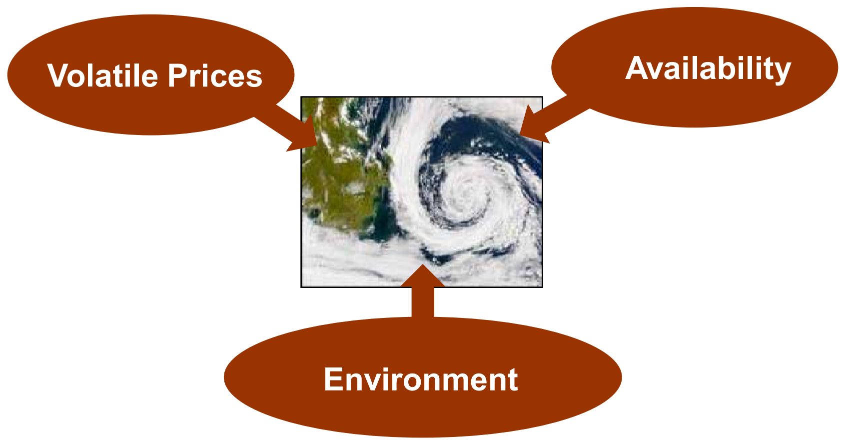
Industrial Energy Technology Conference
May 20th, 2014 New Orleans, Louisiana

Understand Global Energy Realities
Use the Headlines …

- Unpredictable traditional energy pricing
- Political upheavals like Ukraine
- Rapidly falling renewable costs
- Changing patterns of imports and supply
- Uncertain impact of climate change
- Under-invested energy infrastructure
- China and India redefining energy markets
- Blackouts, weather events, water shortages..
- Nuclear rethink impacts natural gas prices?
- Energy innovation & Competitive advantage

Risks and Opportunities

Perfect Energy Storm
Uncertainties combine…



Growing Risks – Growing Opportunities

Superior Corporate Energy Management

- High-level executive commitment
- Empowered Corporate Energy Leader
- Site Energy Teams
- Goals and accountability
- Accurate current energy data
- Resources planned and allocated
- Measure and communicate
- Constantly raise the bar
- Rewards, recognitions and consequences
- Journey – not random efficiency projects
- ***20% - 30% energy productivity advantage***

Any Journey Needs a Map

Site View of Energy
Unique Combination of Risks

Costs

- High/Low energy prices
- Volatility
- Market pressures

Reliability

- Utility infrastructure
- Weather
- Internal infrastructure
- Production interruptions

Emissions

- Carbon legislation
- Carbon taxes/pricing

Need Site Energy Plans for Key Locations

Traditional Energy View of Site
From Fuel to Product

Fuel → Conversion → Distribution — Electricity

Fuel → Conversion → Distribution — Gas

Fuel → Conversion → Distribution — Other Commodities

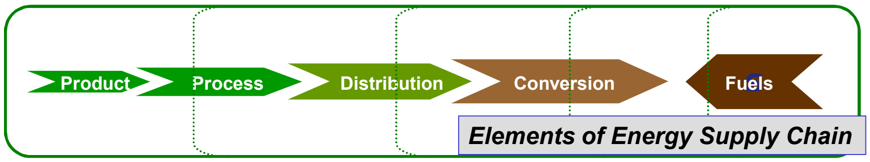
Processes → Product — Efficiency

- High-cost approach with low returns
- Higher future risks
- Major greenhouse gas impacts

Tends to be Sub-optimized & Fragmented

SEP Changes the Thinking
From Product to Fuel

100% of Energy Value Chain

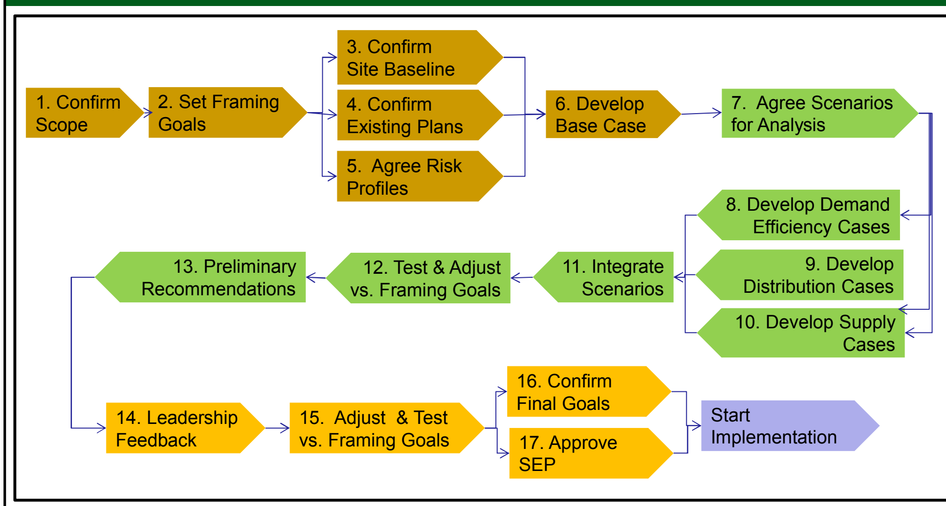


- "How much energy is really needed?"
- "How to minimize greenhouse gas emissions?"
- "Does solution pass risk adjusted hurdle rate of return?"
- "Do it meet supply reliability targets?

- Optimize total investment between efficiency, distribution, conversion, fuel for whole site/system with long-term view
- Plan and resource long-term solutions that meet acceptable returns

Optimized Long-Term Solutions

Developing Site Energy Plan
Process Overview



Supported by Relevant Benchmarking

Establish Site Energy Baseline
SEP Prerequisite

- Detailed picture of site energy flows
  - *Electricity, gas, water, heating and cooling*
  - *Major processes and equipment*
  - *Usage and cost*
  - *By season*
  - *By production loading*
- Sources of direct and indirect emissions
  - *End-uses*
  - *Fuels and utilities*
- Visually intuitive Sankey diagrams often used

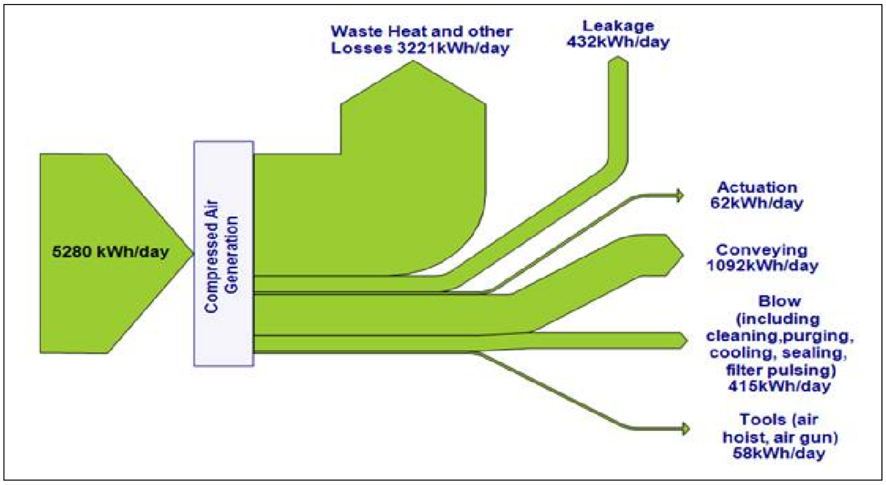
Comprehensive Energy Map

Establish Site Energy Baseline
SEP Prerequisite

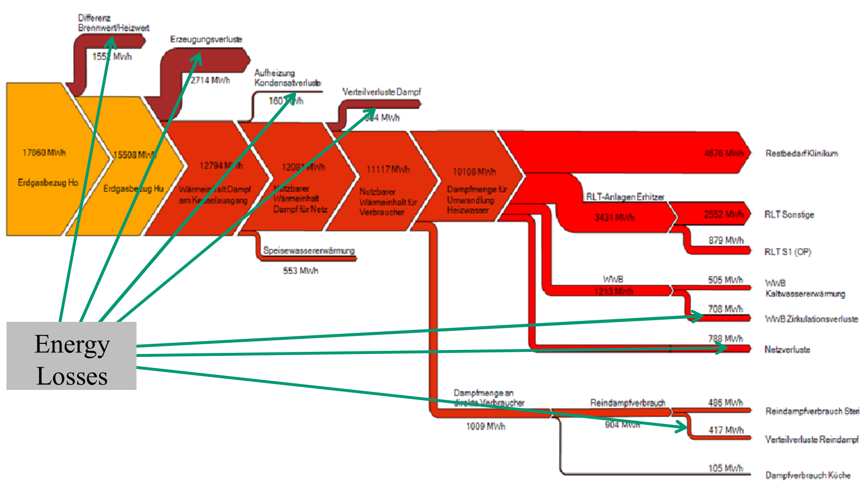
- Detailed picture of site energy flows
  - *Electricity, gas, water, heating and cooling*
  - *Major processes and equipment*
  - *Usage and cost*
  - *By season*
  - *By production loading*
- Sources of direct and indirect emissions
  - *End-uses*
  - *Fuels and utilities*
- Visually intuitive Sankey diagrams often used

Comprehensive Energy Map

Sankey Diagram of a Sub-process
Example: Compressed Air Network



Sankey Diagram of a Site
Example: Heat Flows in a Hospital



Utility Usage – Sample Site Example
2011 Baseline Overview

					End Energy		Primary Energy	
Item	Cost M$/yr	$ inc '06 - '11	Cost/unit $/kWh	$ inc '06 - '11	MMBtu/yr	MWh/yr	MMBtu/yr	MWh/yr
Natural Gas								
Electricity								
Total								

Index (End Energy)	US units	ISO units
Units of Saleable Production	XX.XX Millions	XX.XX Millions
Specific Energy Index (UoSP)	XX MBtu/UoSP	XX kWh_e/UoSP
Grid Electricity GHG Emissions factor	1,133 lb/MWh	515 kg/MWh
Gas GHG Emissions factor	398 lb/kWh	181 kg/MWh
% Renewable Electricity	X%	X%

2011 Carbon Footprint X,XXX Metric Tons CO2e

Note: Numerical example used anonymously in Keynote

Understand and Quantify Site Risks
Sample Site Example

- Energy Productivity
  - *Competition gaining energy productivity advantages*
- Energy Management
  - *Possibility of ISO 50001 being required*
- Electricity Price
  - *Accelerated grid investments*
  - *Cost of meeting Renewable Portfolio Standards*
- Gas Price
  - *Fuel switching by utilities and others*
  - *Accelerating global demand*
  - *Regulation of fracking*

Key to Evaluating Investment Returns

Understand and Quantify Site Risks
Sample Site Example

- Reliability
  - *Regional grid under greater weather stress*
  - *Internal infrastructure*
  - *Lost production impacts*
- Emissions Legislation
  - *Compliance costs of climate regulation*
  - *Compliance impacts of on site-generation*
- Water
  - *Reliability and availability of long-term supply*

Key to Evaluating Investment Returns

Establish Site Framing Goals

- At least 10-year goals which, ***if achieved***, would constitute a clear competitive advantage
- Framing Goals address total site, are specific and easily measured
- Balanced set of goals covering at least:
  - *Reliability / Redundancy*
  - *Energy efficiency*
  - *Environmental performance*
  - *Return on Investment*
- Different scenarios are tested for best-fit to all goals based on at least two future risk pictures
- SEP Recommendation is scenario best meeting Framing Goals taking into account the risks

Framing Goals are Drivers

Example of Framing Goals
Sample Site Example

- Senior Management Challenges
  - *"We must halve the energy use for each product we make to meet best-in-class global competition"*
  - *"Whether we like to or not, carbon pricing in some form will be a reality in the future"*
- Framing Goals
  - *Achieve breakthrough energy performance in five years*
  - *50% increase in energy productivity from 2006*
  - *50% decrease in greenhouse gas emissions*
  - *Ensure acceptable reliability in extreme weather*

Energy Challenge Driven by Competition

Agree Scenario(s)

- Agree on a one or more integrated (efficiency/distribution/supply) scenarios
- Each Scenario will be a combination of:
  - *Measurement and control upgrades*
  - *Portfolio of energy and water efficiency measures*
  - *Heat recovery from both process and infrastructure*
  - *Heating and cooling distribution*
  - *Electricity peak demand management*
  - *Energy and water supply including on-site CHP, renewables, absorption chilling*
- Some features may overlap – efficiency portfolios & sub-metering and control are typical examples
- Major events factored in including major process rebuilds, expansion or significant maintenance replacements
- May have options to test sensitivity – adding a renewable is typical
- Basis for Scenario selection varies
  - *Knowledge and understanding of the site*
  - *Prior studies*
  - *Benchmarking*
  - *Baseline analysis*
  - *Desire to test a particular concept*

Evaluate Integrated Impacts of Different Choices

Select Possible Solution Scenarios
Follow Loading Order

- Energy efficiency – ***If you don't need it don't use it***
  - *Buildings*
  - *Existing manufacturing process*
  - *Reengineered manufacturing processes*
- Heat Recovery – ***If it's already there – use it***
  - *Use existing "waste" heat*
  - *Facilitate with heating and cooling networks*
  - *On-site combined heat and power*
  - *Share waste heat with neighbors*
- Renewable energy – ***If realistic, go carbon free***
  - *Renewable electricity – Photovoltaic, Wind, …..*
  - *Renewable heat - Solar thermal, Biomass, geothermal*
  - *Renewable heat and power – waste-to-energy, biomass*
- Energy Supply – ***Invest where it makes sense***
  - *Optimize site and utility investments*
  - *On-site generation to enhance reliability*

Integrated Scenarios – Tailored for the Site

SEP Scenarios
Sample Site Example

- Base Case (Business-as-usual)
- Basic Efficiency
  - *Implement approved efficiency sub-projects*
- Enhanced Efficiency & Metering
  - *Add extensive sub-metering*
  - *Identified efficiency sub-projects*
  - *Localized heat recovery sub-projects*
- Thermal Integration
  - *Integrating heating/cooling distribution*
  - *Separate hot and cold areas*
  - *Widespread heat recovery*
- Energy Supply Options
  - *Large scale on-site CHP*
  - *Local CHP for critical back-up*

Scenario 0

Scenario 1

Scenario 2

Scenario 3

Scenario 4

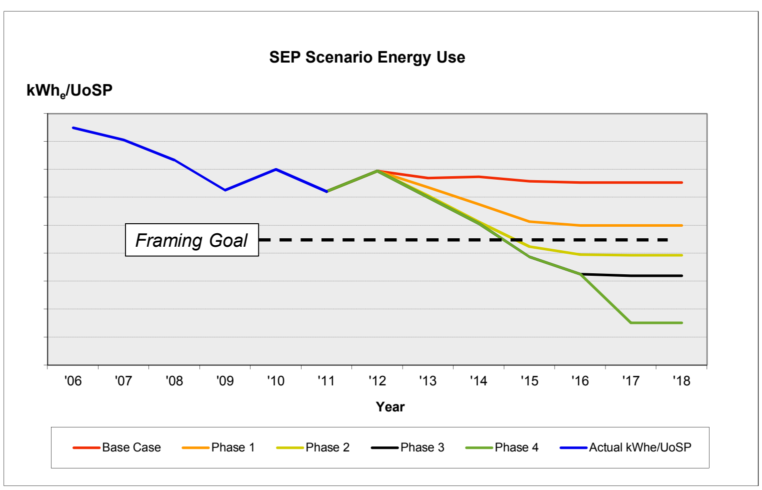
Each are "Fixed Menus" not a Buffet!

Sample Site Integration Workbook
Tailored to Specific Site and Scenarios

- Year-by-year structure
- Assumptions adjustable to do sensitivity tests
- Sub-projects for each Scenario
  - *Investments*
  - *Switchable and assignable*
  - *Efficiency impacts*
- Utility and Emission Pricing
  - *Low and High Risk Prices*
  - *Switchable to each Scenario*
- Outputs by Scenario
  - *Energy use forecasts*
  - *Energy cost forecasts*
  - *Cash flows and returns*
  - *Direct and Indirect emissions forecast*

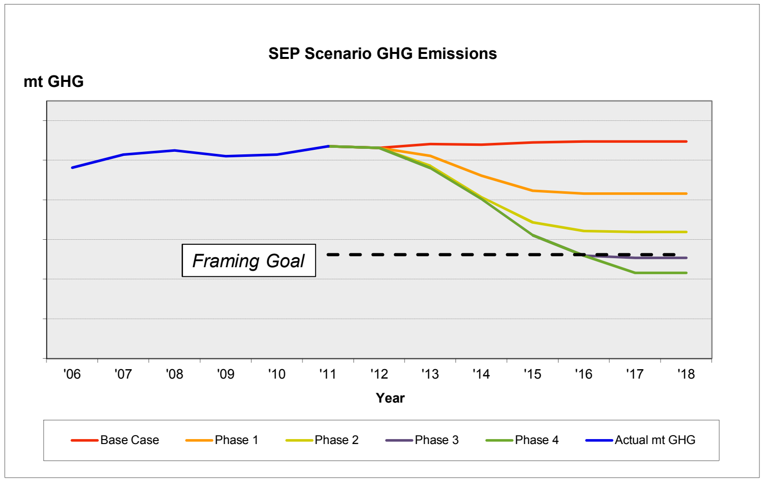
Fully Interactive and Integrated

Sample Site
Energy Index Outlook



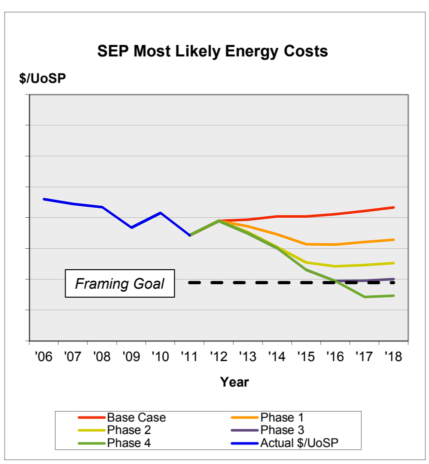
Scenario 2 meets Goal at Constant Prices

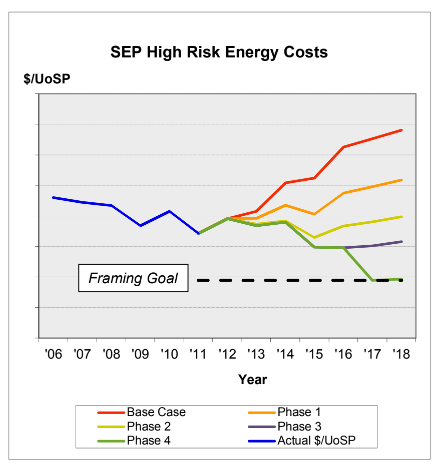
Sample Site
Carbon Footprint Outlook



Only Scenario 4 Meets GHG Goal

Sample Site
Energy Productivity Outlook





Only Scenario 4 Meets Risk-Adjusted Cost Goal

Sample Site
Consolidated Results

	Framing Goals	2011 Base Line	2017 Base Case	Scen 1 "Base Case"	Scen 2	Scen 3	Scen 4
Most Likely IRR	X%	NA	NA	NA	X%	X%	X%
High Risk IRR	X%	NA	NA	NA	X%	X%	X%
$/UoSP Most Likely	$0.X	$0.X	$0.42	$0.X	$0.X	$0.X	$0.X
$/UoSP High Risk	$0.X	$0.X	$0.65	$0.X	$0.X	$0.X	$0.X
$/UoSP ML % gain	50%	NA	NA	XX%	YY%	ZZ%	AA%
$/UoSP HR % gain	50%	NA	NA	XX%	YY%	ZZ%	AA%
GHG Reduction	50%	NA	NA	XX%	YY%	ZZ%	AA%
GHG Emissons mt	XX,XXX	XXX,XXX	109,600	XX,XXX	XX,XXX	XX,XXX	XX;XXX
Total Investment M$	-	-	-	$0	$XX	$XX	$XX

Only Scenario 4 Meets Risk-Adjusted Return Goal

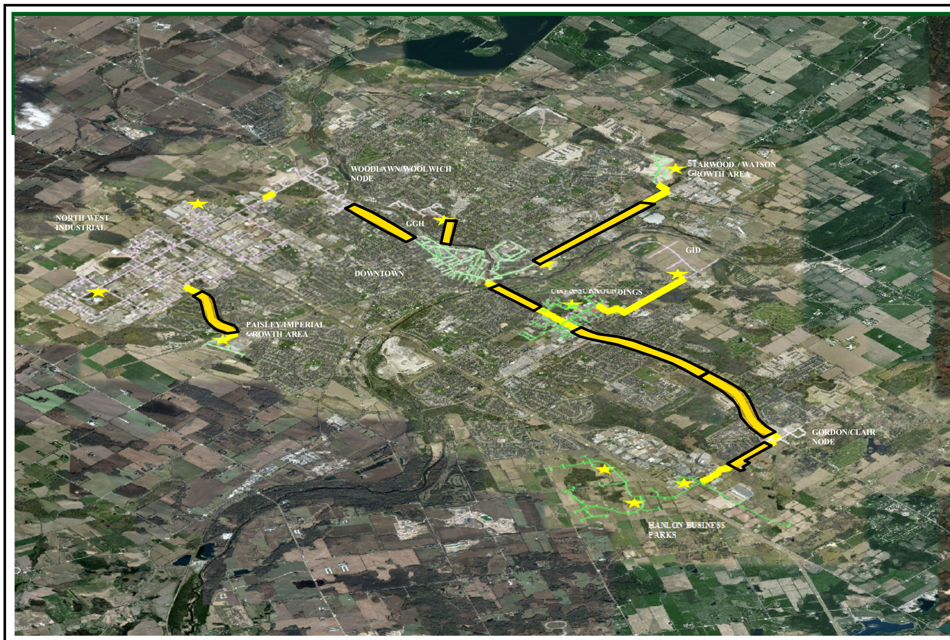
Integrated Site Energy Master Plan
Sample Site Conclusions

- Senior management challenge was key
- Setting Framing Goals before evaluating options was essential to set expectations
- Deep understanding of energy Baseline and Risks was indispensable first step
- Flexible Integration Workbook answered all management challenges
- Framing Goals
  - *All were met in High Risk Case*
  - *Most were met in Low Risk Case*
- SEP is long-term basis for ongoing prioritization of sub-project investments
- SEP Process to be proliferated to other Corporate key sites

Heat Recovery Paradox
Elusive value to capture

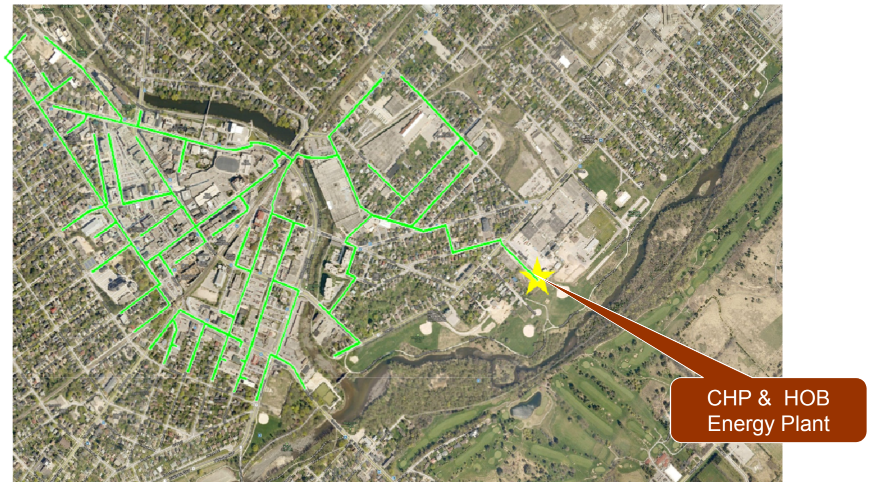
- Up to 50% of site energy is lost as heat
- Priority for Energy Management initiatives
  - *Cost and risk reduction*
  - *Greenhouse gas reduction*
- Valuable uses with good economics
  - *Hot water, space heating, batch pre-heating…*
  - *Use only small portion of available heat*
- Other uses rarely have good economics
  - *Electricity generation from recovered heat*
  - *Cooling from absorption chilling*
- Competing with low-cost electricity
- No economic value for emissions reduction (in US)
- On-site CHP creates even more heat

Can we rethink this?



Creating Citywide Heating Utility

Downtown Example
Integrate Industry Power and City Heat Needs



Network Started –Complete by 2019

Thank You

Peter Garforth
Garforth International llc
peter@garforthint.com
+1 (419) 578 9613 - Office
+1 (419) 320 0664 - Mobile

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Measuring Non-Energy Benefits
of Industrial Energy Efficiency:

THE CURRENT FRONTIER

CHRISTOPHER RUSSELL
Visiting Fellow, ACEEE :: crussell@aceee.org
in cooperation with Navius Research of Canada

American Council for an Energy-Efficient Economy
www.aceee.org

- ACEEE: a nonprofit 501(c)(3). Catalyst to advance energy efficiency policies, programs, technologies, investments & behaviors.
- 50 staff in DC, MD, DE, MI, WA & WI
- Focus on end-use efficiency in industry, buildings, utilities & transportation
- Other research in economic analysis; behavior; national, state & local policy.
- Funding:
  - Foundation Grants (52%)
  - Contract Work & Gov. Grants (20%)
  - Conferences and Publications (20%)
  - Contributions and Other (8%)

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Outline for Today

- Aspiration: define and recognize the full range of non-energy benefits (NEBs) resulting from energy efficiency improvements
- Intermediate findings
- Issues and opportunities for developing and using such information

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3

WHY NEBs?
PLANT LEVEL

- Real dollars, full benefits of energy improvements remain hidden
- NEBs values accrue beyond utility bills
  - Stronger accounting of cash flows and investment returns
  - Broader organizational and business impacts
  - Broader range of interested stakeholders
  - Increased credibility, defense of energy management functions

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WHY NEBs?
REGIONAL ENERGY MARKETS

- Real dollars ➔ enhanced justification for capital investment
- Greater business returns ➔ greater competitiveness and viability of utility ratepayers
- Clear accounting of NEBs values:
  - Stronger transparency of avoided costs for utilities
  - Closer alignment of utility tariffs with actual value and benefit of energy use
  - Improved structuring of demand-side rebates and incentives

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Ideal Outcome: Value Forecasts

Forecast the type and value of NEBs for any single project based on past observations:

\$NEBs = f(type of energy measure, industry application, etc.)

Ratio: NEBs per MMBtu

"Best" data? Already collected in large volume,
formatted for instant querying and interpretation.
Allows NEBs estimate within bounds of statistical certainty.

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"Next Best" Outcomes
If the *ideal* is not available…

- Estimate the effort needed to attain the ideal:
  - Sources?
  - Definitional consistency?
  - Data standardization?
  - Time and effort?
- Census of what currently IS available.

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CRITICAL ASSUMPTIONS

- **INTEGRITY OF OBSERVATION.** Change in energy consumption can be wholly attributable to specific projects. Change in energy consumption and NEBs for any one project can be isolated from other simultaneous projects in the same facility.
- **INTEGRITY OF MEASUREMENT.** Accurate consumption baseline measures. Measurement of savings are standardized across all observations.
- **NORMALIZATION OF VARIANCE.** Before/After consumptions are normalized for production, weather, etc. When comparing two or more facilities, adjustments can be made for differences in utilization factor (annual hours of operation) and overall system design.
- **INTEGRITY OF DATA COLLECTION.** All facilities have the ability and motivation to measure and consistently document project-specific energy use before and after EACH improvement. (NOTE: Utility programs routinely rely on customer self-measurement and reporting.) There are no proprietary issues forbidding the facility to share its energy data.

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U.S. DOE INDUSTRIAL ASSESSMENT CENTER DATABASE
ENERGY CONSERVATION MEASURE CLASSIFICATION SYSTEM

2.3	**ELECTRICAL POWER**
2.31	DEMAND MANAGEMENT
2.311	Thermal Energy Storage
2.313	Scheduling
2.319	Miscellaneous
2.32	POWER FACTOR
2.33	GENERATION OF POWER
2.331	DC
2.332	AC
2.34	COGENERATION
2.35	TRANSMISSION
2.351	Transformers
2.352	Conductor Size
2.4	**MOTOR SYSTEMS**
2.41	MOTORS
2.411	Operation
2.413	Hardware
2.414	Motor System Drives
2.415	Motor Maintenance and Repair
2.42	AIR COMPRESSORS
2.422	Hardware
2.423	Operations
2.43	OTHER EQUIPMENT
2.431	Operations
2.432	Hardware
2.7	**BUILDINGS AND GROUNDS**
2.71	LIGHTING
2.711	Level
2.712	Operation
2.713	Controls
2.714	Hardware
2.72	**SPACE CONDITIONING**
2.721	Maintenance
2.722	Operation
2.723	Hardware - Heating & Cooling
2.724	Hardware - Air Circulation
2.725	Evaporation
2.726	Controls
2.727	Humidity control
2.729	Miscellaneous
2.73	**VENTILATION**
2.74	**BUILDING ENVELOPE**
2.742	Solar Loading
2.744	Infiltration
2.749	Miscellaneous

HOW MUCH DATA?

NAICS	INDUSTRY CLASSIFICATIONS
311, 312	Food, Beverages, Tobacco
313, 314	Textiles & Allied Mill Products
315, 316	Apparel, Leather, & Allied Products
321	Wood Products
322	Paper
323	Printing & Related
324	Petroleum & Coal
325	Chemicals
326	Plastics & Rubber Products
327	Nonmetallic Mineral Products
331	Primary Metals
332	Fabricated Metal Products
333	Machinery
334	Computer & Electronic Products
335	Electrical Equipment, Appliances, and Components
336	Transportation Equipment
337	Furniture & Related Products
339	Miscellaneous

33 Electricity improvement measures
18 Manufacturing industries
-- 594 distinct measure+industry matches
30 replications of each measure+industry
-- **17,820 observations required to achieve statistical validity.**
This is the number BEFORE accounting for regional variance.

9

How close to the ideal can we get?

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10

OUR APPROACH

- Survey of North American experience
- ACEEE covered U.S. contacts, Navius covered Canada
- Obtained 51 U.S. items, 35 Canadian. Sources included utilities and allied regulatory groups, governments, academics, consultants, vendors, and literature.
- "Items" include reports, databases, project summaries

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RESPONSE TYPES

- **REAL, PROJECT SPECIFIC DATA (mostly CADDET)**
  Based on post-implementation measurement
- **EXPERT ESTIMATES BASED ON REAL PROJECT ANALYSES (IAC Database)**
  Central tendencies derived from large numbers of *ex ante* project analyses
- **INDIRECT HARD DATA**
  Statistics describing frequency of NEBs observation, paybacks with/without NEBs, etc.
- **MEASUREMENT PROTOCOLS**
  Formulaic models for evaluating NEBs based on expert consensus
- **PRACTICAL INTERPRETATIONS**
  Project-level rules of thumb for NEB estimation
- **DIOGNOSTIC & METHODOLOGICAL THEORY**
  Approaches for estimating NEBs (program administrator audiences)
- **ANECDOTAL OBSERVATIONS**
  Reference to specific projects' impacts, minimal quantification
- **CONCEPTUAL JUSTIFICATION**
  Theoretical discussion impacts, no quantification
- **DEAD-ENDs**
  No response, or no information to report

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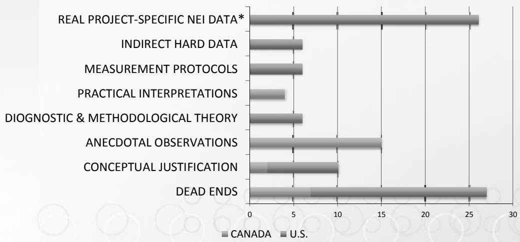
12

86 RESPONSES

This summary DOES NOT include the IAC Database findings (2,378 U.S. project savings estimates)



* Includes many global examples
Not enough for statistically significant measure of of central tendency, confidence intervals, etc. as originally envisioned.

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ABOUT EXISTING NEBs DATA

- Majority of documentation used to support evaluations of energy program cost effectiveness (total resource planning, societal impact costs, etc.) Data are not built up from individual projects (bottom up), but derived from aggregate program results (top down).
- Virtually all top-down NEI/NEB metrics/multipliers are derived from expert consensus, NOT from measurement of actual installations.
- Single largest data source offers estimates, not actuals (IAC Database). 16,300 assessments, 123,000 projects

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EXAMPLE: CADDET* CASE STUDIES

*Centre for the Analysis and Dissemination of Demonstrated Energy Technologies

- Data closest to meeting the criteria sought by this study
- 26 individual industrial, electrotechnology projects. Of these:
  - 77% quantify kWh savings
  - 4% quantify natural gas savings
  - 42% describe gross savings (all forms) in dollars
  - 58% describe electricity savings in dollars
  - Dollar savings sometimes provided for various NEBs (from 4% to 31%)
  - 35% provide simple payback
  - The balance simply note that various NEBs exist, without quantification

Even this “best” data falls FAR short of the quantity and quality needed

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EXAMPLE: INDIRECT HARD DATA:

(Woodruff, et al)
http://www.leonardo-energy.org/sites/leonardo-energy/files/documents-and-links/EECORE%20Benefits.pdf

PERCENT OF RESPONDENTS CLAIMING NON-ENERGY BENEFITS NON-ENERGY BENEFIT	Woodruff, et al Study N=63
Reduced maintenance material cost	92%
Reduced maintenance labor	71%
Permanent CAPEX avoidance	33%
Avoided procurement cost	63%
Avoided purchases of carbon offsets	10%
Enhanced PR, Image	44%

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EXAMPLE: Massachusetts Technical Reference Manual

http://www.ma-eeac.org/Docs/8.3_TRMs/1MATRM_2013-15%20PLAN_FINAL.pdf

O&M ($) SAVINGS PER UNIT INSTALLED OVER ECONOMIC LIFE		
MEASURE	*LOW*	*HIGH*
VARIOUS LIGHTING & LIGHTING SENSOR FIXTURES (p. 418)	$0.41	$33.65

ANNUAL NEI VALUE PER kWh SAVED BY C&I LARGE RETROFIT PROJECTS		
CHP Systems	Administrative costs, O&M	$0.015
Prescriptive Lighting	Administrative costs, material handling, material movement, other labor costs, O&M, sales revenue, waste disposal	$0.027
Prescriptive HVAC	Administrative costs, other costs, other labor costs, O&M, rent revenue	$0.097
Custom HVAC	Administrative costs, material handling, material movement, other costs, other labor costs, O&M, product spoilage, rent revenue, sales revenue, waste disposal	$0.024
Custom Lighting		$0.059
Refrigeration		$0.047
Other		$0.056

Factors based on results of various studies conducted by KEMA, TetraTech and Optimal Energy for Massachusetts program administrators

IAC DATABASE: Highlights

MEASURE	FREQ	ANNUAL kWh SAVED	NATGAS mmBtu SAVED PER MWh	OTHER FUEL mmBtu SAVED PER MWh	NON-ENERGY CENTS SAVED PER kWh	RATIO: $NON-ELEC SAVINGS PER $ELEC SAVED
AIR COMPRESSORS - Hardware	496	105,663,196	0	0	1.43	0.24
AIR COMPRESSORS - Operations	25	1,450,649	0	0	0.34	0.06
MOTORS - Hardware	188	37,641,217	0.47	0	0.43	0.12
MOTORS – Maintenance, Repair	23	3,889,539	0	0	0.84	0.14
MOTORS – System Drives	1,123	331,467,976	0.34	0.17	0.06	0.06
OTHER MOTORS SYSTEMS - Hardware	511	82,807,274	1.54	0.11	12.25	2.21
OTHER MOTOR SYSTEMS - Operations	12	1,255,260	0	0	16.07	2.68

Elec @ $0.06/kWh, natural gas @ $6.00/mmBtu
Savings values are estimates provided by experts across many projects
Ratios are based on multiple project values in summation
Data NOT adjusted for region, annual utilization factors, overall system design, operating strategy, etc.

AVAILABLE NEBs FINDINGS IN 2014

- Overwhelmingly anecdotal data. Statistical reliability remains elusive.
- Indirect measurement of NEBs: rules of thumb or prescribed "percent adders" sanctioned by utility regulators (7.5% to 30% of saved energy value)
- Small samples of describe frequency of observed NEBs by type, no valuation

MOVING FORWARD: Opportunities to Generate Solid NEBs Data

- Entities* interested in improving NEBs data
- Recent North American energy program rebates & incentives have generated lots of custom project feasibility data
- Consider a syndicated effort across participating utilities to generate NEB data from project reports:
  - Pull from past reports, or
  - Develop a collaborative data protocol to ensure consistent data collection across utilities, generate data from future custom projects

* BC Hydro, Ontario Power Authority, Manitoba Hydro, AMEC Environmental Infrastructure, SaskEnergy, NR Canada, Michaels Energy (support contractor to 22+ utilities), National Grid, PGE, WSU Clearinghouse

CONCLUSIONS

- Sufficient data does not yet exist to reliably predict NEBs
- "Second Best" data includes:
  - Expert estimates across many proposals (IAC database, n=2,378 since 2000) and Massachusetts Technical Reference Manual. *Still very limited number of technologies, industries*
  - Actual data for a very small number (n=26) of projects (CADDET)
  - Surveys describing percent of facilities detecting NEBs
- Reconsider: Seek NEBs to improve simple payback? Or seek better investment metrics for energy savings?

ACEEE

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THANK YOU!

Energy Path*FINDER*.com
Christopher Russell
info@energypathfinder.com

@ENERGYpathfndr

View my profile on LinkedIn

ACEEE

SEEA Industrial EE Survey: Drivers of Value for Manufacturers

SEEA
SOUTHEAST ENERGY EFFICIENCY ALLIANCE

SEEA Survey Purpose and Methodology

- January 2013 SEEA wanted to:
  - understand energy efficiency needs of industrial sector in the region
  - identify gaps in existing industrial energy efficiency programs
  - determine how SEEA can offer value to manufacturers
- Two surveys conducted:
  - Existing coalition (~300)
  - Newly identified stakeholders (~200)
- Results from both surveys compared to determine consistency

Survey Questions

1. Name & affiliation
2. How did SEEA provide value in the past (existing coalition members only)?
3. Classification (manufacturer, consultant, vendor, NGO, institution, government/regulator)
4. What activities should SEEA undertake?
5. What types of information should appear on the SEEA website?
6. What topics should SEEA address that yield value?

Survey Results

Existing Coalition (~300)	Additional Contacts (~200)
34 responses, 62% manufacturers, 6% utilities	11 responses, 36% manufacturers, 18% utilities, 9% large commercial
Past experience showed that sharing best practices and networking were valuable	
Top 3 activities: trainings, case studies, technology demonstrations	Top 3 activities: trainings, case studies, technology demonstrations / policy support
Top 3 web resources: Utility/government program information, case studies, financing information	Top 3 web resources: case studies, utility / government program information, tools
Top 3 areas of value: technology demonstrations, energy management, supply chains	Top 3 areas of value: industrial systems, technology demonstrations, energy management / water & energy
Other areas of interest included: policy/ financing, water/energy, industrial systems and new plants	Other areas of interest included: research, policy education, CHP for boiler MACT and energy reliability

Survey “Takeaways”

- Industrial sector interested in energy efficiency
- Technologies, trainings and energy management are key priorities
- Energy efficiency incentives are important to facilitate implementation of EE
- Peer-based resources provide value
- Policies/Programs need clarity/education
- Partnerships between utilities & end users important for EE adoption

Survey Implications

- There is demand for reliable energy efficiency training*/content/technology delivery
  - *Information about trainings & value of trainings
- There is need for policy analysis/education in the region
- Peer-based resources need to be expanded
- Partnerships, regional outreach, recognition are needed for programs to be effective

Value Elements for Manufacturers

- Peer-driven resources:
  - Innovative information-sharing. Examples:
    - Better Plants implementation models
    - IEEN best practices workshops
    - Feedback webinars
  - Industrial EE resource classification. Examples:
    - Mechanism to gauge value of various tools, trainings, materials
    - Program scorecards to identify suitability
    - Mechanism to compile incentives
- Current/emerging technology demonstrations
- Partnerships:
  - Similar to DOE accelerator initiative
- Enhance recognition:
  - Plant-level personnel as well as corporate

Thank you

- Comments/questions?
- industrialeeadvisor@gmail.com
- 202-262-7897

TEAMING UP TO SAVE ENERGY

Protect Our Environment Through Energy Efficiency

ENERGY STAR

CONTENTS

FOREWORD

Organizations with energy programs that achieve results have senior-level support, sufficient energy program staff, and management structures that empower staff to address energy efficiency issues directly. The U.S. Environmental Protection Agency's (EPA) ENERGY STAR® "Guidelines for Energy Management" provide a management structure for organizations to follow in developing a strategy for achieving sustained performance. Forming an energy team is one of the first steps in this framework.

Teaming Up to Save Energy is a "how-to" guide on building an energy management team. The guide discusses the structure, launch, and maintenance of an energy team. Examples from ENERGY STAR partner organizations and a checklist are provided to illustrate practices and help with implementation. This guide complements "Guidelines for Energy Management," which is available online at www.energystar.gov.

AN ENERGY WAKE-UP CALL

Management of energy is good business because it strengthens the bottom line. In many sectors, well-run energy programs may reduce energy costs by 3 to 10 percent annually. By improving financial performance, superior energy practices can create a competitive edge.

Strong energy management is a strategic asset. Besides reflecting overall management acuity, it can be a sign of future profitability. Financial analysts and investment firms increasingly view the quality of energy management as an indicator of financial performance.

Organizations often differ dramatically in energy performance, even when they belong to the same industrial or commercial sector, operate under the same market conditions, and use the same equipment. Why the big performance gap?

The high performers adopt a structured approach to energy management and establish policies and procedures needed to ensure long-term results. They commit to allocating staff and resources to energy management, establishing goals, and adopting a philosophy of continuous improvement.

SITUATIONS:

- Rising energy costs and increasing price volatility.
- Concerns about the reliability of supply.

SOLUTIONS:

- Consider going beyond the traditional organizational focus on energy supply and procurement.
- Reduce supply risks by improving energy efficiency.

SITUATION:

- Your organization's senior managers are convinced that energy management requires capital-intensive purchases or new technology.

SOLUTIONS:

- Use internal examples of energy savings from better management practices and low-cost improvements.
- Find examples of wasted energy and calculate the savings from better practices.
- Use life-cycle costs and benefits to evaluate capital expenditures rather than just initial costs.
- Cite examples of leading companies and organizations with strong energy programs.

The ENERGY STAR "Guidelines for Energy Management" provide a framework for organizations as they develop and implement an energy management program. The steps of the management strategy outlined in the "Guidelines for Energy Management" are broadly illustrated in the graphic on page 3. More details on the "Guidelines for Energy Management" can be found at www.energystar.gov.

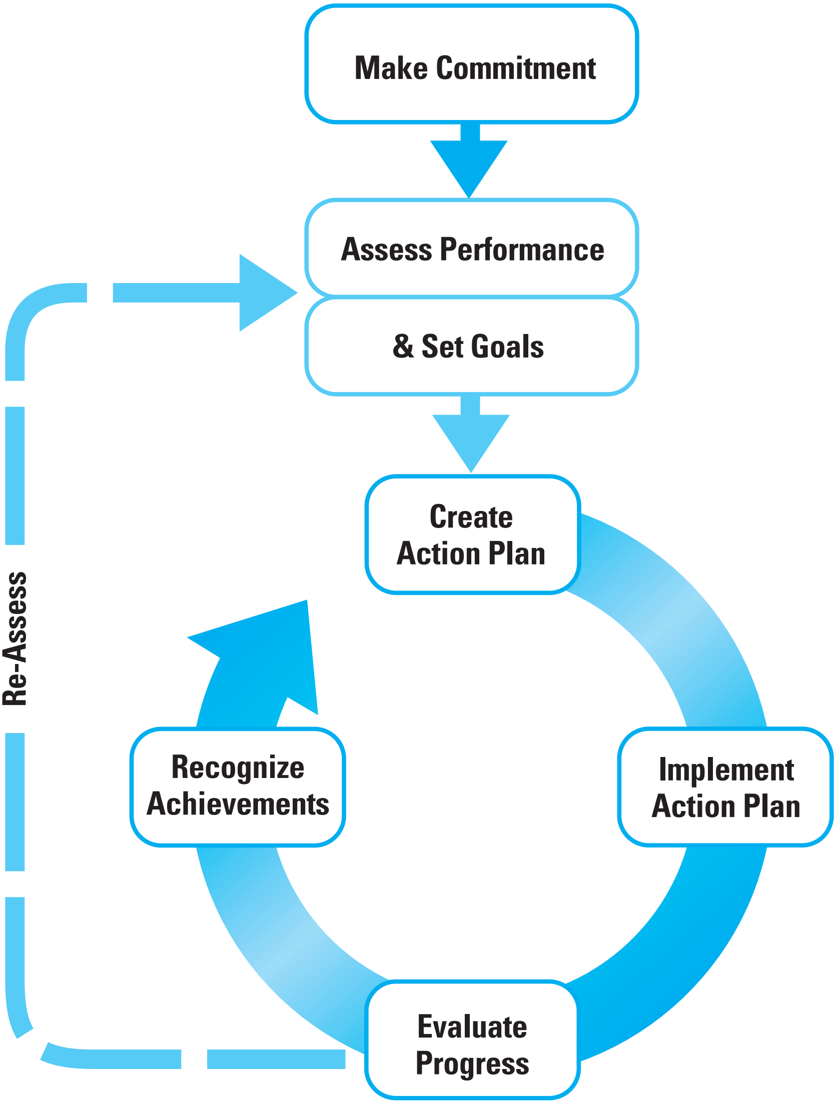
Establishing an energy team is an important part of the first step in energy management, "Make Commitment." The energy team is responsible for planning, implementing, benchmarking, monitoring, and evaluating the organizational energy management program. The team's duties also include delivering training, communicating results, and providing recognition.

This guide is designed to help organizations develop effective energy teams. The guide provides assistance through checklists, guidance, and examples for:

- Organizing your energy team
- Starting your energy program
- Building capacity
- Sustaining the team, and
- Maintaining momentum

FOR EXAMPLE, a culture of energy efficiency is embedded within the organization at **Hines**, an international property development company that builds and manages office space and other real estate. "Making wise use of energy is part of our company culture," says Jim Green, C.P.E., the company's regional manager of engineering services. "If I'm visiting a property and someone shows me new work we've done, I may comment on the quality of the workmanship, but my next question is how does it affect the building's energy picture? Everyone on our staff thinks that way; we mentor them to think in those patterns."

GUIDELINES FOR ENERGY MANAGEMENT



This diagram illustrates the main management elements of the ENERGY STAR "Guidelines for Energy Management." To read the Guidelines, visit www.energystar.gov.

TEAMING UP TO SAVE ENERGY CHECKLIST

ORGANIZING YOUR ENERGY TEAM		See Page	✔
Energy Director	Able to work with all staff levels from maintenance to engineers to financial officers Senior-level person empowered by top management support	7	
Senior Management	Energy director reports to senior executive or to a senior management council Senior champion or council provides guidance and support	8	
Energy Team	Members from business units, operations (e.g., engineering), facilities, and/or regions Energy networks formed Support services (PR, IT, and HR)	9	
Facility Involvement	Facility managers, electrical personnel Two-way information flow on goals and opportunities Facility-based energy teams with technical person as site champion	12	
Partner Involvement	Consultants, vendors, customers, and joint venture partners Energy savings passed on through lower prices	13	
Energy Team's Structure	Separate division and/or centralized leadership Integrated into organization's structure and networks established	14	
Resources and Responsibilities	Energy projects incorporated into normal budget cycle as line item Energy director is empowered to make decisions on projects affecting energy use Energy team members have dedicated time for the energy program	15	

STARTING YOUR ENERGY PROGRAM		See Page	✔
Management Briefing	Senior management briefed on benefits, proposed approach, and potential energy team members	16	
Planning	Energy team met initially to prepare for official launch	16	
Strategy	Success showcased at the official launch	16	
Program Launch	Organizational kickoff announced energy network, introduced energy director, unveiled energy policy, and showcased real-world proof	17	
Energy Team Plans	Work plans, responsibilities, and annual action plan established	18	
Facilities Engagement	Facility audits and reports conducted, energy efficiency opportunities identified	19	
BUILDING CAPACITY		**See Page**	**✔**
Tracking and Monitoring	Systems established for tracking energy performance and best practices implementation	21	
Transferring Knowledge	Events for informal knowledge transfer, such as energy summits and energy fairs, implemented	22	
Raising Awareness	Awareness of energy efficiency created through posters, intranet, surveys, and competitions	24	
Formal Training	Participants identified, needs determined, and training held Involvement in ENERGY STAR Web conferences and meetings encouraged Professional development objectives established for key team members	25	
Outsourcing	Use of outside help has been evaluated and policies established	27	
Cross-Company Networking	Outside company successes sought and internal successes shared Information exchanged to learn from experiences of others	28	

SUSTAINING THE TEAM		See Page	✔
Effective Communications	Awareness of energy efficiency created throughout company Energy performance information is published in company reports and communications	30	
Recognition and Rewards	Internal awards created and implemented Senior management is involved in providing recognition	31	
External Recognition	Credibility for your organization's energy program achieved Awards from other organizations have added to your company's competitive advantage	32	
MAINTAINING MOMENTUM		**See Page**	**✔**
Succession	Built-in plan for continuity established Energy efficiency integrated into organizational culture	33	
Measures of Success	Sustainability of program and personnel achieved Continuous improvement of your organization's energy performance attained	33	

ORGANIZING YOUR ENERGY TEAM

One person cannot do it all. Energy management is a cooperative activity involving a team and, usually, multiple subteams. A team approach improves buy-in from all levels of the organization, which helps to ensure greater energy savings.

ENERGY DIRECTOR

Senior management needs to perceive energy management as part of the organization's core business. The key is an energy team leader at the corporate-level who is empowered by support from the top senior management. The energy director should be passionate about energy management without being a zealot or grandstanding, both of which can decrease team cohesion.

Some energy directors have a technical background; others have financial experience or have been plant managers. Regardless of background, the energy director must be able to work with all staff levels, from maintenance to engineers to financial officers.

DO: Share credit for the achievements of the energy management program with everyone involved. This practice avoids "ownership" struggles and can increase participation because everyone wants to be part of a winning effort.

DO: Visit the organization's facilities on a regular basis to determine their needs.

FOR EXAMPLE, "I'm on the road 50 to 60 percent of the time," says Fred Dannhauser, former global energy manager at **Owens Corning**. "I'm interested in going to the plants and being out on the floor and being their barrier buster with the corporation."

SENIOR MANAGEMENT

The energy director needs to be in touch with the big picture. One way to help ensure empowerment is for the energy manager to report directly to an executive who can serve as a corporate ally.

Another option is a senior management council that provides the energy director with guidance at the strategic level and serves as the corporate champion. The council might meet annually and be composed of representatives from each business unit and, for multinational organizations, each region. Other members might include the CFO, treasurer, and director of purchasing.

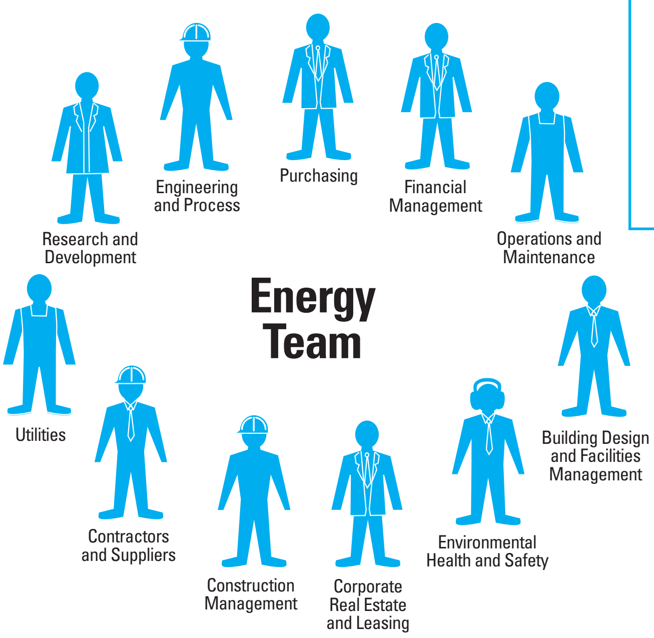
DO: Secure an ENERGY STAR Partnership letter signed by your CEO and use it as one of the team's credentials to help empower your team.

DO: Involve your CEO in recognizing individuals and facilities that achieve significant gains in energy performance.

ENERGY TEAM

As with the strategic-level council, the number of people on the energy team at the operational level depends on the size of your organization. The right mix of players on this energy steering committee is crucial. The energy director might recruit team members based on business units, operational areas, and/or regions.

Consider a representative from each operational area that significantly affects energy use, such as:



Other possible members of the core energy team include plant managers, plant engineers, and electrical supervisors. One important consideration is to ensure that the team is multidisciplinary. A diverse, cross-functional team can find more opportunities for reducing energy use. Some multinational organizations have multiple levels of energy teams, which form an energy network. A small organization may have only a few key representatives.

FOR EXAMPLE, at **California Portland Cement Company**, a subset of the company's energy team is made up of process engineers who visit a different plant every six weeks and do an energy audit. At one plant, the process engineers focused on the finish grinding system and identified $300,000 in opportunities for annual energy savings.

SITUATIONS:

- At many manufacturing sites, investments in process improvements take priority over energy investments.
- Usually the funding of projects is based on first cost rather than life-cycle cost.

SOLUTIONS:

- Include process engineers as part of the energy team to provide access to process improvement planning.
- Consider developing indicators that measure the financial and environmental benefits, as well as productivity improvements, that are understandable to everyone in the organization. Energy savings can be presented as an equivalent amount of product that would need to be sold to obtain the same financial gain (net profits).
- Measure the impact of the program by its effect on earnings and shareholder value. ENERGY STAR provides a financial value calculator to help measure this impact.
- Use financial metrics such as net present value, simple payback, internal rate of return, and hurdle rate to make your case effectively. Speak the language of your organization's financial officers when explaining the program.
- Focus on internal rates of return to demonstrate that energy projects may be better investment alternatives than capital allotted for process improvements.
- Explain how investing in technologies and practices that reduce energy can affect your organization's energy security and help insulate the organization from the risks associated with supply and price uncertainties in a deregulated market.

Additional Support Services:

- **Public Relations:** PR departments can help share information with the organization and help ensure favorable publicity for your organization's energy management accomplishments.
- **Information Technology:** IT personnel can help with tracking systems and web-based communications.
- **Human Resources:** HR personnel help you staff the energy team, train the workforce, and administer performance standards and rewards.

INVOLVING FACILITIES AND PROPERTIES

Most energy improvements are implemented at the facility and property level. Changing current, often inefficient, operating practices to a culture of efficiency requires that facilities or properties buy into the principles of the organization's energy management program.

FOR EXAMPLE, the **General Motors Corporation** has an Energy and Environmental Strategy Board consisting of directors and headed by the executive vice president. At the next level is a Global Energy Team with representatives from GM North America, GM Europe, GM Latin America, and GM Asia/Pacific. The third level is a Manufacturing Leadership Team, which monitors progress on a quarterly basis. A fourth level is the Energy and Utility Services Group, which is responsible for energy consumption and the energy budget for GM North America. Finally, every plant has an Energy Conservation Team that includes both salaried and hourly people.

FOR EXAMPLE, at **Colorado Springs School District 11**, a team with engineering and technical expertise coordinates energy projects. The team meets with a committee made up of principals, teachers, building managers, a procurement department representative, food service managers, security department director, and vendors.

SITUATION:

- Facility employees and managers are too busy to work with the energy team, but are the ones whose help you need.

SOLUTION:

- Attend facility meetings or participate in discussions to learn about their concerns and how you can address them.
- Provide information, tips, and reminders on how to save energy.

FOR EXAMPLE, during visits to **Hines'** managed properties, Jim Green offers suggestions on introducing new technologies, but he also finds that ideas are a two-way street. "I might visit a property that has a technology that I've not seen installed before, so I'll ask the manager to put together a 'best practices,' and I'll show him how to do that. That way, we share information and spread concepts and technologies."

FORMING A FACILITY-BASED ENERGY TEAM

A mechanism to involve people at facilities and properties is essential since day-to-day working practices in the facilities greatly influence energy efficiency.

STEPS:

- Send out the ENERGY STAR Partnership letter signed by your CEO to the facility managers and ask them to participate. The letter is a proven door-opener.
- Ask the plant or property managers to identify a person who will "own" energy management at that facility and serve as the site energy champion.
- Provide the site champion with information on the benefits of energy efficiency to educate other employees.
- Encourage the site champion to form an energy team that includes the plant's key operations and maintenance people.

DO: Meet informally during half-hour breaks so as not to interfere with regular work schedules of the site energy team.

DO: Recruit candidates for the energy team by letting them know that it is a career-enhancing opportunity. They will be saving money for their organization, and that is important in a performance-oriented environment.

DO: Illustrate how energy management practices support the facility's and company's goals.

FOR EXAMPLE, "Instead of a top-down structure, **Toyota** has more of a give-and-take negotiation with the plants," says Bruce Bremer, manager of Facility Engineering–Engineering Support at Toyota. "We are constantly asking them for their input and involvement."

INVOLVING PARTNERS, CONSULTANTS, VENDORS, AND CUSTOMERS

Consider engaging your joint venture partners, customers, vendors, and service providers in the energy management program.

Vendors and service providers who reduce their own energy costs might pass those savings on by charging lower prices. Those suppliers also can help advance your organization's energy management program by providing tips on energy-efficient equipment.

By the same token, helping customers reduce their energy costs might provide a value-added service that can help retain them as purchasers of your company's products.

FOR EXAMPLE, to demonstrate to the community that every possible effort is being made to achieve significant energy improvements without any additional tax burden, **Colorado Springs School District 11** has used multiphase performance contracts with energy service companies to leverage energy savings for financing new capital-intensive projects.

FOR EXAMPLE, **Eastman Kodak** has preferred supplier agreements to buy all its motors from preferred vendors. "With an agreement comes engineering and technical support, so when we're doing energy assessments, we can rely on them to help us decide whether the cost of putting in a high-efficiency motor is justified," says Kodak worldwide energy program manager George Weed.

FOR EXAMPLE, **General Motors**, through the Suppliers Partnership for the Environment™, has helped its suppliers evaluate how to manage and use energy.

THE ENERGY TEAM'S STRUCTURE

Where the energy team lives in the organizational tree is important for its success. Sometimes the team is its own division or a component of Facilities, Operations, or Environmental, Health, and Safety. Who the team members report to is also an important consideration. Often, energy teams are a voluntary network, and the members do not report directly to the energy director. The exception is those organizations that operate energy management as a separate business unit.

The energy team needs to be empowered by "owning" energy management and by having the authority to make decisions. The energy director should be part of the organization's strategic business planning sessions.

Don't go it alone! Successful teams avoid a maverick reputation, which can make energy management seem like a marginal activity and thus at risk of elimination. Energy management should be integrated into the organization's structure as part of its core business, rather than being a stand-alone activity that gives the impression of being in its own world. When energy management is fully integrated, each department or function has an energy management role as part of its staff members' jobs.

DO: Pass credit to others who are not part of the team but are implementing the energy improvements.

FOR EXAMPLE, "As part of our environmental activities, energy savings is listed as one of our key performance indicators," says Bruce Bremer of **Toyota**. "So it's right up there on our radar screen. Over the years, we moved it up on the company's priorities by keeping it visible."

INTEGRATION OF ENERGY MANAGEMENT ACTIVITIES	Establish Energy Goals	Plan Energy Projects	Develop Cost Estimates	Implement Energy Projects	Track Energy Savings
Energy Management Team	✔	✔	✔	✔	✔
Engineering Department		✔	✔	✔	
Financial Management Department			✔		
Building Design and Facilities Department		✔	✔	✔	

RESOURCES AND RESPONSIBILITIES

Funding is a key to the success of the energy management program. Some organizations set aside a percentage of their budgets for energy projects. The challenge is to get energy projects incorporated in the normal budget cycle as a line item. Timing is all-important. Seek funds early, rather than adding projects after the annual budget is finalized.

DO: Strive to establish the energy director as a full-time position and allocate at least 20 percent of each energy team member's time if your company has multiple facilities and large energy expenditures.

DO: Consider securing a different hurdle rate or return on investment (ROI) for large or capital-intensive energy projects that will help hedge against rising energy costs.

DO: Consider developing a capital fund for energy projects based on a percentage of the savings achieved from the projects.

FOR EXAMPLE, "Our biggest areas for potential improvement require a large capital investment," says Stephen J. Coppinger, P.E., chief electrical engineer at **California Portland Cement.** "But we've been able to show plant managers that there are a lot of things we can do short of spending a lot of money. A consultant did a study and came up with a list of projects at one plant with a potential savings of $400,000 and a one- or two-year payback. And those projects can be replicated at other plants."

FOR EXAMPLE, **General Motors** created a business unit that has responsibility for energy supply, consumption, and efficiency for all of the company's North American plants. "The company transferred the energy budgets from the plants to this group," says Kamesh Gupta, GM energy manager. "All energy-consuming assets of the plants, such as compressors and air chillers, are part of this business unit. We have people at the plant level who report to us, and we support the plant energy teams with resources, common systems, and best practices. We have the responsibility for capital expenditures for energy improvements. In the last three years, we spent about $30 million on those projects. If you run energy as a business, you're really focused on making conservation happen and can leverage your efforts rather than relying on each plant and hoping they will deliver results. It takes a business approach and operation to drive this home."

STARTING YOUR ENERGY PROGRAM

The experience of organizations with successful energy programs reveals that careful planning and effective outreach at the launch of the program creates momentum for the energy team. Successful program launches have involved:

- Planning – Prior to any official launch, the energy director should prepare a briefing on the benefits of energy efficiency, the proposed approach, and a list of potential members of the energy team.
- Presentations to Senior Management – The energy director, with the support of a senior energy champion, should brief senior management.
- Team Strategy – A series of meetings of the energy team to prepare for the program's official launch should be held. The team should consider initiatives to highlight, such as a successful pilot project that could be showcased at the program's kickoff. A pilot project with a short payback period can provide credibility and real-world evidence of actual dollar savings.

FOR EXAMPLE, **Raytheon** established an energy awareness month as the launch pad for kicking off its program. "Each site picked a day during the month and held an event," says David Chamberlain, principal energy engineer at Raytheon. "We focused on employee awareness of energy savings at their homes, since people tend to be more interested when they're paying the bill. We teamed up with Lowe's® and local utilities, and people came out in droves to find out about energy-efficient appliances and weatherizing their homes." During the events, Raytheon's corporate energy team identified local energy champions to form a network of plant people who know the equipment that might be wasting energy.

- Organizational kickoff – A formal event (perhaps even a webcast) that involves senior management announcing the formation of the energy team network and introducing the energy director helps to create credibility for the energy program. If this event will be the first time that the program goes live, it also provides an opportunity to unveil the energy policy. As additional real-world proof of the importance of energy management, a guest energy director from another organization could be invited to make a presentation on its energy successes.

FOR EXAMPLE, the energy team at **California Portland Cement** meets every six weeks, each time at a different plant on a rotating basis. "During our initial audit, we learned about energy improvements that we are now applying at other plants," says Stephen Coppinger, "such as putting new timer cards in dust collectors, which save compressed air. And, instead of repairing old, less efficient motors, we're looking at our purchasing policy on premium energy-efficient motors."

ENERGY TEAM PLANS

At the first meeting of the corporate energy team, a schedule for future meetings is established. How frequently the team gets together varies from organization to organization, but monthly meetings appear to be the norm. As communication channels, meetings are superior to emails, which may tend to be ignored. Multinational organizations might conduct monthly team meetings by conference call or webcast, with face-to-face meetings held on a quarterly or annual basis.

At the meetings, the team members report on their progress on assigned tasks and provide monthly reports on energy use so that the team can build up data. The meetings also offer opportunities for presentations on best practices by in-house and outside technical and operational experts. In addition, members can network with each other, learn about key contacts, and share problems for which the other attendees might be able to offer potential solutions. Meetings also are a mechanism for linking facilities so they can replicate best practices and thus avoid reinventing the wheel.

Each year, the energy team should develop an action plan for the year ahead, with activities to be conducted. In this way, the team becomes proactive in planning its time and ensuring that projects are funded.

FOR EXAMPLE, **General Motors'** corporate energy team meets every month with plant energy engineers via webcasts. The plant-level energy teams meet weekly, and internal sharing of information at the plants occurs on a continuous basis. Real-time electric load profiles at the sites, for instance, show the level of energy efficiency achieved during weekend shutdowns. By comparing those readings with the plant's benchmark level, the performance for that week is determined. The energy team network shares information on a weekly, monthly, quarterly, or annual basis, depending on the level of detail needed. "We can tie it all together because our program is a business," says GM's Kamesh Gupta, "not just a staff organization."

ENGAGING FACILITIES

The energy team and technical experts conduct assessments at facilities by performing a physical walk-through to find energy-saving opportunities. The energy team will need to recognize that they will be competing for time and attention against the business of the facility. However, assessments are a powerful tool for involving facilities in a nonthreatening way and encouraging their buy-in.

During the assessments, energy team members may see best practices in action, so the audits are a hands-on learning opportunity for gathering practices and technology to transfer. After a week-long assessment, the members write an in-depth report, which might run as long as 300 pages. A summary is circulated internally on the intranet or published in the organization's newsletter.

FOR EXAMPLE, **Eastman Kodak** conducts quick energy assessments called "kaizens," a Japanese term for "take apart and make new for the good of others"—used for identifying and implementing rapid solutions that do not require large capital investments. A compressed air kaizen, for example, might involve fixing leaks. A lighting kaizen might require ensuring that fixture controls are actually programmed for the correct "time of day schedules." Another kaizen may involve fixing a faulty steam trap that is costing the company thousands of dollars per year. The kaizens raise questions about operations, such as whether a compressed air system should be run at 100 pounds per square inch when 80 psi would do. "In energy management, there is not one big elephant that saves the day," says Kodak's George Weed, "but a lot of small- and medium-size things that add up to big savings. The achievements involve improving the efficiency of the HVAC [heating, ventilating, and air-conditioning] system, right sizing equipment, and adjusting time-of-day electricity rate schedules."

FOR EXAMPLE, "At facilities where we are making the same product at each and every shift," says **Owens Corning's** Fred Dannhauser, "we got some mileage by creating a competition once we were better able to measure energy use." If Shift A consumed less energy than Shift B, for example, the second shift decided to be more conscientious so they could win. "First, we had to have data that would stand the test of integrity," Dannhauser cautions.

DO: "Deliver the goods" by ensuring that responses to suggestions from plant workers are positive and prompt and that results are obtained quickly.

DO: Prioritize the actions and improvement that should take place first and that will lead to early success.

DO: Suggest schedules and timelines to ensure that recommendations will be implemented.

DO: Leverage existing assessment methods and problem-solving techniques employed by your company.

FOR EXAMPLE, **Toyota** also conducts kaizens, plus three-day assessments called treasure hunts. The hunt begins on a Sunday to see whether equipment is shut off, continues on Monday and Tuesday to look at production startup and shutdown. At the closing meeting on Tuesday, the team presents ideas and cost savings to the plant managers. The participants, gathered from Toyota's other plants, frequently take some of the ideas back to their own plants, so it is not just the host facility that benefits. Toyota's Bruce Bremer adds, "As part of our cycle of kaizens, we also build energy reductions into the design of new plants so the improvements don't have to be done later."

BUILDING CAPACITY

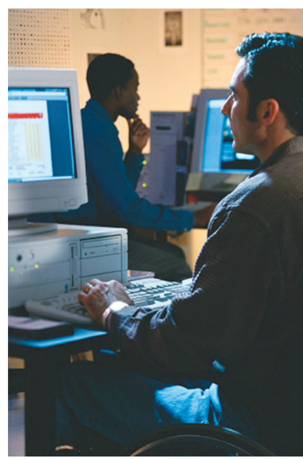
Two essential components of your organization's energy management program are:

- Mechanisms for tracking and communicating progress; and
- Informal and formal tools for transferring that information to managers and workers.

Systems that track energy performance, implementation of best practices, and progress toward goals are also effective tools for evaluating progress and communicating successes. A second key element is a knowledge management system or best practices database. The sophistication of this tool can range from a database published internally on the organization's intranet, or spreadsheets and electronic charts provided to facility managers and engineers only. Case studies on successful projects can be published on either tool, with information on the relevant contact persons.

ENERGY STAR provides a tool for tracking, normalizing, and benchmarking energy use in buildings over time. To use this tool, see ENERGY STAR's Portfolio Manager. Also available are ENERGY STAR's energy performance indicators (EPI) for plants in select manufacturing sectors. The indicators enable energy comparisons of a plant's energy efficiency to that of its industry. All of these tools are available at www.energystar.gov.

FOR EXAMPLE, **General Motors** uses a scorecard to track performance at each plant. The GM 2100 data-gathering system contains a built-in mechanism for generating charts that compare energy use at the facilities on a monthly and quarterly basis.



FOR EXAMPLE, **Toyota** sends out monthly reports on targets versus actuals for the plants as a whole, monthly reports by shops (paint shop, plastics shop, weld shop, etc.), monthly productivity reports on energy use by unit of production, monthly reports on nonproduction energy use over weekends and between shifts, and annual summary reports that are sent out to all plants. "We go through the reports with the president for North America on a regular basis," says Toyota's Bruce Bremer. "He receives the reports for North America as a whole and for each plant."

FOR EXAMPLE, **Frito-Lay** holds a three-day energy summit annually for all members of the energy team, key plant personnel, and selected service and product provider partners. Other organizations, such as **United Technologies Corporation** and **GlaxoSmithKline,** hold annual two-day energy summits.

TRANSFERRING KNOWLEDGE

Two powerful tools for informal training are energy summits and energy fairs.

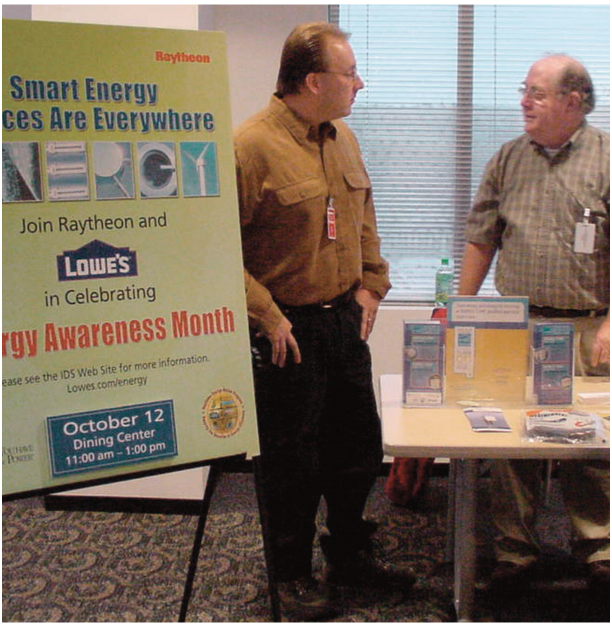
Energy summits are usually annual get-togethers for technology transfer. The energy network gathers to exchange information on the program and best practices, and to discuss new project ideas. Energy summits also provide an excellent time to offer training and bring in outside speakers to discuss energy management issues.

Attendees can include outside experts from another industry sector, voluntary program partners, consultants, and nonenergy corporate divisions such as environment, health, and safety.

At the summit, a senior manager could articulate the goals for the coming year and provide recognition for people in the energy team network. A workshop at the end could offer a forum for focusing on action steps.

For a multinational organization, the energy summit could be a global webcast. In other cases, companies might prefer to host the summit at corporate headquarters and facilities on a rotating basis. When held at a plant, the summit could include a walk-through to showcase successes.

Energy fairs and exhibitions are one- to three-day events for all employees, their families, and even neighbors to educate them about basic energy strategies for the home. Energy fairs normally are held at facilities and can include representatives from outside organizations, such as government or local utilities, to man the booths. The energy fair could be held in connection with Earth Day, Energy Awareness Month (October), or in conjunction with "Bring Your Daughter or Son to Work" days. One approach is to work with your organization's event planner to help stage the exhibition. The expected outcome is that employees' increased knowledge will translate to a culture of energy efficiency in the workplace.



FOR EXAMPLE, to solicit energy project ideas, **Starwood Hotels** held a competition where the prize was a Porsche® Boxster convertible. The energy management team received more than 200 suggestions.

OTHER TOOLS FOR RAISING AWARENESS

Posters, intranet sites, surveys, and competitions are additional tools for informally raising awareness of energy efficiency and transferring knowledge. Attractive and informative posters and intranet sites keep the energy program vividly in front of people's eyes and educate them at the same time.

DO: Consider conducting a short survey or questionnaire that polls the entire workforce or a sample subset of employees to raise energy awareness and gauge employee attitudes toward energy efficiency.

DO: Hold contests to build interest and keep the energy program fresh.

DO: Use free ENERGY STAR Partner and Employee Awareness poster templates to help raise awareness of your energy program.

FOR EXAMPLE, **Hines** is always looking for a thoughtful, diplomatic way of fostering healthy competition among its properties. But, in the meantime, the company is alert to opportunities for saving energy that develop out of satisfying needs expressed by tenants. When one tenant complained about noise near the air-handling rooms, Hines considered sound-deadening technologies, but found instead that installation of variable frequency drives on the air-handling units would solve the problem while also cutting energy use in half.

FORMAL TRAINING

Investing in training that promotes employee development helps ensure the success of the energy program by building overall organizational capacity. Informed employees are more likely to contribute ideas, operate equipment properly, and follow procedures.

Formal training can be targeted to address specific energy management issues and transference of skills, and it also can be used as an opportunity to gather feedback. Training can be conducted at a particular site, or it can be organization-wide. Consider whether the participants should include a mix of departments and a mix of managers and other employees. Including managers can demonstrate organizational commitment but might inhibit discussion.

Training that promotes the professional development of key energy team members sustains the success of the corporate program. Organizations such as the Association for Energy Engineers offer a one-week course that qualifies successful participants to become certified energy managers. Some utilities and community colleges offer specialized training, such as the Building Operator Certification for building managers.

FOR EXAMPLE, **Owens Corning**, by educating its employees, improved the operation of air dampers in order to use less air and natural gas during the incineration process, reducing energy consumption for incineration by 10 percent. Training paid off big time.

EPA offers several opportunities to keep abreast of energy issues. Web conferences on energy management featuring ENERGY STAR partners are held monthly. ENERGY STAR Focuses identify and reduce barriers to energy efficiency in specific sectors through technical guidance, performance indices, and meetings. In addition, online training in ENERGY STAR sector-specific tools, such as Portfolio Manager, is free and is offered regularly.

DO: Training that is interesting and fun is more likely to stick with nonenergy team employees.

DO: If you use a professional instructor, avoid overscheduling the person's time, lest the sessions begin to sound canned.

DO: Consider training specific individuals to become technical experts in key equipment and facility utilities that affect energy use, such as HVAC systems and compressed air.

OUTSOURCING AND SERVICE PROVIDERS

Outsourcing to external consultants to perform maintenance and metering to gather data can sometimes have certain advantages. For example, if your organization has insufficient in-house staff to perform regular maintenance of steam traps, it can make sense to hire a consultant. Outside eyes also can catch inefficient practices that are often overlooked by company employees or even by the energy team. Using third-party consultants and service providers can be especially effective when conducting assessments and technical audits.

If outsourcing is your choice, watch out for certain pitfalls. Consultants and service providers should not become the master of the knowledge, leaving no expertise within your organization. To avoid that, make the outsourcing company a true partner and team member. Remember, when meaningful performance metrics, incentives for good performance, and penalties for lack of performance are established, there is a common set of expectations that can reduce problems.

DO: Consider outsourcing turn-key projects, such as lighting upgrades, that are easily replicated and monitored across multiple sites.

FOR EXAMPLE, **Owens Corning** hired a consulting company that placed project managers in the plants. Some are experts in process improvement, others are energy experts. "We believe that when you have people on staff, they have a tendency to be pulled in a hundred different directions," says Owens Corning's Fred Dannhauser. "We couldn't get enough traction without getting a resource dedicated 100 percent of the time for a certain period. But we didn't necessarily need someone in that role forever, just while we addressed the backlog of projects. Whether you use outsiders is not as important as using someone who is really going to dedicate time and who will be held accountable for reducing energy consumption. We kept the charges for the project managers at the corporate level, but the plants did the implementing."

FOR EXAMPLE, **California Portland Cement** learned from ENERGY STAR about a U.S. Department of Energy-funded research project on energy-efficient motors. The project provides rebates, so the cement manufacturer will receive a number of new motors gratis in return for providing readings to the researchers four times per year.

CROSS-COMPANY NETWORKING

Active participation in industry and energy-focused associations can provide a way to share program experiences and results, as well as to learn from others. Speaking engagements at industry events are an effective way to share your organization's successes and motivate others to improve energy performance.

Exchange of information and ideas on energy efficiency within and across industrial and commercial sectors and from ENERGY STAR can translate into significant cost savings credited to your organization's energy management program.

FOR EXAMPLE, **Eastman Kodak** leveraged its partnership with ENERGY STAR to look into saving energy on exhaust hoods in laboratories. "I sent out an email and got five or six notes back," says Kodak's George Weed. "We learn from each other all the time. We just did a two-day benchmark exercise with **Toyota**, with a day in each plant, and we learned a lot from them and them from us. So now we're sending a person to participate in a Toyota energy treasure hunt in California. Then after that, they will be helping us with an energy assessment."

SUSTAINING THE TEAM

Keeping the energy management program alive and fresh is perhaps the greatest challenge. Sustaining the program requires ensuring that managers and employees are aware of the results. Maintaining motivation also may entail offering recognition and rewards.

SITUATION:

- Your organization's program has lost momentum, and poor energy habits are creeping back in.

SOLUTIONS:

- Energy efficiency needs to become a part of the culture of your organization, integrated into its management systems, so that the energy program is self-sustaining and not just a flash in the pan that is vulnerable to cost-cutting.
- The action plan's communications strategies should celebrate successes and target key audiences, including staff, stakeholders, and customers.
- A system of incentives, including individual- and team-focused recognition, can encourage staff to improve performance.

FOR EXAMPLE, **Hines'** Jim Green says the biggest challenge is sustainability. "Our mission is to keep repeating the message and educating our tenants on the advantages of energy efficiency, and standing ready to deliver when they're ready to go forward."

FOR EXAMPLE, Vincent Gates, energy manager at **Merck & Co., Inc.'s** facility in Rahway, NJ, says, "Creating a unique name and logo is critical for building awareness of your program and marketing it effectively. We include our program logo and the address of our internal energy web page on all energy communications. We have begun adding the phrase, 'Merck is now an ENERGY STAR Corporate Partner,' and including the ENERGY STAR logo as well. The greater recognition of the ENERGY STAR logo has caught employee interest and helped to increase recognition of our program."

EFFECTIVE COMMUNICATIONS

Publicizing the results of the energy management program helps to integrate it into the organization's culture and foster organizational pride. If you have a good thing going, let others know.

Getting across the benefits of saving energy and the results of your program takes effective communications skills. Possible newsletter subjects include facility achievements and brief summaries of assessment reports. You may be able to link your news to corporate or world events. Also consider asking your organization's public relations department for advice on your communications plan.

Methods for communicating results include internal progress reports, reports on assessments, emails, pay statement mailers, and publications such as newsletters, magazines, videos, the organization's intranet, posters, flyers, energy calendars posted on bulletin boards, and meetings and conferences.

For celebrating successes externally, press releases and the World Wide Web are your best bets.

DO: Promote your energy program by using the ENERGY STAR Partner mark in conjunction with your logo.

DO: Pace your delivery of good news and always have something worthwhile to say.

DO: Tailor your messages and communications for your different target audiences, such as management, employees, and outside stakeholders.

DO: Promote the program at a grassroots level by educating employees about your organization's partnership with ENERGY STAR.

RECOGNITION AND REWARDS

Recognizing the contributions of teams and individuals helps to reinforce the value of energy efficiency and encourage even greater improvements. Acknowledging successes will help sustain motivation. Verbal appreciation, simple forms of thanks ranging from coffee mugs to formal written commendations and certificates, plaques presented at award ceremonies, salary increases, and stock options can all act as motivators.

Consider recognition to individuals, departments, teams, and facilities. Look at incentives from the point of view of employees and ask: "What's in it for them?" Ensure that all recognition and rewards are equitable and based on published criteria. You may choose to recognize the best energy-saving ideas, the greatest reductions in energy use, and savings increased by "x" amount.

FOR EXAMPLE, **Food Lion's** Energy Awareness Plan rewards maintenance staff by awarding quarterly bonuses for improving energy performance. Keeping maintenance staff motivated to save energy has helped Food Lion reduce its utility cost per store per week by 5.5 percent.

FOR EXAMPLE, EPA recognized **3M** with the 2005 ENERGY STAR Partner of Year Award for Sustained Excellence. For the past five years, 3M has reduced its energy use by 4 percent annually across all facilities for more than $190 million in savings.

EXTERNAL RECOGNITION

External recognition from a third party (government agencies, nonprofits, the media, and trade associations) validates the importance of the energy program, provides satisfaction to those who earned the award, and enhances your organization's public image. A solid reputation contributes to your organization's competitive advantage by making it more attractive to customers, current and potential employees, lenders, and business partners.

Awards, particularly from an outside organization, are one of your most powerful tools for persuading senior management to support the energy program. Besides creating a sense of ownership by the corporate officer, the award attracts media attention and positive PR for the organization.

ENERGY STAR brings credibility to an organization's energy management program. Once an organization wins an ENERGY STAR award or earns the ENERGY STAR for a facility, it becomes an unquestionable symbol of commitment to achieving excellence in energy performance.

DO: Invite corporate officers to accept awards at high-profile industry and government conferences.

Corporate leaders from industrial organizations receive the ENERGY STAR Award for Sustained Excellence–Energy Management at the 2013 Partner of the Year Award event.

MAINTAINING MOMENTUM

One test of whether your organization's energy management program is successful is whether the energy director would be replaced if he or she left or was promoted. Another test is whether your organization's energy use is showing continuous improvement despite changes in key personnel.

DO: Recharge commitment by reviewing and updating your organization's energy policy to ensure that it is not just regarded as corporate wallpaper.

FOR EXAMPLE, between 1997 and 2004, **Toyota** decreased energy use per unit of production (cars going out the door) by 20 percent for all its North American plants. "Everyone has responsibility for improving the environment," says Toyota's Bruce Bremer, "not just at work, but also at home."

SITUATION:

- The energy director has been promoted to another position or the senior manager who served as the program's champion has retired. The new senior manager lacks a personal commitment to energy efficiency.

SOLUTION:

- The organization's energy management program should contain a built-in plan for succession, such as a provision for the energy team and organization executives to select a new energy director.

FOR MORE INFORMATION

Participation in ENERGY STAR presents an excellent opportunity for an organization to benchmark itself against peers, reduce costs, and improve and gain recognition for its voluntary energy efficiency accomplishments. Producing an energy management program with results that the entire organization can be proud of can lead to recognition for the team and management respect for the energy manager.

EPA's ENERGY STAR program offers the following information and resources for creating effective teams:

- Sample briefings
- Financial analysis calculators
- Communications materials
- Tracking and benchmarking training
- Technical guidance
- Networking
- Access to energy professionals

Visit www.energystar.gov or contact:

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1200 Pennsylvania Avenue NW (6202J)
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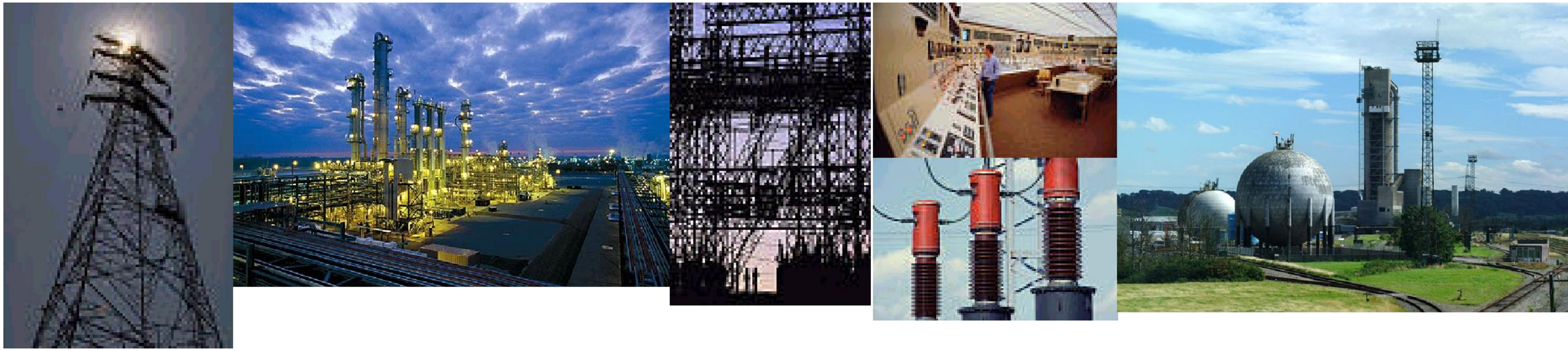

The Gulf Coast Industrial Investment Renaissance and New CHP Development Opportunities

IETC Conference
May 20, 2014
New Orleans, Louisiana

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

LSU CENTER FOR ENERGY STUDIES

Acknowledgments

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Overview: Louisiana Industrial Electricity Sales and Prices

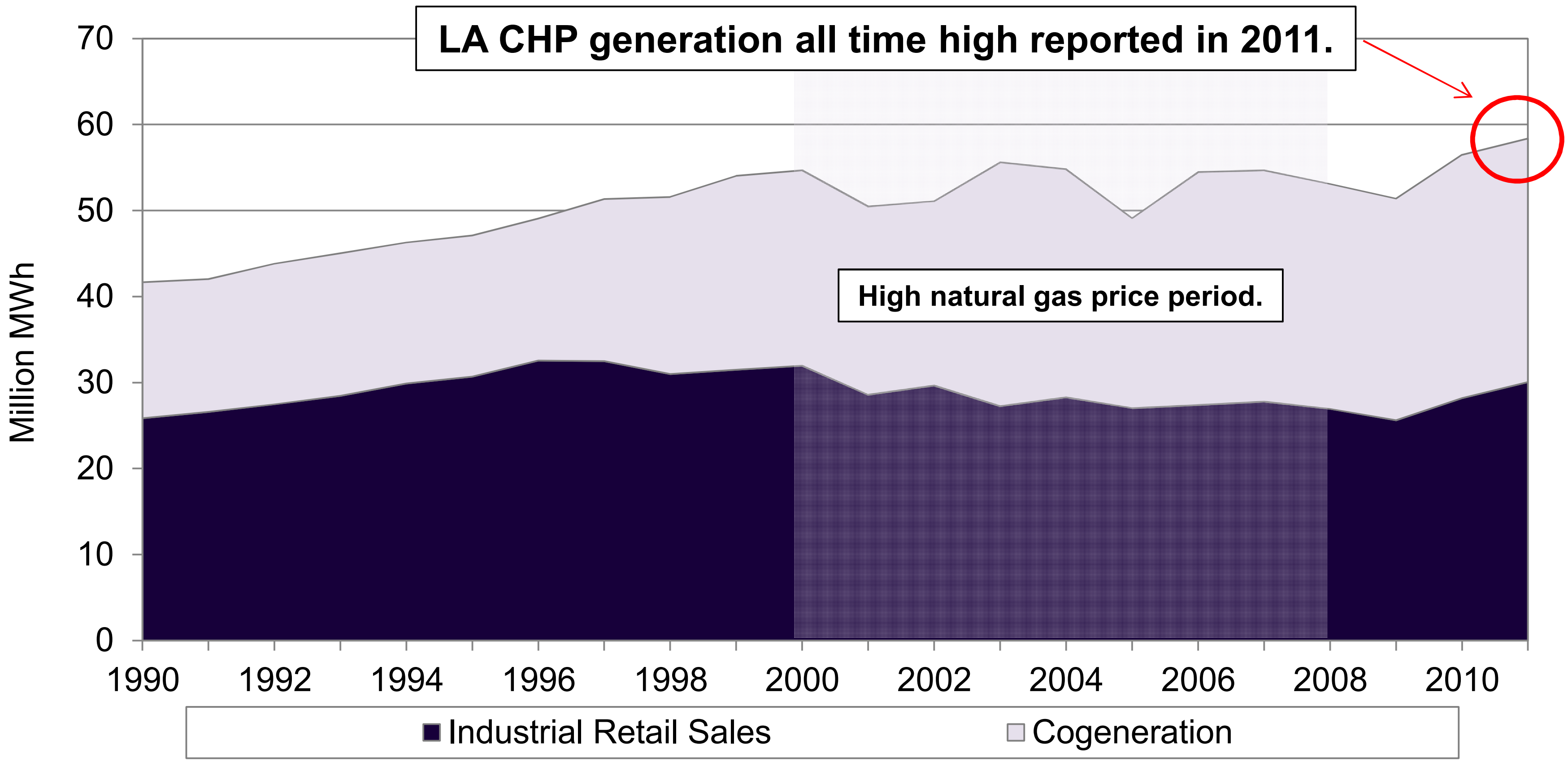
Louisiana has one of the highest concentrations of retail industrial sales in the U.S. The state also has one of the highest concentrations of industrial CHP-based generation.

Industrial sales and CHP generation from industrial facilities grew in a similar and proportional fashion until about 1995 when on-site industrial CHP began to grow, and industrial sales started to contract. By 2000, generation from industrial CHP sites was larger than total retail industrial sales.

CHP generation moved up and down over the course of the past decade at between 48 million to 55 million MWh. While CHP generation and industrial sales both fell during the 2008-2009 recession, both have rebounded to relatively healthy levels. In fact, Louisiana CHP generation in 2011 was at all time high of almost 60 million MWh.

Historic Louisiana Industrial Retail Sales and Cogeneration

Since 2009, Louisiana's industrial retail sales have increased by five percent while industrial CHP generation has increased 29 percent, for a combined 16 percent overall increase in CHP generation and industrial use.



Note: Includes Industrial CHP only, as defined by Energy Information Administration.
Source: Energy Information Administration, U.S. Department of Energy.

Estimated Industrial Average Usage by NAICS (2011)

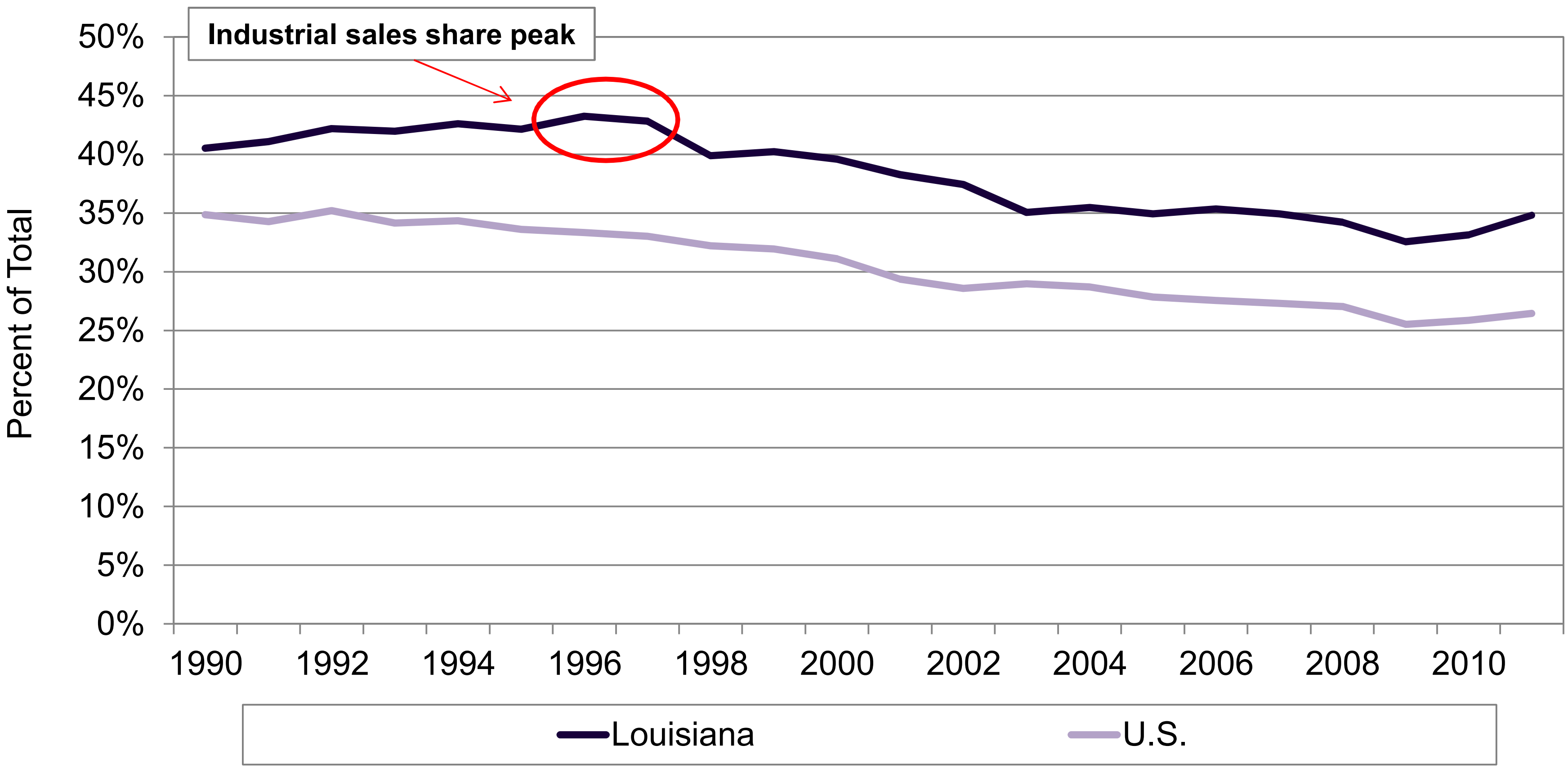
Major industrial electric users include the chemical industry (15.2 million MWh), the refining industry (9.4 million MWh) and the paper products industry (4.0 million MWh). In total, Louisiana industry used 30.1 million MWh.

NAICS Category	Total Electric Use (MWh)	Percent of Total (%)	Per Customer Average Use (MWh)
311-312 Food, Beverage and Tobacco	261,667	0.9%	9,986
313 Textile Mills	4,572	0.0%	5,583
314-315 Textile Products and Apparel	1,010	0.0%	617
316 Leather and Allied Products	1,956	0.0%	1,194
321 Wood Products	165,447	0.6%	14,431
322 Paper Manufacturing	4,032,947	13.4%	378,839
323 Printing and Related Support	38,763	0.1%	3,381
324 Petroleum and Coal Products	9,416,959	31.3%	605,247
325 Chemical Manufacturing	15,159,127	50.4%	272,233
326 Plastics and Rubber	335,630	1.1%	68,310
327 Nonmetallic Minerals	93,505	0.3%	22,837
331 Primary Metal Manufacturing	319,623	1.1%	48,789
332 Fabricated Metal Products	49,419	0.2%	4,642
333 Machinery Manufacturing	107,630	0.4%	6,918
335 Electrical Equip. and Components	14,322	0.0%	17,489
336 Transportation Equipment	53,023	0.2%	6,475
337 Furniture and Related Products	917	0.0%	560
339 Miscellaneous	1,900	0.0%	349
	30,058,415	**100.0%**	**156,197**

Source: MIPD.

Industrial Electric Sales as a Percent of Total Electric Sales

In Louisiana, industrial electric sales as a percent of total electric sales have fallen 19.5 percent since their high in 1996. Similarly, during the same period, U.S., industrial electric sales fell just over 20 percent.

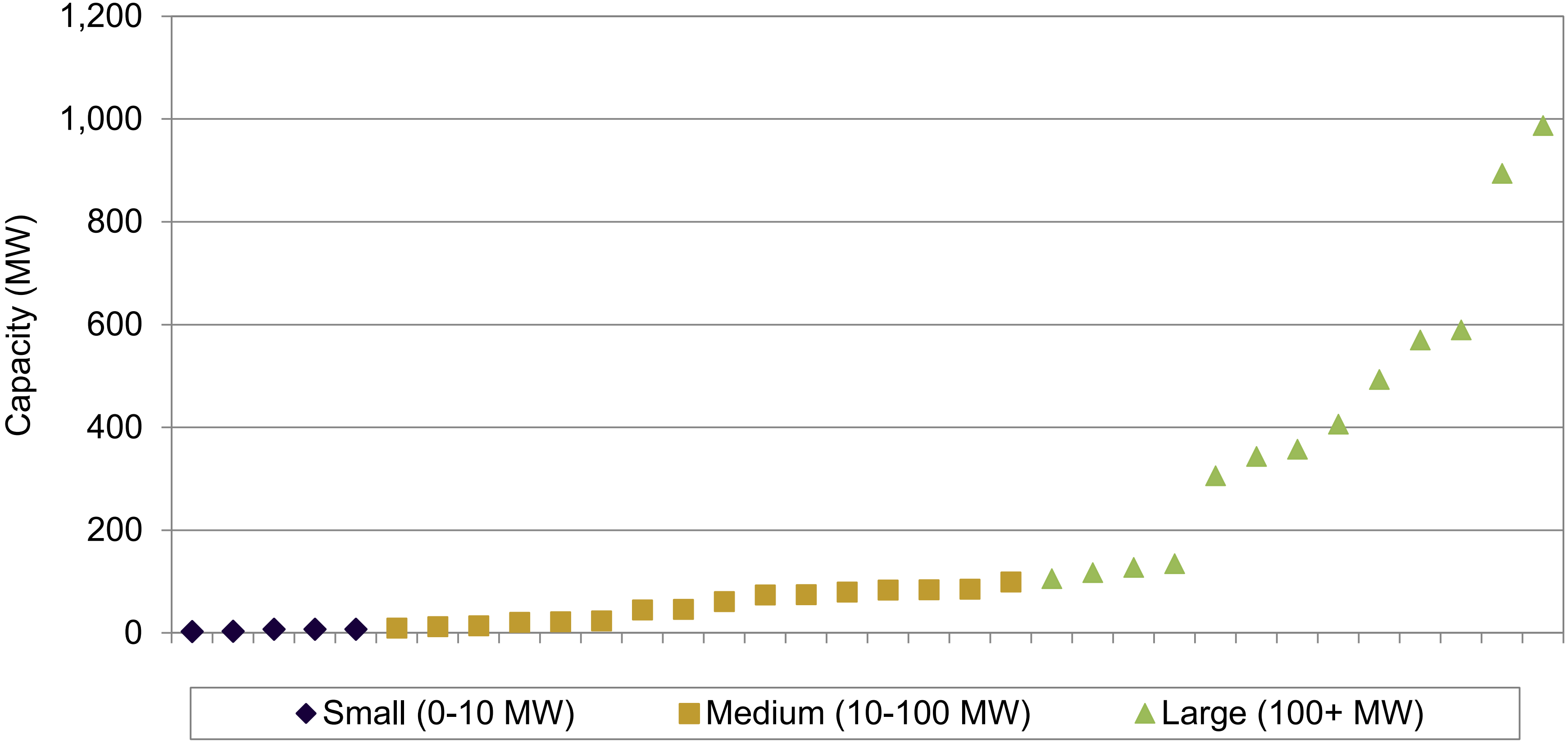


Source: Energy Information Administration, U.S. Department of Energy.

Unit Specific CHP Statistics and Trends

Louisiana CHP Facilities by Capacity

There are 35 CHP facilities in Louisiana. These facilities range in size from 3 MW to 987 MW. Five facilities are considered small, or up to 10 MW; 16 facilities are medium (between 10 and 100 MW); and 13 are large, or greater than 100 MW. The large facilities account for 86 percent of total capacity.



CHP Capacity and Average Capacity by Sector

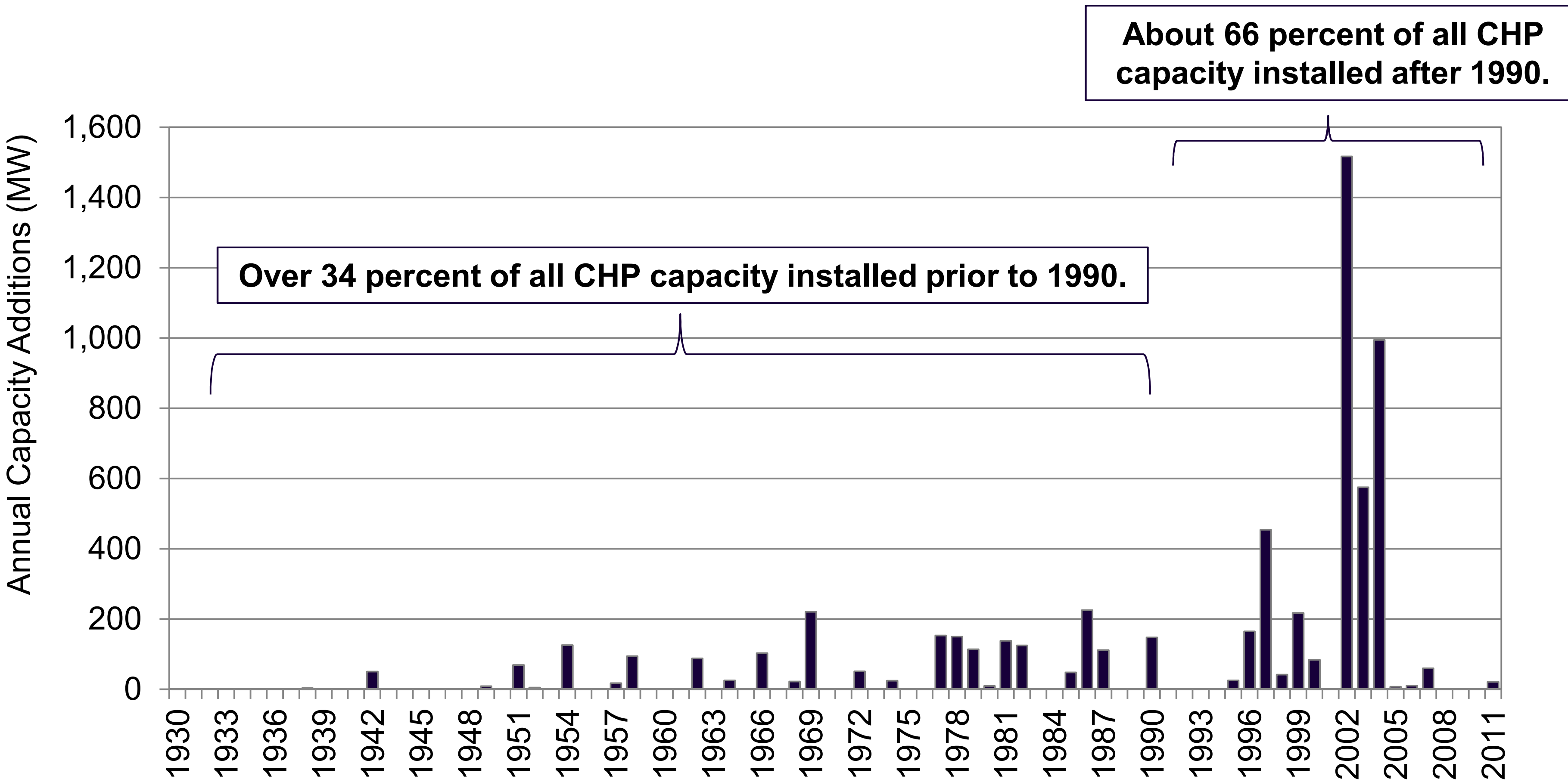
In Louisiana, CHP capacity totals 6,300 MW. Chemical manufacturing is the largest category, accounting for almost 5,000 MW, or about 80 percent of total CHP capacity. These units also tend to be the largest, averaging 91 MW per unit.

NAICS		Capacity (MW)	Percent of Total	Average Capacity (MW)
311-312	Food, Beverage and Tobacco	24	0.4%	2.7
322	Paper Manufacturing	556	8.8%	30.9
324	Petroleum and Coal Products	644	10.2%	35.8
325	Chemical Manufacturing	4,984	79.1%	90.6
331	Primary Metal Manufacturing	84	1.3%	28.0
	Misc	8	0.1%	7.5
	Total	**6,299**	**100.0%**	**60.6**

Note: The “Misc” category includes the Louisiana Tech University Power Plant in Lincoln Parish.

CHP Capacity by Installation Year

Over 1,500 MW (24 percent) of CHP capacity was installed in Louisiana in 2002 alone. Most capacity was developed after 1990.



Analysis & Methods

Modeling Overview

Study Goal: Estimate firm/industry-specific CHP opportunities.

Model: Based upon four primary components including: (1) market identification; (2) technical potentials analysis; (3) economic potentials analysis; (4) and sensitivity analyses.

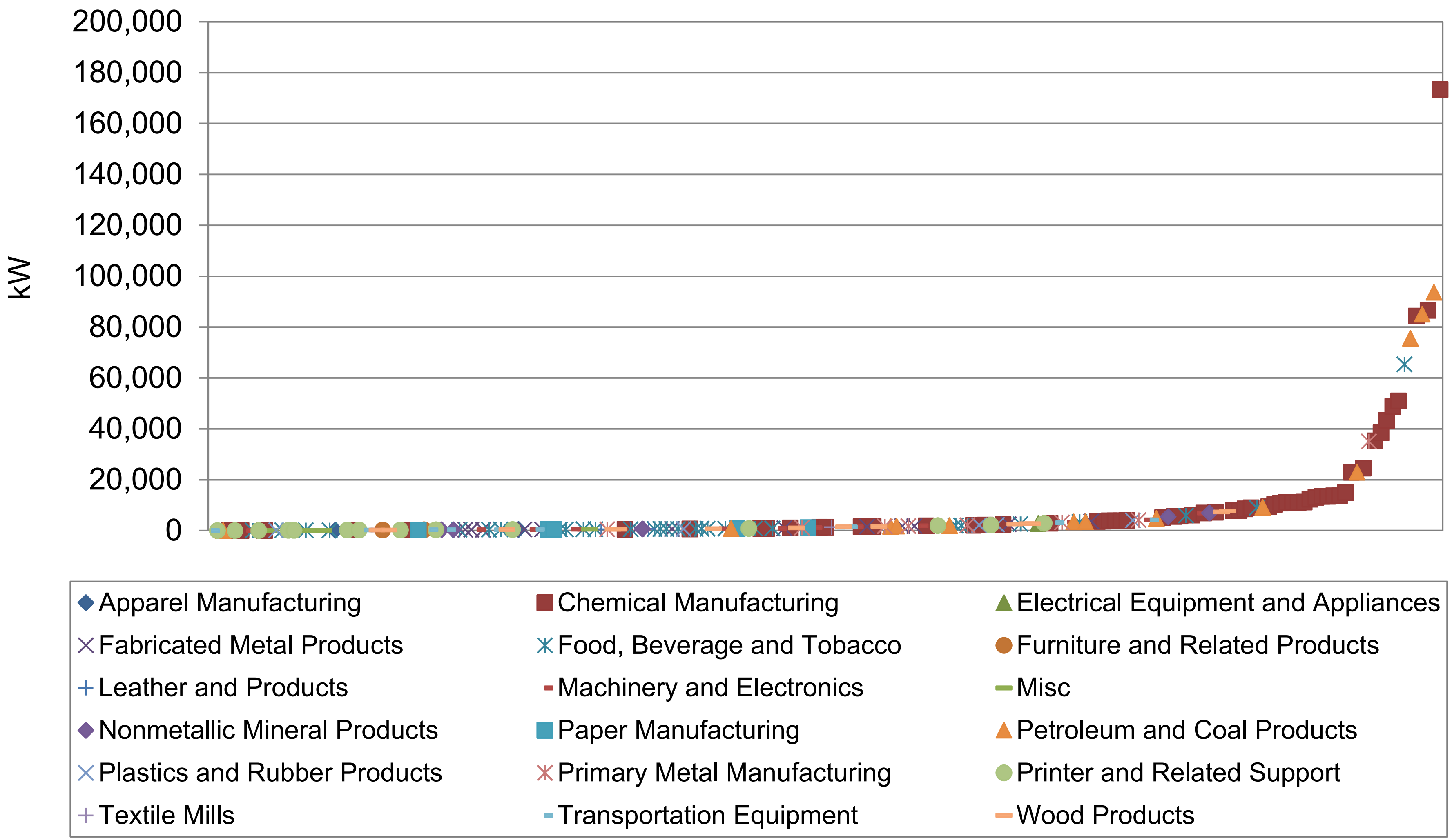
1. **Market identification** analysis will identify the relevant firms and industries that have the opportunities for CHP development.
2. **Technical potentials analysis** will screen all firms included in the market identification for their technical abilities to install CHP, which are based primarily upon each firms' thermal and electrical energy use characteristics.
3. **Economic potential analysis** starts with all firms having the technical capability for CHP. Costs and benefits for each of these firms will be evaluated and only those firms with cost-effective CHP opportunities will be selected.
4. **Sensitivity analyses** will subject the economic potentials to a variety of sensitivities in order to ascertain the robustness of the empirical results.

Summary of Potential Louisiana CHP Market by NAICS

Phase 1 identified 209 candidate facilities with an average demand of 1,480 MW. The overwhelming bulk of the potential Louisiana CHP market (in capacity terms) is in the chemical and refining sectors (~ 600 MW). The food, beverage and tobacco; primary metals; and wood products sectors comprise the next three largest potential CHP markets.

NAICS Category		Number of Facilities	Electric Use (MWh)	Average Electric Usage (MWh)	Electric Demand (kW)	Average Electric Demand (kW)	Boiler Fuel (MMBtu)	Furnace Fuel (MMBtu)
311-312	Food, Beverage and Tobacco	30	308,027	10,268	102,736	3,425	1,782,242	912,846
313-314	Textile Mills	1	5,583	5,583	1,395	1,395	-	125,282
315	Apparel Manufacturing	2	1,233	617	592	296	-	5,382
321	Wood Products	14	202,038	14,431	30,172	2,155	1,490,389	754,301
337	Furniture and Related Products	2	1,120	560	537	269	-	2,736
322	Paper Manufacturing	5	17,361	3,472	3,114	623	33,194	65,873
323	Printer and Related Support	14	47,337	3,381	9,660	690	-	65,112
325	Chemical Manufacturing	59	7,259,477	123,042	893,533	15,145	101,440,609	128,921,300
324	Petroleum and Coal Products	13	2,633,909	202,608	304,653	23,435	19,044,294	28,160,021
326	Plastics and Rubber Products	5	59,860	11,972	9,268	1,854	-	164,345
316	Leather and Products	2	2,389	1,194	1,171	586	2,034	-
327	Nonmetallic Mineral Products	5	114,185	22,837	13,684	2,737	62,475	3,029,388
331	Primary Metal Manufacturing	8	390,313	48,789	49,543	6,193	99,942	1,861,698
332	Fabricated Metal Products	13	60,349	4,642	15,600	1,200	1,851	290,477
333-334	Machinery and Electronics	19	131,434	6,918	27,290	1,436	64,050	444,245
335	Electrical Equipment and Appliances	1	17,489	17,489	2,802	2,802	-	100,000
336	Transportation Equipment	10	64,750	6,475	11,974	1,197	158,040	15,052
339	Misc	6	2,320	387	1,112	185	-	21,745
Total		**209**	**11,319,173**	**54,159**	**1,478,836**	**7,076**	**124,179,120**	**164,939,803**

Distribution of Potential Louisiana CHP Market, Electric Demand



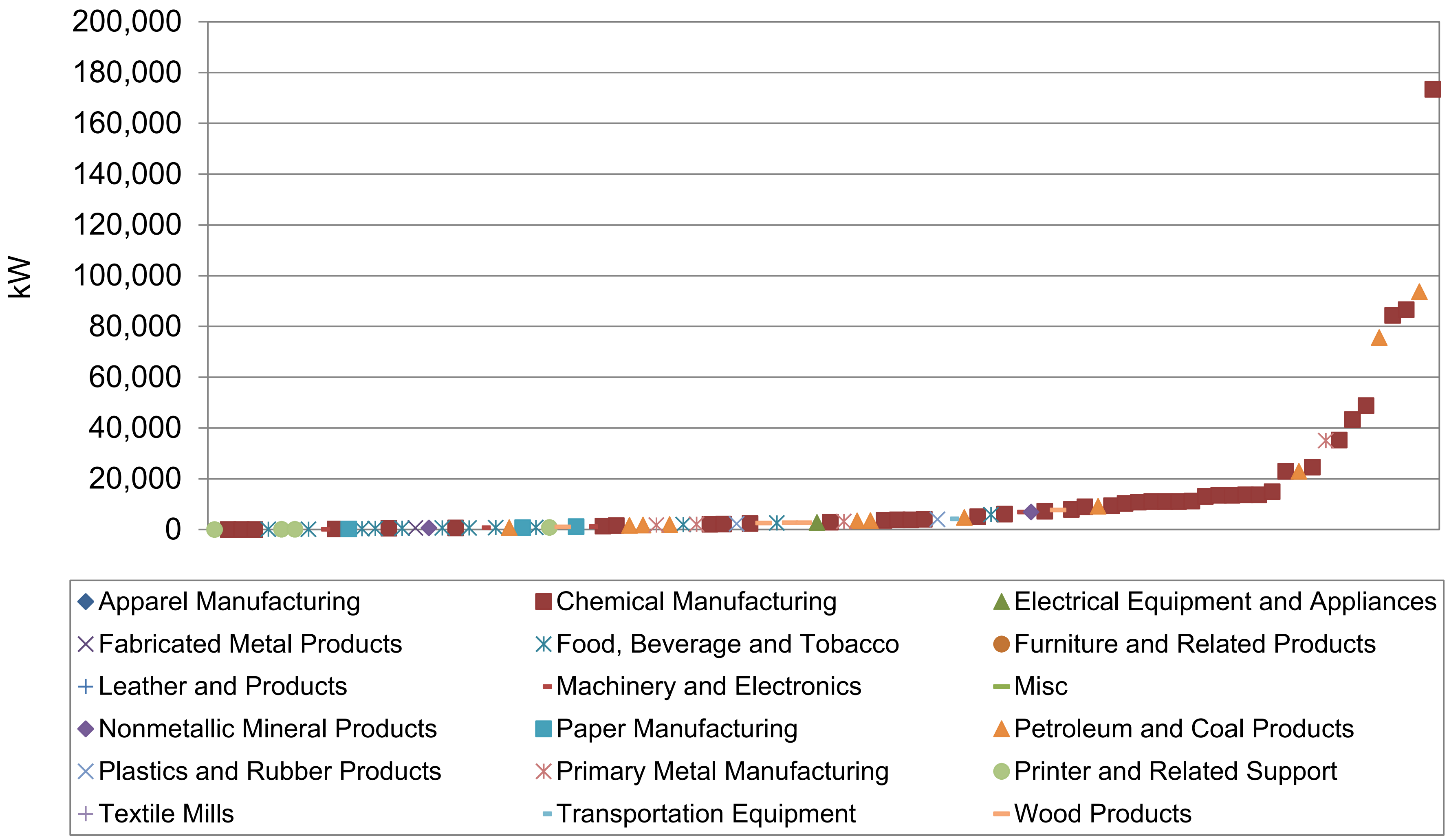
Technical Potentials

Summary of Potential Louisiana CHP Market by NAICS

Phase 2 identified 92 facilities with the technical potential for CHP. Most of these are from the chemical and petroleum refining sectors with a combined total of 960 MW of load, or 90 percent of the overall market not already supplied by CHP.

NAICS Category		Number of Facilities	Electric Use (MWh)	Average Electric Usage (MWh)	Electric Demand (kW)	Average Electric Demand (kW)	Boiler Fuel (MMBtu)	Furnace Fuel (MMBtu)
311-312	Food, Beverage and Tobacco	12	101,133	8,428	15,144	1,262	763,682	481,637
313-314	Textile Mills	-	-	-	-	-	-	-
315	Apparel Manufacturing	-	-	-	-	-	-	-
321	Wood Products	5	141,319	28,264	16,954	3,391	704,101	749,489
337	Furniture and Related Products	-	-	-	-	-	-	-
322	Paper Manufacturing	3	13,595	4,532	2,208	736	33,194	63,397
323	Printer and Related Support	4	6,784	1,696	1,049	262	-	23,663
325	Chemical Manufacturing	42	6,322,795	150,543	741,598	17,657	100,566,995	127,951,718
324	Petroleum and Coal Products	11	1,904,636	-	219,538	-	17,793,514	25,173,321
326	Plastics and Rubber Products	2	53,679	26,840	6,298	3,149	-	152,982
316	Leather and Products	-	-	-	-	-	-	-
327	Nonmetallic Mineral Products	2	65,791	-	7,530	-	-	1,830,284
331	Primary Metal Manufacturing	4	360,461	-	42,056	-	39,942	1,699,779
332	Fabricated Metal Products	1	3,533	3,533	606	606	-	8,000
333-334	Machinery and Electronics	4	56,355	14,089	9,013	2,253	-	146,905
335	Electrical Equipment and Appliances	1	17,489	-	2,802	-	-	100,000
336	Transportation Equipment	1	37,394	37,394	4,280	4,280	158,040	-
339	Misc	-	-	-	-	-	-	-
Total		**92**	**9,084,963**	**98,750**	**1,069,076**	**11,620**	**120,059,468**	**158,381,176**

Distribution of Potential Louisiana CHP Market, Electric Demand



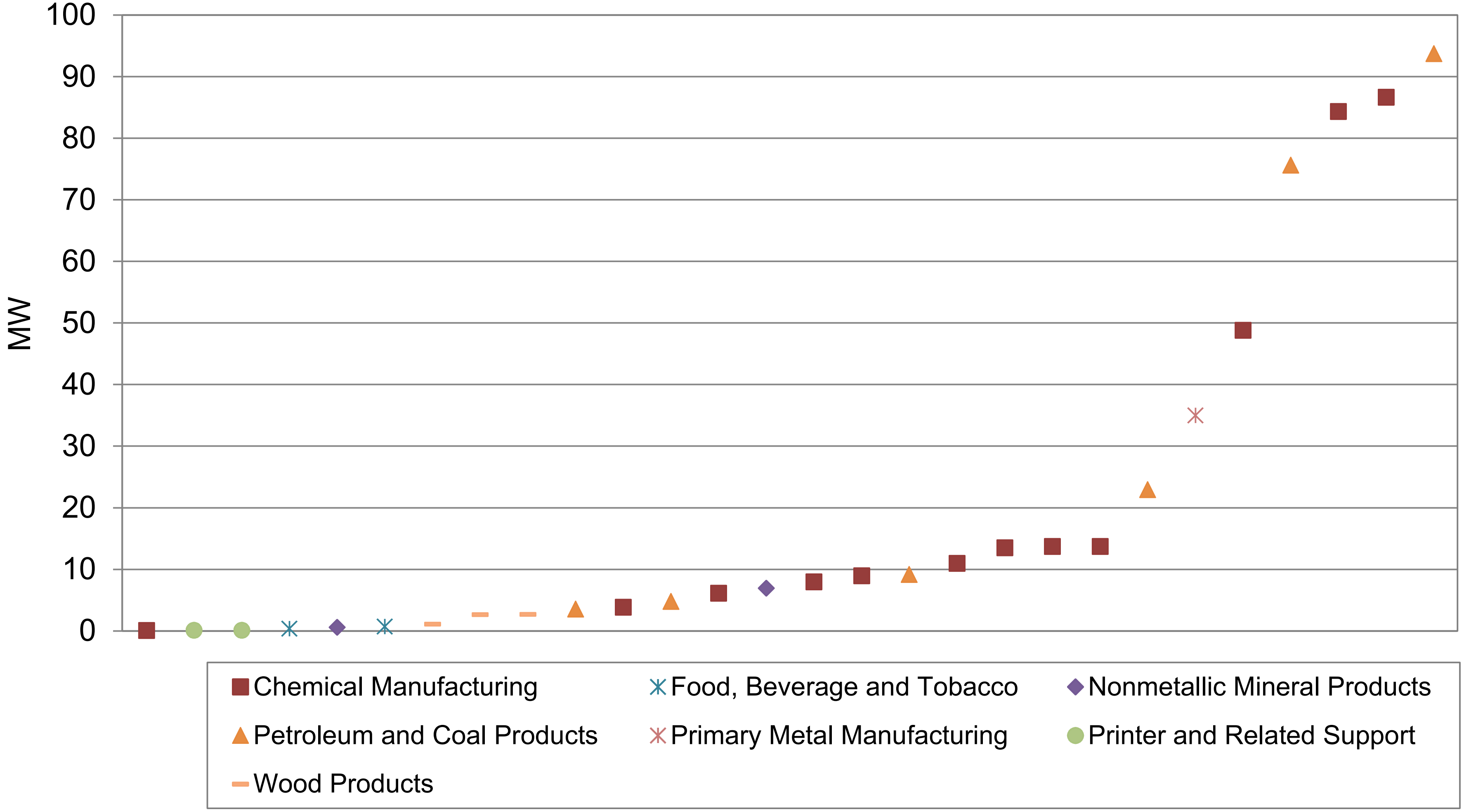
Cost Effective Potentials

Summary of Potential Louisiana CHP Market by NAICS

Of the 92 facilities identified in Phase 2, just 28 have been deemed cost-effective. Again, most of these are from the chemical and petroleum refining sectors with a combined total of almost 510 MW of load, or 90 percent of the overall market not already supplied by CHP.

NAICS Category		Number of Facilities	Electric Use (MWh)	Average Electric Usage (MWh)	Electric Demand (MW)	Average Electric Demand (MW)	Boiler Fuel (MMBtu)	Furnace Fuel (MMBtu)
311-312	Food, Beverage and Tobacco	2	7,496	3,748	1,059	530	43,072	44,395
313-314	Textile Mills	-	-	-	-	-	-	-
315	Apparel Manufacturing	-	-	-	-	-	-	-
321	Wood Products	3	49,319	16,440	6,424	2,141	261,730	165,118
337	Furniture and Related Products	-	-	-	-	-	-	-
322	Paper Manufacturing	-	-	-	-	-	-	-
323	Printer and Related Support	2	1,777	889	202	101	-	5,362
325	Chemical Manufacturing	12	2,550,214	212,518	298,704	24,892	28,411,835	34,271,393
324	Petroleum and Coal Products	6	1,820,658	303,443	209,860	34,977	17,422,593	12,549,190
326	Plastics and Rubber Products	-	-	-	-	-	-	-
316	Leather and Products	-	-	-	-	-	-	-
327	Nonmetallic Mineral Products	2	65,791	32,896	7,530	3,765	-	1,830,284
331	Primary Metal Manufacturing	1	300,000	300,000	35,014	35,014	-	1,092,500
332	Fabricated Metal Products	-	-	-	-	-	-	-
333-334	Machinery and Electronics	-	-	-	-	-	-	-
335	Electrical Equipment and Appliances	-	-	-	-	-	-	-
336	Transportation Equipment	-	-	-	-	-	-	-
339	Misc	-	-	-	-	-	-	-
Total		**28**	**4,795,256**	**171,259**	**558,793**	**19,957**	**46,139,230**	**49,958,242**

Distribution of Potential Louisiana CHP Market, Electric Demand



Summary of Cost-Effectiveness & Sensitivity Results

NAICS Category		CHP Capacity (MW) Existing	Market Identification	Technical Potential	Cost Effective: Baseline	Scenario 1 - Relax Benefit-Cost Ratio	Scenario 2 - Add Carbon Restriction	Scenario 3 - High Natural Gas Prices	Scenario 4 - High Capacity Prices
311-312	Food, Beverage and Tobacco	24.4	104.6	102.7	4.4	5.1	0.4	0.4	1.1
313-314	Textile Mills	-	1.4	1.4	-	-	-	-	-
315	Apparel Manufacturing	-	0.6	0.6	-	-	-	-	-
321	Wood Products	-	30.2	30.2	6.4	14.2	2.6	-	6.4
337	Furniture and Related Products	-	0.5	0.5	-	-	-	-	-
322	Paper Manufacturing	555.6	566.3	3.1	-	-	-	-	-
323	Printer and Related Support	-	9.7	9.7	1.0	1.0	0.1	0.1	0.2
325	Chemical Manufacturing	4,983.5	2,181.6	893.5	323.9	699.8	39.4	39.4	519.1
324	Petroleum and Coal Products	643.7	1,319.5	304.7	213.6	213.6	-	9.2	209.9
326	Plastics and Rubber Products	-	49.3	9.3	-	-	-	-	-
316	Leather and Products	-	1.2	1.2	-	-	-	-	-
327	Nonmetallic Mineral Products	-	13.7	13.7	7.5	7.5	-	-	7.5
331	Primary Metal Manufacturing	84.1	49.5	49.5	35.0	40.3	-	-	35.0
332	Fabricated Metal Products	-	15.6	15.6	-	-	-	-	-
333-334	Machinery and Electronics	-	27.3	27.3	1.2	1.2	-	-	-
335	Electrical Equipment and Appliances	-	2.8	2.8	2.8	2.8	-	-	-
336	Transportation Equipment	-	12.0	12.0	-	-	-	-	-
	Misc	7.5	1.1	1.1	-	-	-	-	-
	Total	**6,298.8**	**4,386.8**	**1,478.8**	**595.9**	**985.6**	**42.5**	**49.0**	**779.2**

Note: In Scenario 1, the Benefit-Cost ratio is reduced from 1.0 to 0.9. In Scenario 2, a carbon cost is added to the cost of generation, assuming an average emission rate of 1,135 lbs/MWh and a cost of $40/ton. In Scenario 3, the cost of natural gas is increased 107 percent, from an average spot price of $3.86/Mcf to $8.00/Mcf. In Scenario 4, the market clearing heat rate is increased from 10,816 Btu/kWh to 20,000 Btu/kWh, thereby increasing the wholesale price of electricity by 85 percent.

Cost-Effectiveness Sensitivities as a Percent of Louisiana Generation

NAICS Category		Share of Total LA Generation Capacity (%)							
					Cost Effective				
		Existing	Market Identification	Technical Potential	Baseline	Scenario 1 - Relax Benefit-Cost Ratio	Scenario 2 - Add Carbon Restriction	Scenario 3 - High Natural Gas Prices	Scenario 4 - High Capacity Prices
311-312	Food, Beverage and Tobacco	0.09%	0.40%	0.39%	0.02%	0.02%	0.00%	0.00%	0.00%
313-314	Textile Mills	-	0.01%	0.01%	-	-	-	-	-
315	Apparel Manufacturing	-	0.00%	0.00%	-	-	-	-	-
321	Wood Products	-	0.12%	0.12%	0.02%	0.05%	0.01%	-	0.02%
337	Furniture and Related Products	-	0.00%	0.00%	-	-	-	-	-
322	Paper Manufacturing	2.12%	2.16%	0.01%	-	-	-	-	-
323	Printer and Related Support	-	0.04%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%
325	Chemical Manufacturing	19.02%	8.33%	3.41%	1.24%	2.67%	0.15%	0.15%	1.98%
324	Petroleum and Coal Products	2.46%	5.04%	1.16%	0.82%	0.82%	-	0.03%	0.80%
326	Plastics and Rubber Products	-	0.19%	0.04%	-	-	-	-	-
316	Leather and Products	-	0.00%	0.00%	-	-	-	-	-
327	Nonmetallic Mineral Products	-	0.05%	0.05%	0.03%	0.03%	-	-	0.03%
331	Primary Metal Manufacturing	0.32%	0.19%	0.19%	0.13%	0.15%	-	-	0.13%
332	Fabricated Metal Products	-	0.06%	0.06%	-	-	-	-	-
333-334	Machinery and Electronics	-	0.10%	0.10%	0.00%	0.00%	-	-	-
335	Electrical Equipment and Appliances	-	0.01%	0.01%	0.01%	0.01%	-	-	-
336	Transportation Equipment	-	0.05%	0.05%	-	-	-	-	-
	Misc	0.03%	0.00%	0.00%	-	-	-	-	-
	Total	**24.0%**	**16.7%**	**5.6%**	**2.3%**	**3.8%**	**0.2%**	**0.2%**	**3.0%**

Note: Assumes total Louisiana generation capacity of 26,200 MW. In Scenario 1, the Benefit-Cost ratio is reduced from 1.0 to 0.9. In Scenario 2, a carbon cost is added to the cost of generation, assuming an average emission rate of 1,135 lbs/MWh and a cost of $40/ton. In Scenario 3, the cost of natural gas is increased 107 percent, from an average spot price of $3.86/Mcf to $8.00/Mcf. In Scenario 4, the market clearing heat rate is increased from 10,816 Btu/kWh to 20,000 Btu/kWh, thereby increasing the wholesale price of electricity by 85 percent.

Policy Issues

CHP Policy Issues

CHP developers and utilities have considerable differences of opinion in CHP policy issues that became more divergent during the merchant power development period of the past decade.

From a CHP-developers perspective, past CHP policy/market barriers have historically centered around the same three primary problems:

(1) lack of price transparency (on CHP market/utility sales);

(2) having an open and objective transmission operations, planning, and longer-run development process;

(3) lack of market institutions to support expanded sales of CHP output into wholesale markets.

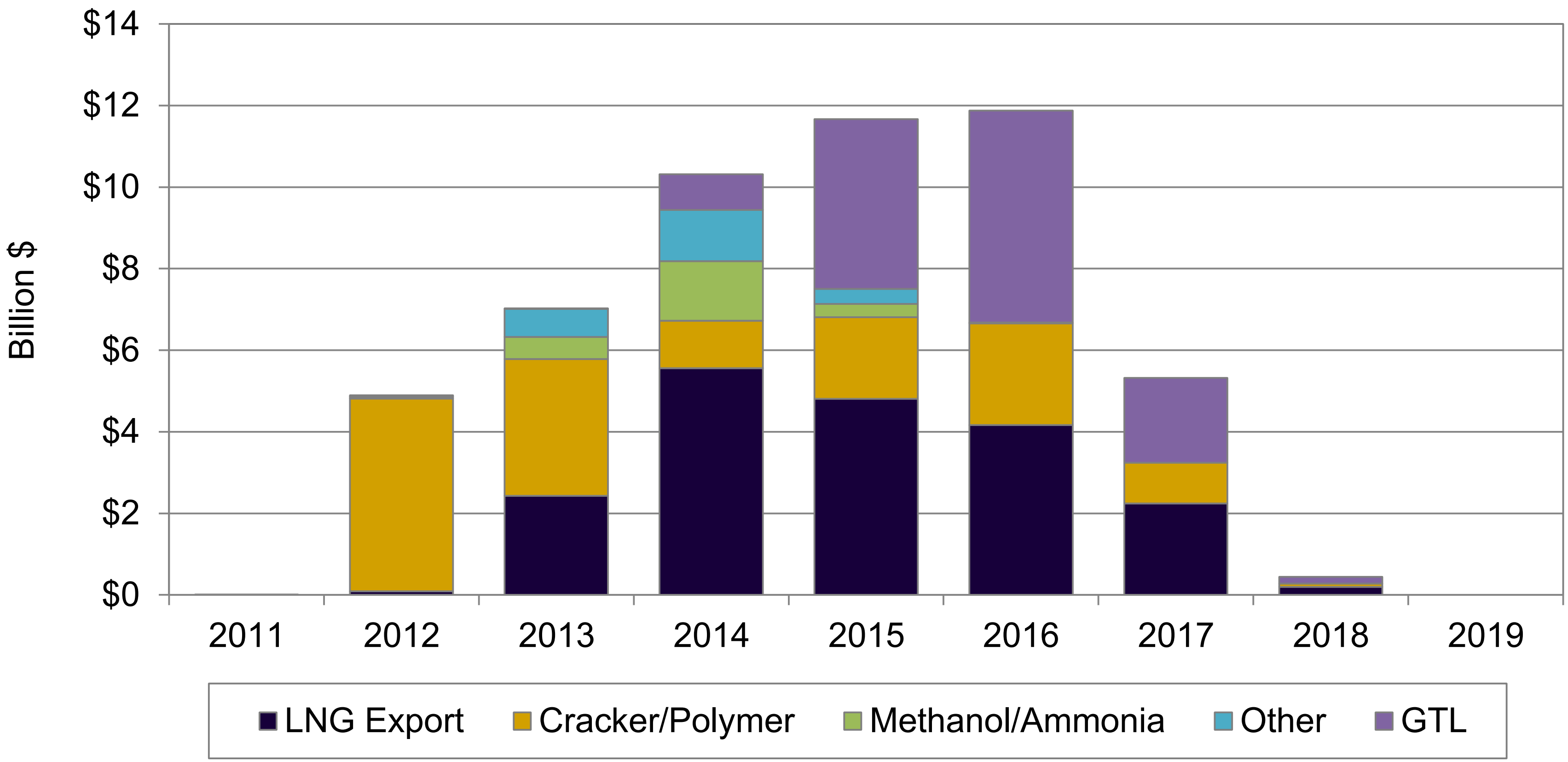
CHP Outlook

The current Louisiana “industrial renaissance,” coupled with Entergy’s recent move to the Mid-continent Independent System Operator (“MISO”), should help to alleviate many of the perceived developer problems associated with in-state CHP expansion.

- Over $61 billion in industrial, energy-intensive capital expenditures (“capex”), will result in the need for considerable new generation capacity, some of which will likely be CHP-oriented.
- Having the main Louisiana industrial corridor included in the MISO footprint will help to provide:
  (1) price discovery and transparency;
  (2) open access transmission operations and planning; and
  (3) greatly expanded market scope for all suppliers.

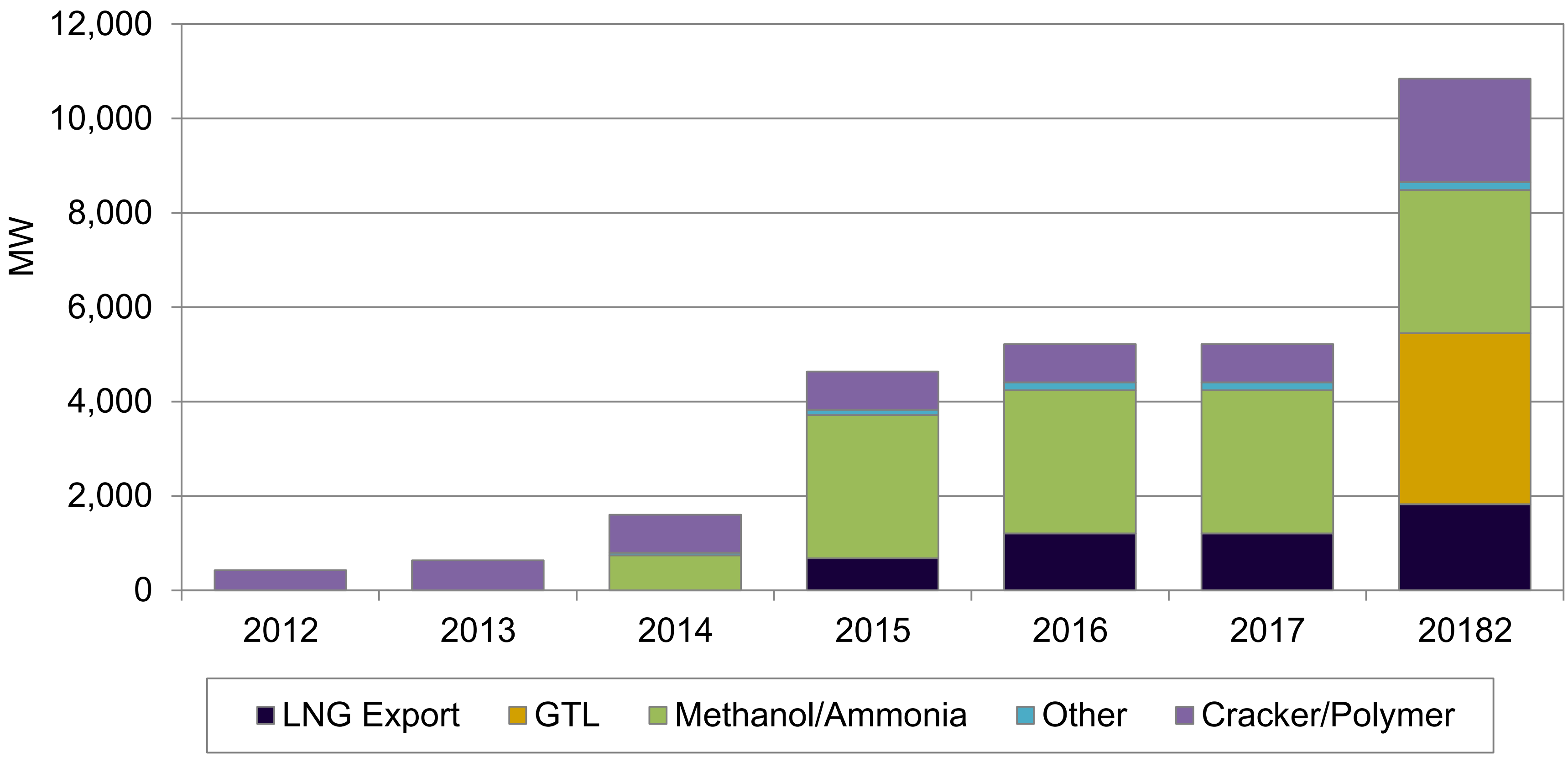
Total Capital Expenditures by Sector

The total capital investment associated with all announced natural gas-driven manufacturing investments in Louisiana totals over $61 billion. Most of the investment is anticipated to occur between 2014 and 2017.



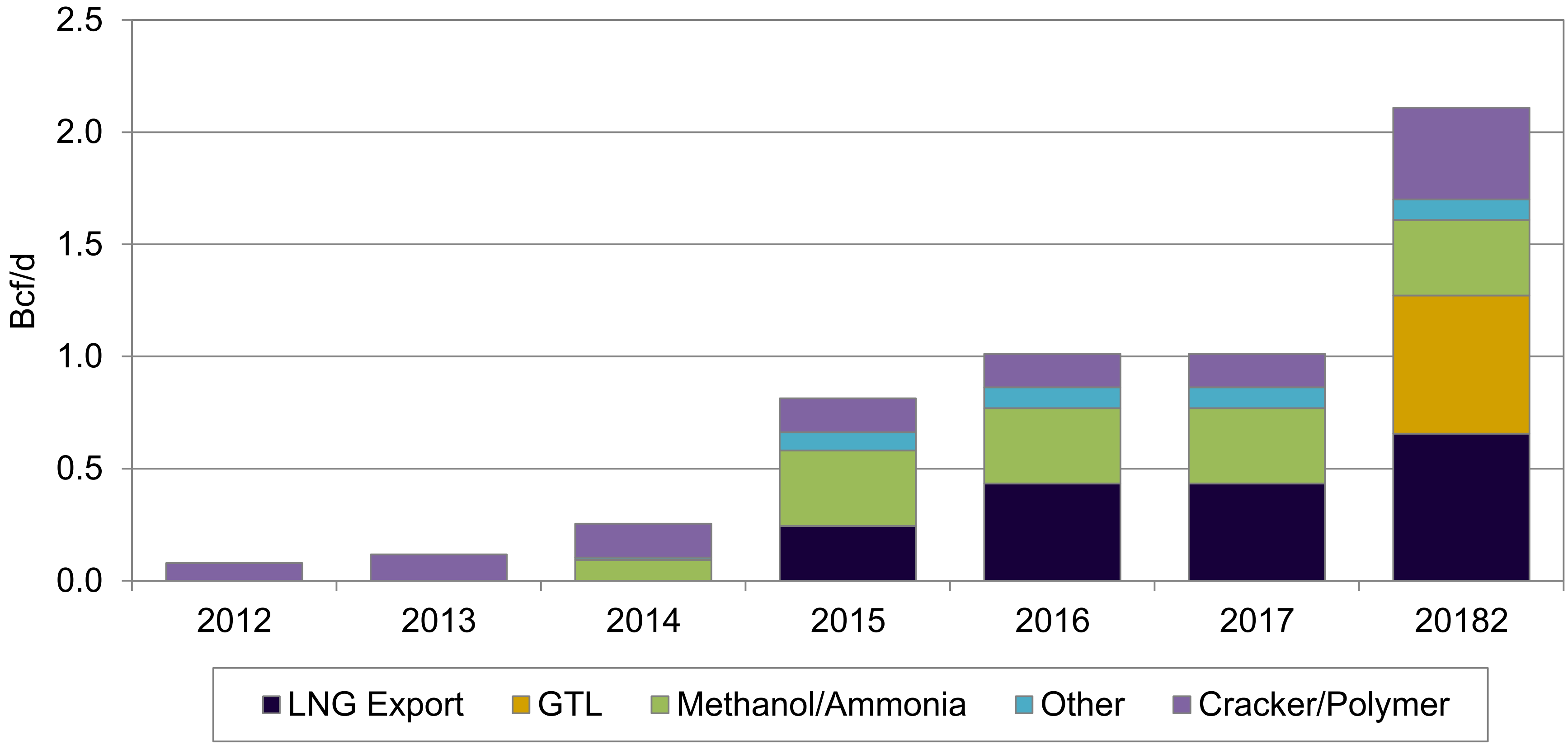
Electric Capacity by Sector and Online Date

Capacity requirements associated with all currently-announced projects would come close to doubling in-state generation capacity. All of this capacity has the technical capabilities for CHP development. The extent of CHP development will be a function of final project development, which is unknown at this time.



Total Natural Gas Capacity by Sector and Online Date

Industrial gas demand could also double given current project announcements.

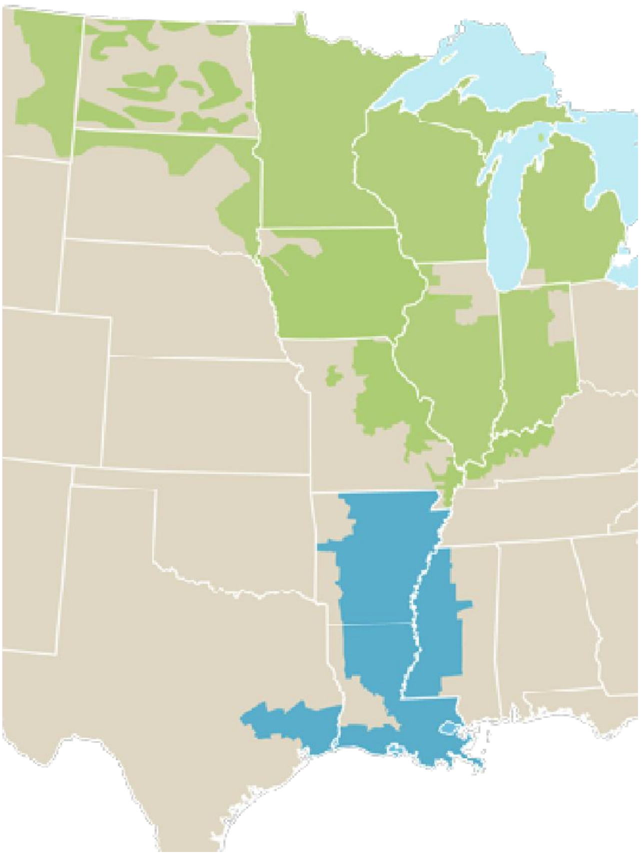


Potential Economic Impacts/Benefit: Construction, State

Not quiet as clear will be the additional power/gas requirements for all the new residential and commercial activities supporting development/operation. Should elevate regional usage trends relative to national averages and provide for additional opportunities to sell currently-underutilized CHP capacity to host utilities.

	Construction Impacts									
	Total	2011	2012	2013	2014	2015	2016	2017	2018	2019
Output (million $)										
Direct	$ 17,080.2	$ 4.4	$ 1,715.4	$ 2,458.1	$ 3,535.5	$ 3,765.0	$ 3,764.9	$ 1,696.2	$ 140.7	$ -
Indirect	$ 2,742.2	$ 0.7	$ 275.4	$ 394.6	$ 567.6	$ 604.5	$ 604.4	$ 272.3	$ 22.6	$ -
Induced	$ 5,315.3	$ 1.4	$ 533.8	$ 765.0	$ 1,100.2	$ 1,171.7	$ 1,171.6	$ 527.9	$ 43.8	$ -
Total	**$ 25,137.6**	**$ 6.4**	**$ 2,524.6**	**$ 3,617.7**	**$ 5,203.3**	**$ 5,541.1**	**$ 5,540.9**	**$ 2,496.4**	**$ 207.0**	**$ -**
Employment (jobs)										
Direct	115,726	30	11,623	16,655	23,955	25,510	25,509	11,493	953	-
Indirect	18,500	5	1,858	2,662	3,829	4,078	4,078	1,837	152	-
Induced	47,241	12	4,745	6,799	9,779	10,414	10,413	4,692	389	-
Total	**181,468**	**47**	**18,225**	**26,116**	**37,563**	**40,001**	**40,000**	**18,022**	**1,495**	**-**
Wages (million $)										
Direct	$ 5,566.6	$ 1.4	$ 559.1	$ 801.1	$ 1,152.3	$ 1,227.1	$ 1,227.0	$ 552.8	$ 45.8	$ -
Indirect	$ 804.7	$ 0.2	$ 80.8	$ 115.8	$ 166.6	$ 177.4	$ 177.4	$ 79.9	$ 6.6	$ -
Induced	$ 1,493.1	$ 0.4	$ 150.0	$ 214.9	$ 309.1	$ 329.1	$ 329.1	$ 148.3	$ 12.3	$ -
Total	**$ 7,864.5**	**$ 2.0**	**$ 789.8**	**$ 1,131.8**	**$ 1,627.9**	**$ 1,733.6**	**$ 1,733.5**	**$ 781.0**	**$ 64.8**	**$ -**

MISO Integration: Competitive Wholesale Market Changes/Benefits

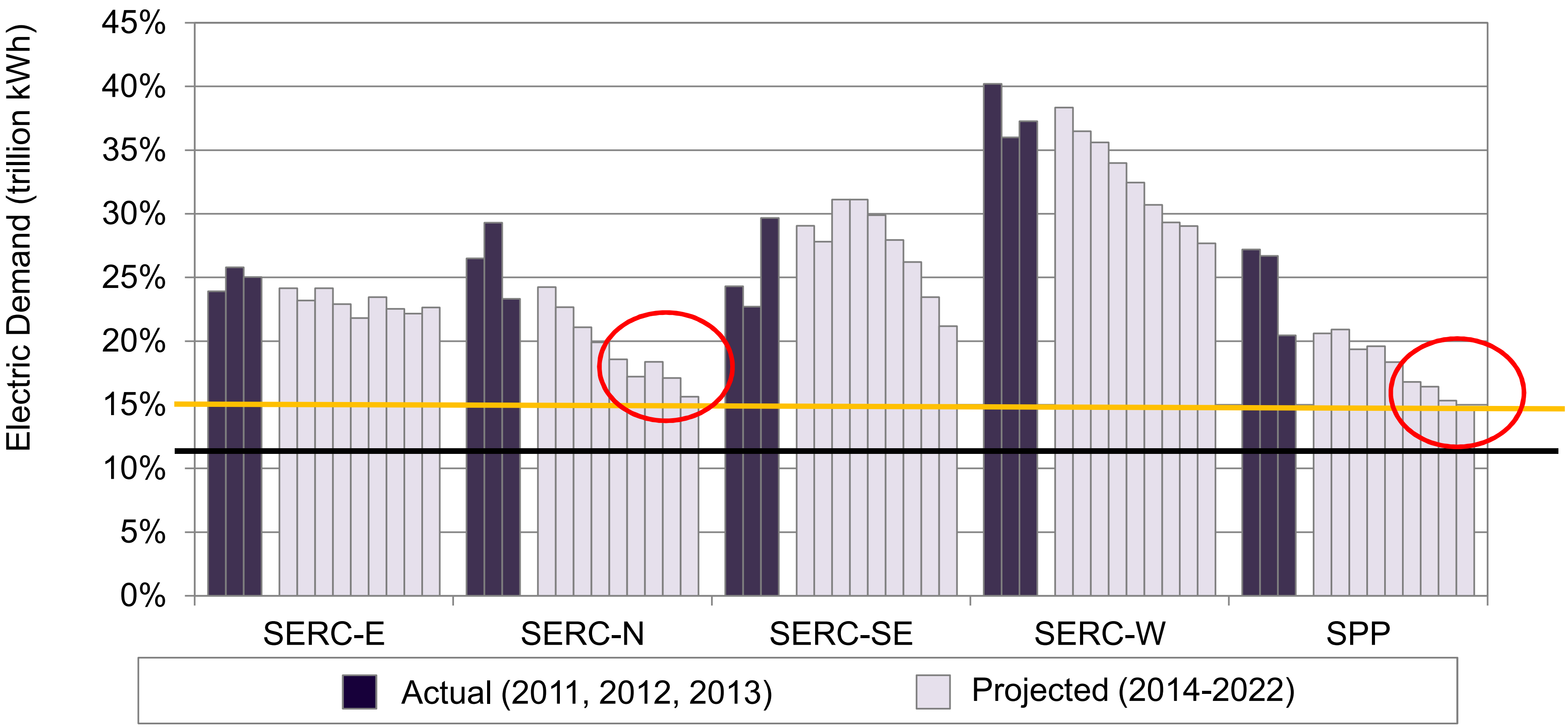


- There are a number of wholesale market benefits that can arise from the expansion of MISO to the Gulf Coast that include:
- Greater power generation market efficiencies.
- The ability to move highly-efficient and environmentally-friendly natural gas fired generation into an area historically dominated by coal-fired generation.
- Greater market scope opportunities by providing lower-cost, highly efficient natural gas generators easier access to quickly growing mid-western electric power markets.

Source: Entergy.

SERC/SPP Historic and Projected Reserve Margins

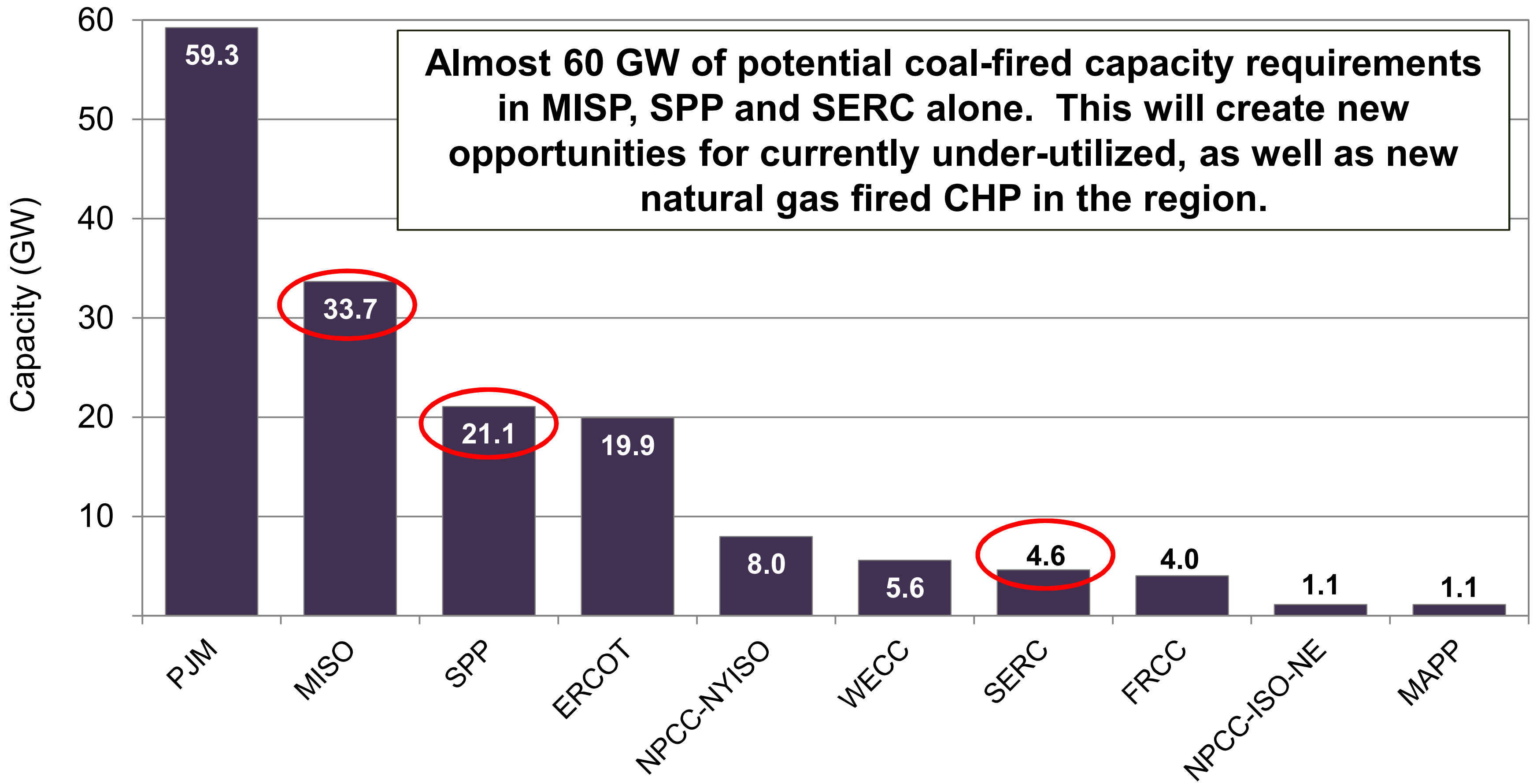
While margins are anticipated to fall, the conventional wisdom is the decrease will be slow. Does not appear these forecasts include the exceptional increases in power generation requirements will be needed from new industrial expansions.



Source: NERC; SERC planning standard line at 15 percent; SPP planning standard line at 13.6 percent.

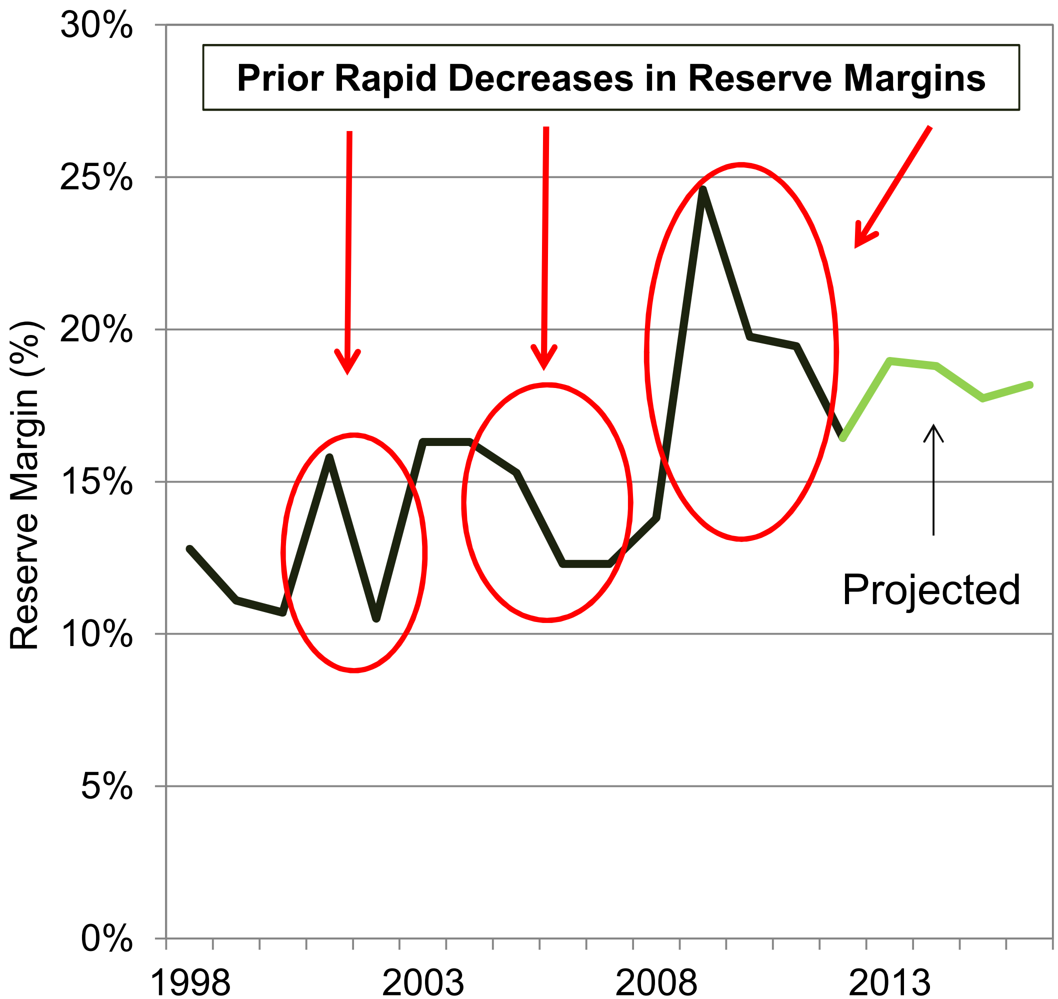
Estimated Environmental Retirements by NERC Region

NERC estimates that 160 GWs (339 units) will need retrofits by 2016. NERC also estimates that MISO will need to control over 33 GW of fossil-fueled generation to comply with new EPA regulations.



Source: NERC.

Historic and Projected Reserve Margin Changes



Have seen examples in the past where excess generation can be burnt off relatively quickly.

Source: Energy Information Administration, U.S. Department of Energy.

Policy Summary

- Projected industrial development is large and unprecedented and will create new opportunities for CHP.
- The "multiplier" impacts associated with this economic activity and its impacts on electricity use are not often considered but could move what has been flat to decreasing power and gas use upward for smaller use customer classes (increasing the opportunities for CHP off-system sales).
- Environmental regulations will preference more gas: movement to MISO will facilitate the movement of gas-by-wire, including (new/existing) CHP-based gas-by-wire.
- MISO will provide better price and transmission planning transparency and will likely lead to a considerable re-investment in transmission assets opening up historic bottlenecks that have restricted past CHP output flows.
- History shows how quickly reserve/capacity margins can evaporate: new economic growth could result in the need for capacity quickly.

Conclusions

Conclusions

- Louisiana has a long historic with CHP development. Over 24 percent of all in-state generation capacity is CHP-based.
- Some additional industrial plants have the technical capability for CHP (~1,500 MW), while a smaller number of plants have the ability to cost-effectively generate CHP-based electricity (~600 MW), but for some reason, are not employing this potential efficiency opportunity. Thus, most of those facilities that can cogenerate, do.
- Considerable future CHP opportunities given $61 billion in new industrial capex: results in estimated power requirement of close to 10 GW (assuming all is developed).
- MISO integration will likely eliminate decades-old issues associated with price discovery; transmission operations/planning transparency; and market scope.
- The future looks very bright for the operation of existing CHP, and the development of new CHP, in Louisiana.

Questions, Comments, and Discussion

dismukes@lsu.edu

www.enrg.lsu.edu