EPA Energy Efficiency Workshop

In Cooperation with Ohio Department of Development-Office of Energy Efficiency

June 29, 2004

WELCOME

Ron Smith-Environmental Specialist

Today's Presenters

- Tony Sutor-ODOD
- Chandan Rao-Graphet Inc
- Jack Ciesa- **JCC ENERGY-SOLUTIONS, LLC**
- Bob Scott-Scott Energy Technologies
- Jose Antommarchi-TQ Technology
- Jeff Lyon-ECO Engineering

Purpose of Today's Training

Energy Efficiency = Emission Reduction

- Electric consumption conservation
  - Ohio generation portfolios significantly dependant upon coal based facilities
  - Less power generation
  - Reduction of greenhouse gases associated with combustion of coal

Energy Efficiency = Emission Reduction

- Other fossil fuel consumption conservation
  - Reduction of greenhouse gases associated with combustion

Compressed Air System Efficiency What is it all about!!

Chandan Rao-Graphet Inc

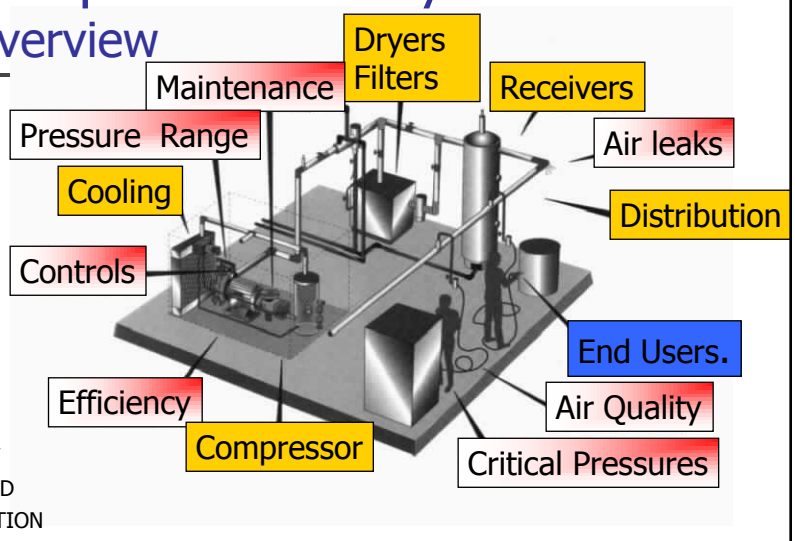
Objective:

- Provide an overview of compressed air systems
- Understand what it is about
- Create an awareness of the opportunities that can generate value for your customers

Compressed Air Systems
Overview

- Required for Industrial Plant Operations
- Some Compressed Air Applications
  - Air tools / Air motors / Air Brakes / Air gages
  - Agitation
  - Conveying / Clamping
  - Blending / Drying / Spraying
  - Controls
  - ……
- A critical utility for production

Compressed Air Systems
Overview



Compressed Air Systems
Understand what it is about

- Of the total electric usage in the US Industrial Market Compressed Air Systems Consume ?
  - A) 5-10% of total electricity
  - B) 10-15% of total electricity
  - C) >15% of total electricity
- Answer C – represents $4,500,000,000 /yr

BASIS DOE 2001 COMPRESSED AIR MARKET EVALUATION

Compressed Air Systems
Understand what it is about

- Systems improvements can reduce in electric costs for producing compressed air by ?
  - A) 5-10% of total electricity
  - B) 10-15% of total electricity
  - C) 16 to 50% of total electricity
- Answer C – represent >$800,000,000

BASIS DOE 2001 COMPRESSED AIR MARKET EVALUATION

Compressed Air Systems
Understand what it is about

- So why isn't it being done – customers feedback?
- A) Lack of understanding of benefits
- B) No time / have more urgent issues
- C) Lack of communication & shared goals between maintenance & production engineers
- D) All of the above

Compressed Air Systems
Understand what it is about

- So why isn't it being done – service providers?
- A) Skepticism about energy savings
- B) Customers feel they already do this
- C) Conflict of interest in the case of equipment distributors
- D) All of the above

Compressed Air Systems
Opportunities – System Components

Utilities Perspective:

We make it they use it.

WORKING DON'T MESS WITH IT

- Compressors
- Dryers / Coolers
- Filters
- Tanks
- Drains / Traps
- Piping
- Leaks
- Flow Controllers
- End Users

End User Perspective:

Maintain production.

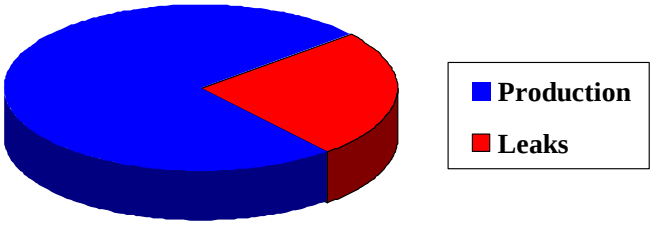
MORE IS BETTER – IT IS FREE

Compressed Air Systems
Opportunities – Traditional Approach

Engineered & retrofit on the supply side only

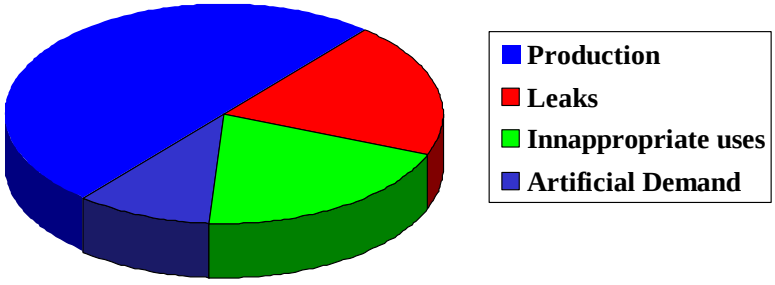
- Higher efficiency compressors & motors
- Variable speed drives
- Microprocessor controls
- Energy efficient dryers
- Heat recovery and cooler retrofits

Demand side viewed as a system with two components:



Compressed Air Systems
Opportunities – Demand Side

*Real-world analysis of the demand side:



*Information based on averaged data from industry consultants participating on the energy efficiency council of the Compressed Air Challenge

Compressed Air Systems
Opportunities – Leaks

Industry average is 26% of total compressed air demand

Leak repair program consists of many components:

- Leak load analysis
- Establish goals at a reasonable benchmark
- Detect, tag and catalog
- Assign a cost based on size
- Prioritize repair based on assigned cost
- Repeat above steps

Compressed Air Systems
Opportunities – Inappropriate Uses

Can you think of where you may be doing any of these?

- Open blowing
- Sparging
- Aspirating
- Atomizing
- Padding
- Dilute phase transport
- Dense phase transport
- Air Motors
- Vacuum generation
- Personnel cooling
- Open hand held blow guns
- Air lances
- Cabinet cooling
- Diaphragm pumps
- Timed drains
- Open drains

Compressed Air Systems
Opportunities – Artificial Demand

Compressed air system pressure requirements are set by "pressure critical" end uses in the plant.

Operating plant pressure at levels higher than necessary:

- Leaks expel more compressed air
- Cylinders consume more than is needed to perform tasks
- Unregulated points of use consume more compressed air

Typically, less than 5% of demand is represented by the "pressure critical" end uses -

- Packaging
- Automated assembly lines
- Air tools

Compressed Air Systems
Opportunities – Systems Approach

Entire system can be configured for efficiency:

- Inappropriate uses supplied by alternate means
- Artificial demand eliminated by stabilizing plant pressure at true requirement
- Leak program implemented
- Supply side components optimized for lowest kW/Scfm

Savings in compressed air system can approach 50% of the existing cost to operate or 5+% of total utilities cost per year!

Compressed Air System Opportunities

- Example – Bakery
  - (2) 75hp compressors lubricated rotary screws,
  - 1-2 in. diameter distribution piping with ½ in. equipment connections.
  - Air motors / lifters / controls / baggers
- Improvements
  - Leak reduction
  - Increase diameter of portions of header
  - Remove secondary oil separator
  - Use unloading controls
  - Reduce discharge pressure by 10 psig
- **Savings $7,800 (1.5 yr simple payback)**

Compressed Air System Opportunities

- Example – Manufacturing Plant
  - (4) lubricated rotary screws in three rooms
  - One distribution system
  - Pumps / controls / filter press / Mixers / Tools / Vacuum / Clamps / Open blowing…
- Improvements
  - Leak reduction
  - Apply dedicated storage and metered recovery
  - Install shut off air valves
  - Compressed air systems controls and flow controller
  - Reduce on-line hp from 200 to 125 hp.
- **Savings $19,000 (2.8 yr simple payback)**

Compressed Air System Opportunities

- What we typically find?
  - Typically 10 to 40% of electricity is used for compressed air
  - About 30% to 50% of that can be conserved
  - These projects usually meet customers return on investment requirements
  - System improvements are particularly of value when
    - there are capacity issues
    - quality issues or
    - reliability issues

Compressed Air System Opportunities

- What to look for?
  - Size of compressors
  - No of compressors
  - Operating pressure range
  - Production problems / capacity issues?

Compressed Air Systems Opportunities – Benefits

Taking a systems approach to compressed air will provide a vital "fourth utility" that:

- Is manageable
- Is more reliable
- Is very stable
- Has enhanced air quality
- Improves production throughput
- Reduces waste and scrap

GRAPHET INC - *your* partner of choice for compressed air systems solutions.

JCC ENERGY-SOLUTIONS, LLC
Jack Ciesa

Ohio EPA

STEAM SYSTEM OPTIMIZATION

JUNE 29, 2004

JCC ENERGY-SOLUTIONS, LLC

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V. Performance Improvement Plan
VI. Other Benefits
VII. Rules of Thumb
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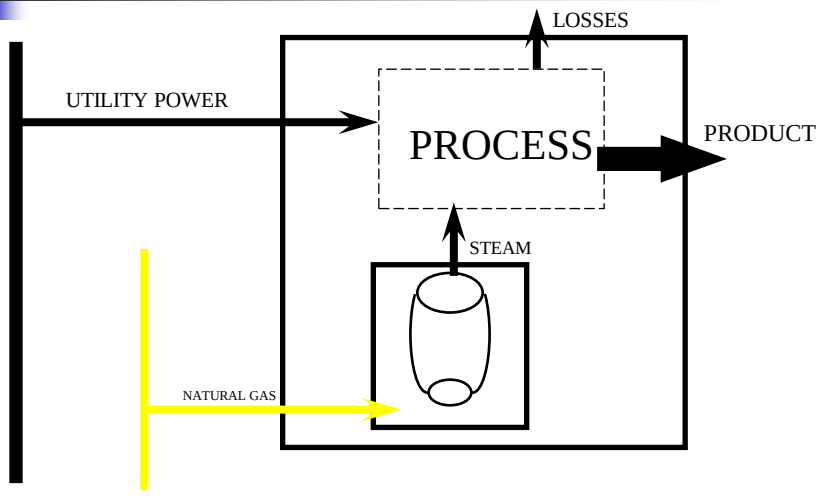
TYPICAL INDUSTRIAL STEAM SYSTEM



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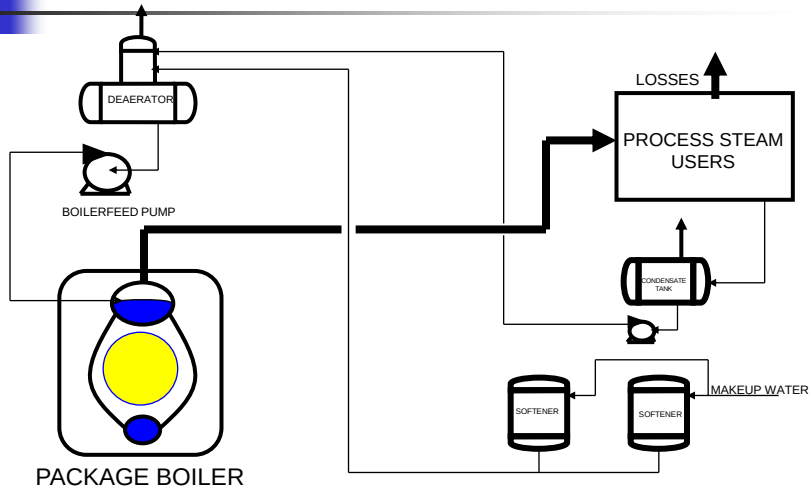
INDUSTRIAL STEAM SYSTEM DETAILS:



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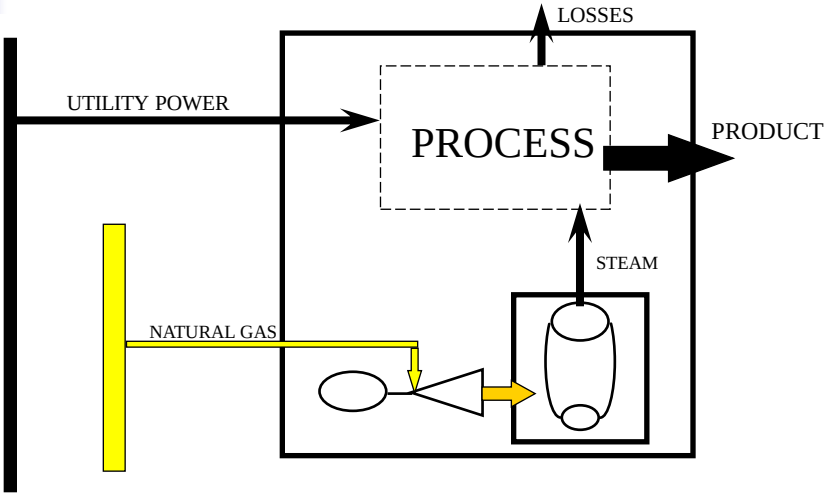
TYPICAL COGENERATION STEAM SYSTEM:



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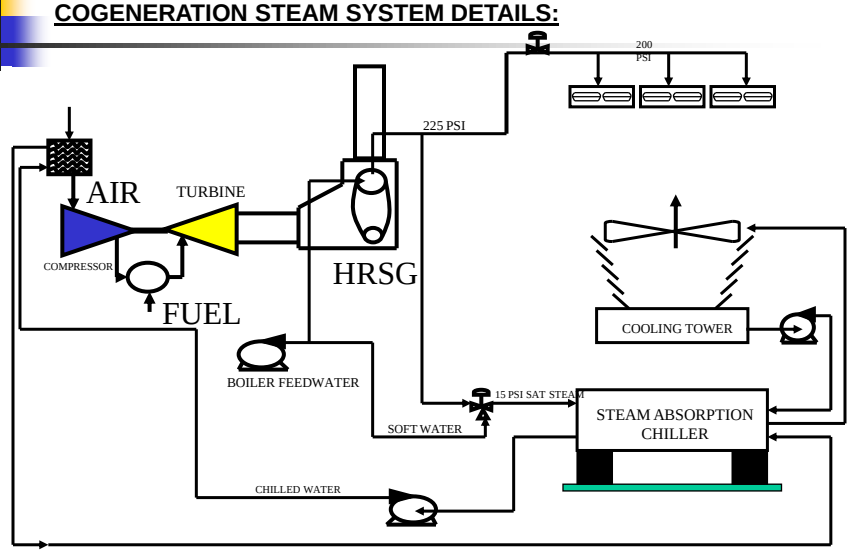
COGENERATION STEAM SYSTEM DETAILS:



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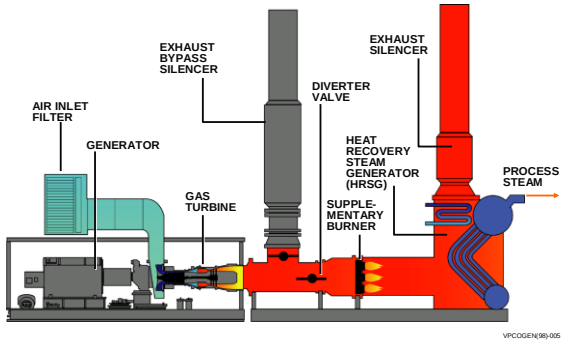
Solar Turbines
A Caterpillar Company

CHP



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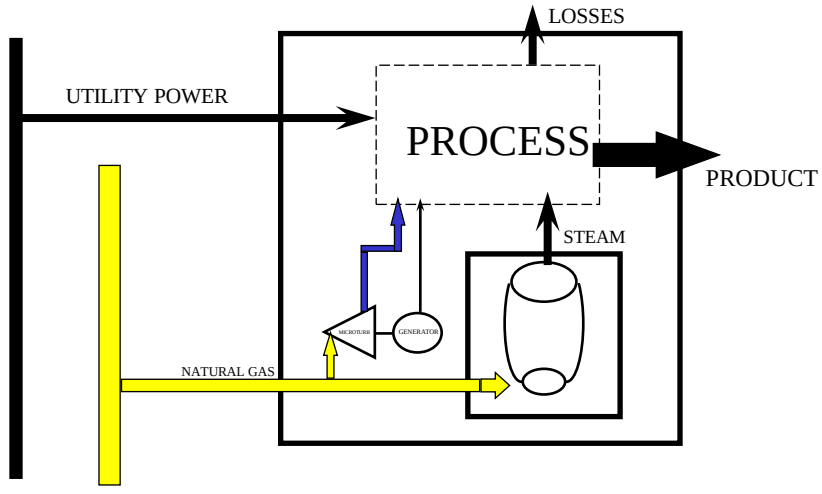
TYPICAL DISTRIBUTED GENERATION STEAM SYSTEM:



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II. DOE FACTS, STEAM SYSTEMS & EMISSIONS:

1. Over 45% of fuel burned in the U.S. is consumed to generate steam.
2. Typical Industrial facility can realize as much as 20% steam savings.
3. This represents $4.0 billion in fuel cost reductions & 32 million metric tons of emission reductions.

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III. RELATIONSHIP BETWEEN ENERGY USE & EMISSIONS:

CONVERSION FACTORS (LBS PER MMBTU)

	CO2	NOX
1. NATURAL GAS	117	0.133
2. NO. 2 OIL	168	0.143
3. NO. 6 OIL	179	0.357
4. COAL	225	0.833
5. PROPANE	174	0..96

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IV. STEAM SYSTEM EFFICIENCY MEASURES:

	POTENTIAL ENERGY REDUCTION
1. LEAKS/INSULATION	10-50%
2. TRAPS	10-50%
3. LOWER PRESSURE	1-5%
4. LOAD LEVELING	1-5%
5. TUNING	1-10%
6. DEPOSITS	2-4%
7. LOWER BLOWDOWN	1-5%
8. CONDENSATE RETURN	10-20%
9. BOILER ECONOMIZER	2-6%
10. COMBUSTION AIR PREHEAT	1-2%
11. LP PRESSURE STEAM RECOVERY	10-20%

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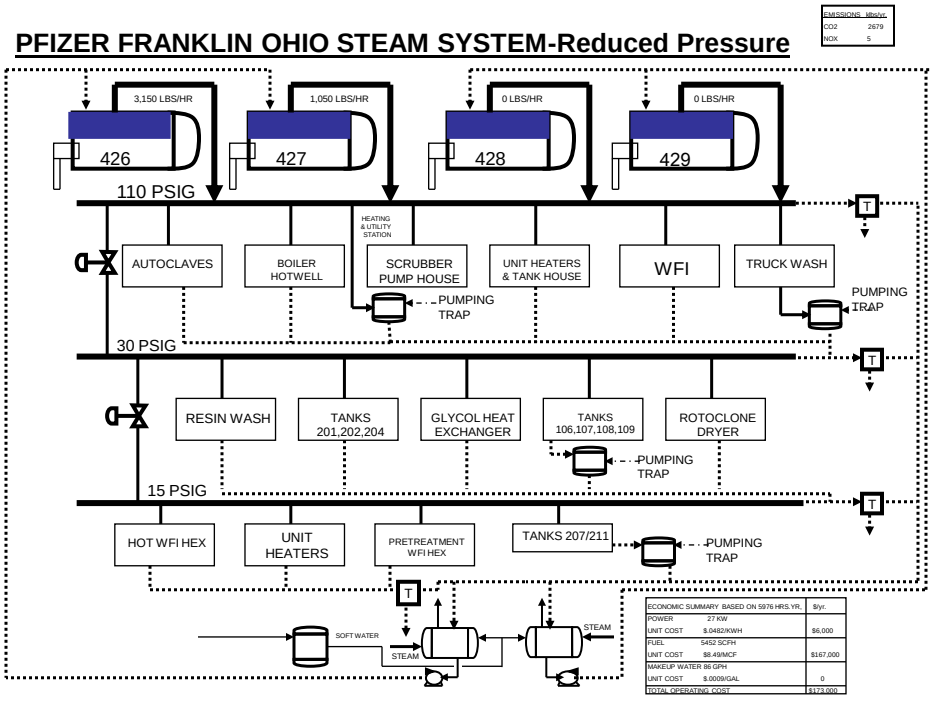
V. 5-STEP PERFORMANCE IMPROVEMENT PROCESS:

1. CREATE STEAM SYSTEM SCHEMATIC
2. MODEL THE STEAM SYSTEM
3. BALANCE THE SYSTEM
4. DETERMINE STEAM SYSTEM EFFICIENCY MEASURES
5. JUSTIFY STEAM SYSTEM SAVINGS IMPROVEMENTS

PFIZER FRANKLIN OHIO STEAM SYSTEM-Reduced Pressure



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DOE SSAT (Steam System Assessment Tool)

Purpose- Model Steam Systems for Efficiency.

SSAT Format:

- Site Power
- Power Cost
- Operating hours
- Makeup water cost
- Makeup water temperature
- Site fuel cost
- Steam pressure
- Steam volume
- Steam turbines
- Power generation
- Steam traps
- Boiler efficiency
- % blowdown
- Steam conditions
- Deaerator
- Feedwater heat recovery
- Steam losses, leaks etc.
- Insulation

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Steam System Assessment Tool

3 Header Model

Data Entry Form for Current System

The data entry form is split into two sections. ***"Quick Start"*** enables you to enter a minimum amount of information about your site and to start modeling your system right away. ***"Site Detail"*** allows you to provide more detailed information about your site to improve the accuracy of the model.

Yellow shaded cells require user input.

Where different options can be chosen by the user, the required supplementary data input cells are shaded green and are indicated by ***red arrows*** .

Quick Start

Enter Case Description	SSAT Default 3 Header Model

General Site Data	Input Data	Notes/Warnings
Site Power Import (+ for import, - for export)	13000 kW	Power import + site generated power = site electrical demand
Site Power Cost	0.0700 $/kWh	Typical 2002 value: $0.07/kWh
Operating hours per year	8000 hrs	
Site Make-Up Water Cost	0.0025 $/gallon	Typical 2002 value: $0.0025/gallon
Make-Up Water Temperature	50 F	

Note: Enter average values for the operating period being modeled

Boiler fuel - Choose from this drop-down list	Natural Gas
Site Fuel Cost per 1000 s.cu.ft	5.00 $ — Typical 2002 value: $5.00/(1,000 s.cu.ft)

Note: Fuel HHV is 1,000 Btu per s.cu.ft (21,022 Btu/ft3)

Steam Distribution	Input Data	Warnings
High Pressure (HP)	600 psig	
Medium Pressure (MP)	150 psig	
Low Pressure (LP)	20 psig	
HP Steam Use by Processes	50 klb/h	
MP Steam Use by Processes	100 klb/h	
LP Steam Use by Processes	200 klb/h	

Note: Enter process steam use at each pressure level. Excludes turbines, letdowns, leaks, trap losses, deaeration steam and vents

Steam Turbines	
Do you have a steam turbine installed between HP and LP?	Yes
Do you have a steam turbine installed between HP and MP?	Yes
Do you have a steam turbine installed between MP and LP?	No
Do you have an HP to condensing turbine installed?	No

For a **Condensing Turbine**, please define how the turbine operates and then provide supplementary information below:

Mode of Operation	Not installed
Option 1 - Fixed power generation	1000 kW
Option 2 - Fixed steam flow	50 klb/h

Steam Traps	Input Data	Warnings
Number of traps at each pressure level		
Traps on HP header	250 traps	
Traps on MP header	300 traps	
Traps on LP header	500 traps	

Select the approximate timing of your last trap testing and maintenance program	3-5 years ago

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ENERGY EFFICIENCY MEASURE SAVINGS SUMMARY

Energy Efficiency Measures	Steam Savings Lbs/Hr.	Fuel Savings CFH	CO2 Reduction Lbs/Yr.	Fuel Energy Savings $/yr	KWH Savings	Energy Savings $/yr.	KW Savings	Energy Savings $/yr.	Installed Cost	Total Savings $/yr.	Simple Payout Years
1. Boiler Tuning	NONE	137	96,000	$7,000	NONE	NONE	NONE	NONE	0	$7,000	0
2. Boiler Steam Pressure Reduction	NONE	212	147,000	$11,000	NONE	NONE	NONE	NONE	0	$11,000	0
3. Boiler Economizers	1,000	204	142,000	$10,000	NONE	NONE	NONE	NONE	$44,000	$10,000	4.4
4. Steam Trap Repairs	300	390	271,000	$20,000	NONE	NONE	NONE	NONE	$3,000	$20,000	.15
5. Process Water Use Reduction WFI Still & Tank 205	NONE	NONE	NONE	$5,000	Min	Min	Min	Min	$4,000	$5,000	.8
6. Air Leak Repairs	NONE	NONE	718,000	NONE	61,653	$1,761	10.8	$1,837	$3,000	$3,599.	.8
7. Air Press Reduction	NONE	NONE	264,000	NONE	22,678	$648	3.7	$636	0	$1,284	0
Totals	1,300	943	1,638,000	$53,000	84,331	$2,409	14,5	$2,473	$51,000	$57,883	0.9

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VI. Other Benefits:

- CAPEX Postponed, Longer Time Between Equipment Replacement
- CAPEX Reduced, Less Redundancy Required
- Operating Costs are Reduced
- Utility Equipment requires less Maintenance, is more Reliable, and Safer
- Future Energy Price Escalation Impact Reduced

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VII. Rules of Thumb:

1. Boiler Feedwater Temperature 10 degrees F Increase=1%
2. Boiler Flue Gas Temperature 40 degrees F Decrease= 1%
3. Combustion Air Preheat 40 degrees F increase= 1%
4. Deposits 1/16” Increase=1% Efficiency Decrease
5. Low Pressure Steam= 1,000 BTU’S
6. Failed Low Pressure Steam Trap Approx. Flow= 40 lbs/hr.

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VIII. CONTACT INFORMATION:

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DOE PHAST (Process Heating Assessment & Survey Tool) Specialist

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Process Heat and Cogeneration

Bob Scott
Scott Energy Technologies
6/29/2004

Process Heat

Types of Process Heating

- Furnaces
- Kilns
- Heaters
- Kilns
- Ovens
- Lehrs

Process Heat Facts

- Process heat accounts for 10% of total US energy use
- Process heat efficiency ranges from 20% to 60% (relatively low)
- Improvements in process heating performance offer potential for 50% energy savings
- Process heat equipment accounts for 80% of carbon emissions from industrial end-users

Thermal Processes

- Steam Generation
- Fluid Heating
- Calcining
- Drying
- Heat Treating
- Metal Heating
- Metal and Non-metal melting
- Smelting
- Curing and Forming
- Other Heating (Thermal oxidizers, ladle heating, etc.)

Fuels

- Natural gas
- Oil
- Propane
- Waste Gases
- Electricity

Combustion System Components

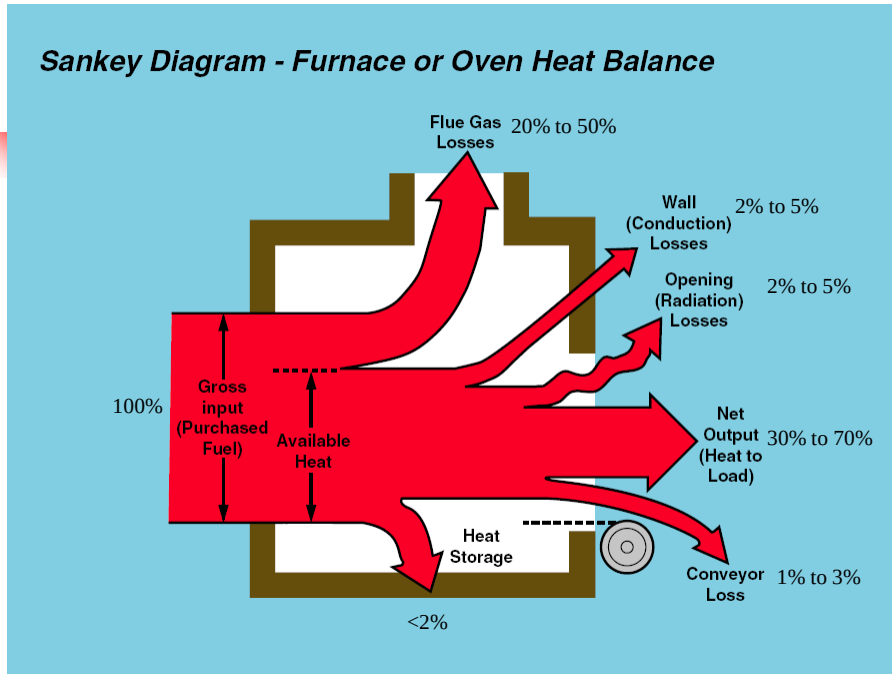
- Burners
- Air-fuel flow control systems
- Air-Fuel supply system
- Ignition system
- Flame monitoring-supervisory system
- Air preheating system
- Oxygen supply system

Effects of Combustion System on Performance

- Heat transfer to load - furnace productivity
- Product quality – reactions of combustion products with the load
- Thermal efficiency
- Emissions
- Safety

Available Heat

- Heat that is available to load
- Available Heat = (Furnace Heat Input – Heat in Flue Gases)
- % Available Heat $= \left\{ \frac{(\text{Heat Input-Heat in flue gases})}{\text{Heat Input}} \right\}$



Emissions

- CO - not enough excess air
- NOx – too much excess air, high temperatures
- UHCs – not enough excess air

Process Heating Energy Saving Opportunities

- Operations and maintenance
- Retrofits and improvements
- Selected emerging new technologies

Process Heating Efficiency Improvement

- Combustion systems for furnaces and ovens
- Improved heat transfer
- Reduction of wall losses and air infiltration
- Waste heat recovery (flue products)
- Control systems (sensors, control strategies)
- Furnace scheduling - operations

Want to Learn More?

- **http://www.oit.doe.gov/bestpractices/process_heat/**

Cogeneration

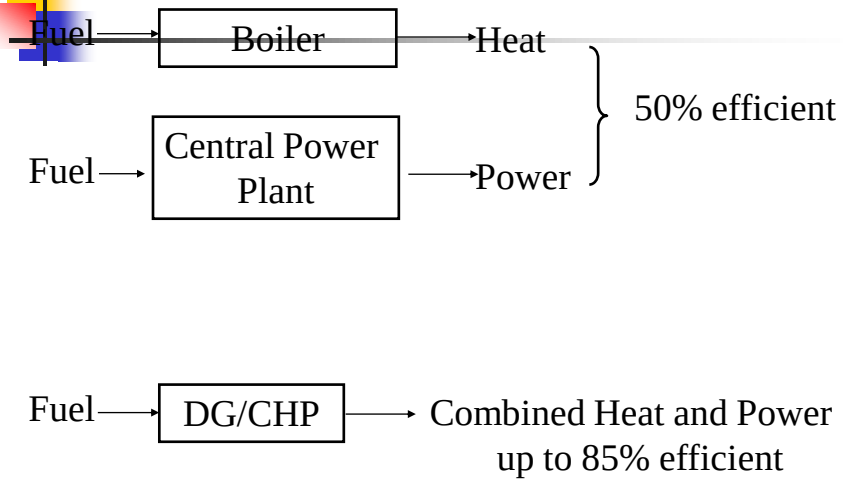
Cogeneration

- The simultaneous generation of power and useful heat
- Systems must be designed to match process energy usage unless power or heat is exported
- Systems can be electrically loaded or thermally loaded

Types of Prime Movers

- Industrial Gas Turbines
- Reciprocating Engines
- Microturbines
- Fuel Cells

Cogeneration Efficiency Advantage



What is CHP?

- Combined Heat and Power
- CHP systems sequentially produce electricity and thermal energy
- Site must have continuous thermal use
- Thermal energy is typically LP/HP steam, hot water
- CHP boasts energy utilization efficiencies up to 85%
- CHP and DG are perfect together

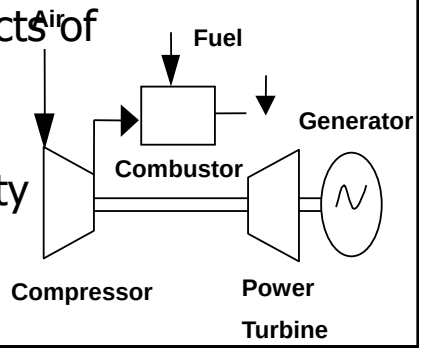
Technology Options

	Status	Size	Efficiency (%)	Installed Costs ($/kW)	O&M Costs ($/kWh)
Reciprocating Engine	Commercial	30 kW - 20 MW	30 - 38	500 - 1400	0.007-0.02
Combustion Turbine	Commercial	500 kW - 150 MW	25 - 40	600 -900	0.003-0.008
Microturbines	1999	25 kW - 300 kW	20 - 30	600 - 1500	0.003-0.01
Fuel Cells	1996 - 2010	3kW - 3MW	36 - 60+	1900 - 3500	0.005-0.010

Gas Turbines

Principle of Operation Gas Turbines

- Compressor - raises pressure of inlet air
- Combustor - fuel and air mixed and ignited
- Power turbine - hot products of combustion rotate blades
- Generator converts shaft power to electricity



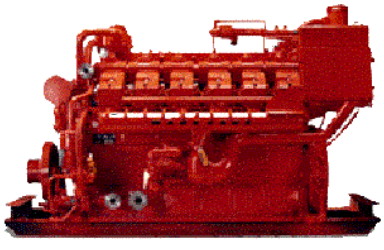
Emission Control - Gas Turbines

- Water/Steam Injection (42 ppm NOx)
- Lean-Premix, Dry LoNOx (25 ppm NOx)
- Selective Catalytic Reduction, ammonia (9 ppm NOx)
- Control technologies can be used in series (3 ppm NOx)
- Emerging technologies: catalytic combustion - 3 ppm, SCONOx™ -2 ppm, lean pre-mix <15 ppm

Reciprocating Engines

Reciprocating Engines

- Size Range: 30 - 6,000 kW
- Electric efficiency: 30 - 38%
- Start-up time: 10 sec
- Fuel gas compressor usually required
- Requires owner-supplied enclosure for noise attenuation



Emission Controls - Reciprocating Engines

- Lean Burn with Electronic Air/Fuel Ratio Control (<1 gm NOx/hphr)
- Rich Burn with Three-Way Catalyst (<0.5 gm NOx/hphr)

Microturbines

- Size range: 25 - 300 kW
- Electric efficiency: 20 - 30%
- Start-up time: 1 min.
- Fuel compressor may be required
- Factory furnished enclosure for noise attenuation
- Commercial introduction 2000

Microturbines

- Recuperators available on most models (results in >25% efficiency) / reduced opportunity for CHP heat recovery
- Emission Controls - Lean Premix, Dry LoNOx (25 ppm NOx)

Fuel Cells

Fuel Cells

- Size range: 3 - 3,000 kW
- Start-up time: 3hrs -
- Electric efficiency: 40-70%
- Fuel gas compressor usually not required
- Quiet operation - no sound attenuating enclosure generally required

Fuel Cells

- Residential units promised for 2004
- Emission controls - Exempt status

Motors and Drives Opportunities

EPA TRAINING

TUESDAY JUNE 29, 2004

by:

JOSE ANTOMMARCHI – TQ TECHNOLOGY

Motors and Drives Opportunities

SUBJECTS COVERED

- **Adjustable Speed Drives (ASD)**
- **High Efficiency Motors**

Motors and Drives Opportunities

- General
  - Virtually used in 100% of industrial, commercial and residential buildings
  - 23% of all electricity consumed in US
  - 70% of all electricity consumed by US mfg

Motors and Drives Opportunities

- **ASD**
  - **DEFINITION: SPEED (IN RPM) CAN BE ADJUSTED BY USER**
  - **OTHER TERMS**
    - **VSD**
    - **VFD**
    - **AFD**

Motors and Drives Opportunities

- General
  - Virtually used in 100% of industrial, commercial and residential buildings
  - 23% of all electricity consumed in US
  - 70% of all electricity consumed by US mfg

Motors and Drives Opportunities

- **ASD**
  - **3 FUNCTIONAL CONSIDERATIONS**
    - **Constant Torque**
    - **Constant Hp**
    - **Variable Torque**

Motors and Drives Opportunities

- **ASD**
  - **CONSTANT TORQUE**
    - **Load most frequently encountered**
    - **Load requires the same amount of torque at low speed as at high speed**
    - **Example: A 10-ton load on a conveyor requires about the same torque at 5 feet per minute as it does at 50 feet per minute**

Motors and Drives Opportunities

- **ASD**
  - **CONSTANT HP**
    - **Load decreases with increasing speed.**
    - **application usually applies to processes that are changing diameters**
    - **Examples: Lathes, winders and metal-cutting tools operating over wide speed ranges**

Motors and Drives Opportunities

- **ASD**
  - **VARIABLE TORQUE**
    - **Load increases with speed**
    - **The hp varies as the cube of the speed**
    - **Examples: Fans, pumps**

Motors and Drives Opportunities

- **ASD**
  - **WHAT TO LOOK FOR**
    - **Any application where a motor's load is variable**
      - **Pumps**
      - **Fans and blowers**
      - **Hoists**
      - **Cranes**
      - **Machine tools**
      - **Film lines**
      - **Extruders**

Motors and Drives Opportunities

- **ASD**
  - **CONCERNS**
    - **Harmonics**
    - **Transient voltages**
    - **Sags and Surges**

Motors and Drives Opportunities

- **ASD**
  - **BOTTOMLINE**
    - **Consider** Variable/Adjustable Speed or Frequency drives for low-load operations

Motors and Drives Opportunities

- **HIGH EFFICIENCY MOTORS**
  - **DEFINITION: Motors whose efficiency, i.e., output-to-input ratio is higher than conventional motors -- e.g., 91% vs 88%**

Motors and Drives Opportunities

- **HIGH EFFICIENCY MOTORS**
  - **FUNCTIONAL CONSIDERATIONS**
    - **Load Factor; i.e., percent of time used**
    - **Size in HP**
    - **Deployment Strategy**

Motors and Drives Opportunities

- **HIGH EFFICIENCY MOTORS**
  - **LOAD FACTOR**
    - **Less Than 50% - No**
    - **Over 80% - Yes**
    - **50% - 80% - Maybe**

Motors and Drives Opportunities

- **HIGH EFFICIENCY MOTORS**
  - **SIZE**

    4% savings of 10 HP = 0.4 HP

    vs

    2% savings of 200 HP = 4.0 HP

Motors and Drives Opportunities

- **HIGH EFFICIENCY MOTOR**
  - **DEPLOYMENT STRATEGY**
    - **Change Out Program**
    - **Replacement Program**

Motors and Drives Opportunities

- **HIGH EFFICIENCY MOTORS**
  - **ECONOMIC CONSIDERATIONS**
    - **Initial Cost; 25% more**
    - **Repair/Rehab Costs**

Motors and Drives Opportunities

- **HIGH EFFICIENCY MOTORS**
  - **BOTTOMLINE**
    - **Consider installing high efficiency motors in higher HP applications with continuous use as part of a motor replacement program**

Process Cooling – Chilled Water Systems Energy Conservation Opportunities

Chandan Rao-Graphet Inc
Bob Scott-Scott Energy Technologies

Chandan Rao
(513)-474-4870
June 2004

Objective:

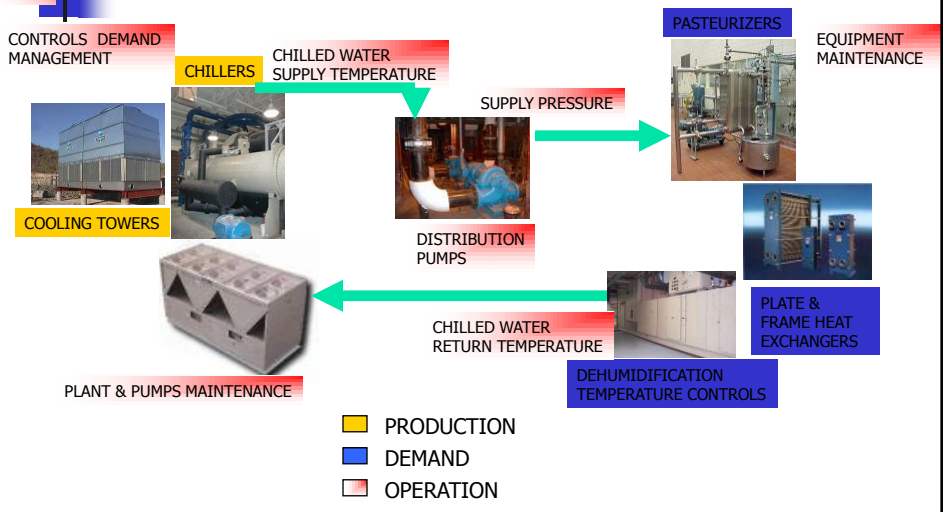
- Provide an overview of chilled water system components
- Understand what it is about
- Create an awareness of the opportunities that can generate value for your customers

Chilled Water Systems
Overview

- Required for HVAC and Process Cooling Applications
- Some Chilled Water Applications
  - Die cooling / film cooling / press cooling
  - Reactor / batch process cooling
  - Product cooling from production temperatures to storage and distribution temperatures
  - Production machine cooling
  - Critical temperature and humidity space cooling
  - ….

  A critical utility for production particularly Food & Beverage / Plastics / Chemical and Allied / Printing / Pharmaceuticals…

Chilled Water Systems
Overview



Chilled Water Systems
Understand what it is about

- Supplying cooling water at the right temperature to the load
  (design criteria)
- Ensuring adequate cooling water flow
  (distribution sytem optimization)
- Achieving as high a return temperature as possible to reduce pumping costs
  (end user controls)
- Cooling the return chilled water efficiently
  (plant optimization)

Chilled Water Systems
Cooling Plant Options

- Centrifugal Chillers **(0.75kw/ton – 0.43kw/ton)**
  - Electric Motor drives
  - Gas/Oil Combustion Engine drives
  - Steam turbine drives
- Screw / Reciprocating Chillers – **(1.4 kw/ton – 0.7kw/ton)**
  - Electric motor drives

Chilled Water Systems
Cooling Plant Options

- Absorption Chillers
  - Gas fired two stage **(approx 10 MMBTUH/ton)**
  - High pressure steam(>100 psig steam) **(approx 10 MMBTUH/ton)**
  - Low pressure steam(<10 psig steam) **(approx 20 MMBTUH/ton)**
- Thermal Storage (Chilled Water/Ice) **(demand management)**

Chilled Water Systems
Centrifugal Chiller Efficiencies

kW/ton for Non-Standard Centrifugal Chillers Centrifugal Chillers >300 tons kW/ton (std) = .576								
			Condenser Flow Rate (gpm/ton)					
			2	2.5	3	4	5	6
Leaving Chilled Water Temp (•F)	Entering Cond. Water Temp (•F)	LIFT (•F)	Required kW/ton					
46	85	39	0.609	0.575	0.558	0.539	0.529	0.522
45	85	40	0.624	0.586	0.567	0.547	0.536	0.529
44	85	41	0.643	0.599	**0.576**	0.555	0.543	0.537
43	85	42	0.663	0.612	0.588	0.563	0.552	0.544
42	85	43	0.688	0.628	0.600	0.573	0.560	0.552
41	85	44	0.717	0.646	0.614	0.584	0.570	0.561
40	85	45	0.751	0.668	0.630	0.596	0.579	0.570
Condenser DT (•F)			14.04	11.23	9.36	7.02	5.62	4.68

ASHRAE STANDARD 90.1 EFFICENCY TABLE FOR CENTRIFUGAL CHILLERS

Chilled Water Systems
Sample Evaluation of Plant Options

CHILLER OPTIONS OPERATING COSTS PER TON HOUR

	Minimum	Design	Design	Design	Auxilliary	Generation	Design Load	After Generation
						Credit	Operating	Credit
Chiller Description	Supply Temp	kw/ton	125#stm lbh/ton	20# stm lbh/ton	kw/ton	$/ton-hr	Cost $/ton-hr	Cost $/tonhr
Electric Centrifugal	39	0.68			0.2055		0.0443	0.0443
Low Pressure Absorber (new)	42			18.78	0.2788	-0.0667	0.0703	0.0036
High Pressure Absorber	42		10.22		0.2763	-0.0210	0.0445	0.0235
Steam Turbine Drive	39		10		0.2692	-0.0205	0.0435	0.0230
Ammonia Screw Chiller	38	0.746			0.2042		0.0475	0.0475

Utility Costs		0.05	3.0	3.0	Cost/1000# of steam out of the boiler
		$/kw	$/1000 lb steam	$/1000 lb steam	
kwh per 1000 lb stm using 850 psig steam			41	71	

Coal Cost	$46	per ton

Cogeneration using high pressure steam and back pressure turbine to get 125 psig or 20 psig steam

Net design operating point cost after accounting for electric savings from cogeneration

Chilled Water Systems
Distribution Pumping Options

- Primary pumps only
- Primary secondary pumping
- Variable speed drives for primary and/or secondary pumps
- Variable speed drives for condenser water pumps for water cooled chillers
- Variable speed drives for cooling tower fans for water cooled chillers

REFERENCE ARTICLE ATTACHED FOR VARIABLE SPEED PUMPING

Chilled Water Systems
System Optimization Issues

Plant:	Distribution System:	End User Perspective:
•Chiller types •Supply Temperature •Thermal Storage •Free Cooling •VFD Drives •Controls •Demand Management	•Pipe sizing •VFD's for pumps •Interface to chillers	•Maintain production •Colder the better •Max flow •Controls to maximize return temperature

TYPICALLY A MAJOR AREA FOR SAVINGS

Chilled Water Systems
Opportunities – Benefits

Taking a systems approach to chilled water particularly in industries with significant cooling requirements >500 tons will result in:

- Reduced energy costs for operation
- A more reliable system
- Reduced pumping costs
- Reduced maintenance costs
- Improved production throughput
- Often frees up capacity bottlenecks to facilitate expansion
- Reduces environmental impact.

GRAPHET INC - *your* partner of choice for chilled water systems solutions.

HVAC Opportunities

EPA TRAINING

TUESDAY JUNE 29, 2004

by:

JOSE ANTOMMARCHI – TQ TECHNOLOGY

HVAC Opportunities

- **HVAC**
  - **Considerations**
    - **Check for opportunities for heat recovery from high-heat processes that can be used for employee comfort or other heating needs**
    - **Infrared radiant heating systems are very efficient**

HVAC Opportunities

- **HVAC**
  - **Energy Efficiency Options**
    - **Geothermal, radiant floor systems/storage systems and heat pumps**
    - **Use programmable thermostats/controls for set-backs or shutdowns during non-occupancy periods**
    - **Look at fuel switching options**

- HVAC
  - DEFINITION
    - Heating, Ventilation and Air Conditioning systems used for personnel comfort, process control and air quality.

- HVAC
  - FUNCTIONAL CONSIDERATIONS
    - Type of Equipment/Fuel
    - Capacity

- HVAC
  - TYPE OF EQUIPMENT/FUEL
    - Heating
      - Gas/LPG Furnaces
      - Resistance Furnaces
      - Infrared Units
      - Boilers
      - Heat Pump (Electric, Gas, Geothermal)
    - Cooling
      - Electric Air Conditioning
      - Gas Absorption
      - Heat Pump (Electric, Gas, Geothermal)
    - Ventilation
      - Fans

- HVAC
  - CAPACITY
    - Heating
      - Heat Loss - Ceiling, floor, walls, windows, doors
        - Transmission : R-Value
        - Infiltration
        - Delta-T
    - Cooling
      - Heat Gain - Roof, walls, windows, doors, people, equipment
        - Transmission: R-Value
        - Solar Gain
        - Delta-T
        - Moisture Load - Relative humidity, people, processes
    - Ventilation
      - Air changes

Best Practices, Energy Efficient Lighting

Jeff Lyon-ECO Engineering

June 29, 2004

Best Practices, Energy Efficient Lighting

- Introduction
- Common Lighting Terms
- Industrial Design Principles
- Commercial Design Principles
- Lighting Maintenance Overview
- Disposal Issues
- How to get started

Eco Engineering overview

- Founded 1993
- Based in Cincinnati, Ohio
- > Energy efficient lighting upgrades
- > Energy auditing & consulting
- > Lighting maintenance
- Strong process orientation
- Industry-leading project tracking systems
- Strong supplier partner relationships in place
- EPA Energy Star Ally
- "Energy solutions for a brighter future"

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Lighting Terms/Definitions

- CRI (Color Rendering Index), Color Temperature
- Foot-candles, IES Standards for acceptable Light levels
- Lumen Depreciation, Lamp Life
- KW Demand, KWh usage
- Cost of Light
- Energy Star

Color Rendering Index (CRI) & Color Temperature

- CRI is measured on a scale of 1 - 100. Daylight and most in-candescent light would measure 100. Other lamp sources are compared to these. An example would be "older technology Fluorescent" such as T12, has a CRI of just over 60. "New technology Fluorescent" such as T8 could be measured in the 70's to 80's
- Color Temperature is measured in degrees Kelvin. It relates to the appearance of metal that is heated. The hotter it gets, the brighter. An example is the temperature of a cool white lamp which is close to 4100 Kelvin

Foot-candles (fc) & IES Standards

- IES, or the Illuminating Engineering Society, is recognized as the benchmarking organization responsible for setting quality standards in the lighting industry
- Foot-candles are the generally accepted measure of the level of light at the work surface. Lumens is the common measurement related to fixture output.
- IES has published recommended schedules of acceptable minimum light levels for various tasks
- The IESNA Lighting Handbook is the industry standard reference and application book

Lumen Depreciation & Rated Lamp Life

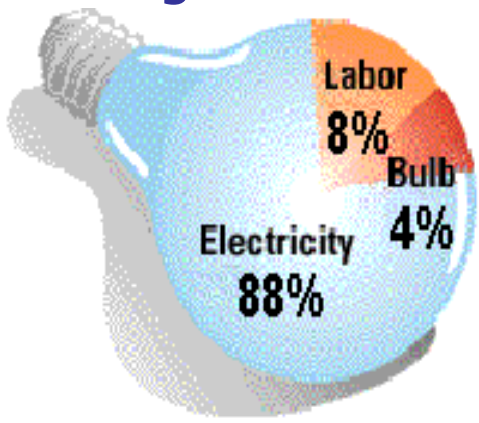
- Lumen Depreciation refers to the loss of light output that a lamp experiences as it matures, or approaches its rated lamp life. New technology lighting typically has significantly lower Lumen Depreciation

- Rated Lamp Life refers to the hours a lamp will last before burning out. The typical rated life of a lamp would be the hours at which half of the total number lamps of lamps installed would fail. Example - 1000 lamps installed. The rated lamp life is the number of hours when 500 lamps fail

KW Demand & KWh

- KWDemand is the maximum number of kilowatts per defined time interval used by the customer. Typically based on the the largest number of kilowatt - hours used in any 15 minute to half hour period of a billing period. Also known as *true power.*
- Kilowatt - hours is the quantity of true power times time. 1000 watts of power used for one hour equals one kilowatt - hour. They are also considered to be the measure of electrical energy that is converted into forms of useful energy such as heat or light.

Cost of Light



Energy Efficient Lighting Session

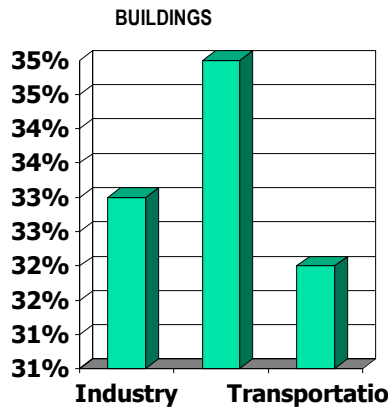
- Why should we consider the implication of a lighting system on energy use?”

Global Climate Change - the Problem and the Challenge

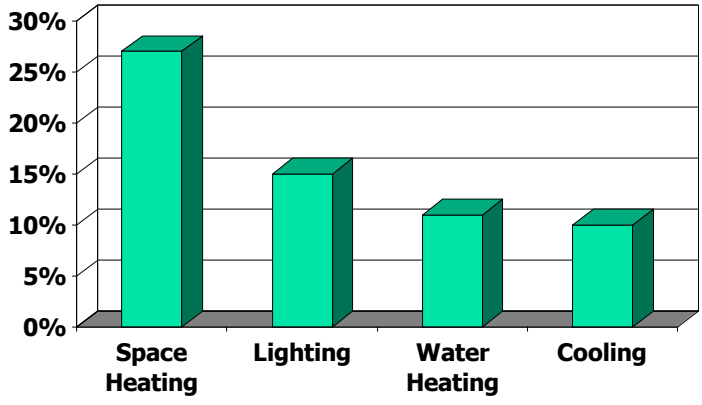
- Increasing concentrations of atmospheric greenhouse gases (GHG) could cause global climate change
- Significant reductions in GHG emissions required
- US contributes 23% of world's total GHG emissions
- Problem is connected to energy - 88% of GHG is energy related
- Challenge -- reduce US emissions without slowing economic growth

GHG Emissions and Energy are Closely Linked

- US GHG Emissions - 88% are energy related
  - Carbon Dioxide 84%
  - Methane 9%
  - Nitrous Oxide 5%
  - Other GHG 2%
- Electricity 36% of US CO_2 Emissions by Energy Sector



Carbon emissions for US Buildings - top four areas



EPA's ENERGY STAR Buildings^{SM} Partnership

- ENERGY STAR Buildings^{SM} is a voluntary partnership between U.S. organizations and the U.S. Environmental Protection Agency (EPA) to promote energy efficiency in buildings
- Potential savings -- $130 Billion
- Integrated approach to building system interactions -- save 30% or more!

The ENERGY STAR Buildings Five Stage Program

1. Green Lights - energy efficient Lighting upgrades
2. Building Tune- Up
3. Load Reductions
4. Fan System Upgrades
5. HVAC Improvements

This staged approach provides a strategic approach for comprehensive energy efficiency upgrades

Industrial Lighting Design Considerations

- Adequate Illumination for Task
  - Foot-candles: not too much, not too little (IESNA guidelines) and fixture types
- Adequate Color (CRI/temperature) for Task
- Control Fixture Brightness/Glare
  - Differences
  - Ceiling color
  - Coated lamps
- Design Uniformity
  - Spacing to mounting height
  - Shadows/glare

Industrial Lighting Design Considerations

- Steps to Determine Target Illumination
  - Define visual task/type of activity
  - Select illuminance category
  - Determine illuminance range
  - Establish target illuminance

Industrial Lighting Design Impacts

- Productivity
  - Reduce errors/mistakes to improve quality
  - Improve productivity to improve profitability
- Environment
  - Reduce disposal costs/pollution
  - Low mercury lamps up to 90% less mercury; lead-free solder

Industrial Lighting Design Impacts

- Aesthetics
  - Cleaner, bright look for employees/customers "image"
  - Color rendering index can improve quality (ceramic metal halide)

Industrial Lighting Design Impacts

- Safety
  - Less employee "eye fatigue"
    - reduce injuries/accidents
  - Close rated vs. open rated lamps
  - Turn off weekly or group relamp at end of rated life

Industrial Lighting Design Impacts

- Energy
  - Reduce energy use/"demand charge"
  - Balance quality and quantity of light
  - Pulse Start and low bay fluorescent fixtures

Industrial Lighting Design - Common Choices

- Industrial - Common Design Choices
  - HID - high bay >25 feet
  - HID - low bay 18 - 35 feet
  - Fluorescent - direct/indirect <35 feet
  - 2004 - Pulse Start technology and new specialized fluorescent fixtures that can go higher

Quiz Time

What is the most expensive industrial light bulb on the market today?

The Most Expensive Light Bulb You'll Ever Own

400W/U

- 6500 Hours/Year
- 460 Total Watts Used
- $.06 KWH Cost

Cost: $180/year

Retrofit and Save

- **Save up to 275 watts per fixture**
- **Save between $50 - $100 in energy costs/fixture/year**

*** Retrofit or replace 400W standard with Pulse Start or Fluorescent @ $.06/KWH @ 6500 HRS/YR**

Commercial Lighting Design

- Proper Illumination Level
  - 20 to 50 foot-candles
    - large size/high contrast; i.e., CRT
  - 50 to 100 foot-candles
    - paper tasks

Commercial Lighting Design

- Quality of Light
  - Color rendering index
    - truer, more natural colors
  - Maintenance of light level as lamps age
  - Impact of white ceiling/ skylights
  - Glare

Energy Efficient Lighting Summary of common ECM's

- T8 upgrade from T12 (Delamping with reflectors or hi watt lamps/ballasts)
- Compact Fluorescent Lamps (CFL's)
- Exit Light Retrofit LED Lamps
- Occupancy Sensors & Switch/Timers
- Daylight Harvesting/ Dimming Ballasts/ Skylights
- Pulse Start/ Fl/ HID retrofits
- Ongoing Lighting Maintenance/Relamping

Next Steps

- Consider energy use whenever you are designing the right lighting
- The best way to save energy is to have the lights OFF (Controls/switches, sensors, etc)
- Don't underestimate importance of maintenance programs
- Technology is improving every year

Improved Work Environment

- Uniform light levels maintained - creates a better environment
- Facility looks better - more impressive to customers and employees
- Appropriate light levels shown to reduce mistakes and increase productivity

Responsible Disposal/ Recycling, and Environmental Impact

- Federal Regulations on Lamp Disposal
- US Lamp Disposal Trends
- PCB containing ballasts, and pending ballast regulations
- Pollution Impact

Federal Regulations on Lamp Disposal

- Facilities generating less than 100 kg of hazardous waste per month are exempt from Federal hazardous waste regulations.

- A.) 360 4' T12 lamps weigh 100kg (12 cases)
- B.) 540 4' T8 lamps weigh 100kg (15 cases)
- C.) 180 8' T12 lamps weigh 100kg (12 cases)

- A facility would be exempt from Federal regulation if under these limits and generating no other hazardous wastes.

US Lamp Disposal Trends

- 1992 EPA Estimates:
- 82 % of lamps land-filled
- 16% of lamps incinerated
- 2% of lamps recycled
- 2000 Industry Estimate:
- 63% of lamps land-filled
- 13% of lamps incinerated
- 24% of lamps recycled

Ballast Management and regulation

- Currently Pcb ballasts are considered hazardous waste and depending on quantity generated, may be subject to state and Federal regulation. Check with your local EPA representative. Our position is to recycle.
- Proposed efficiency requirements will eliminate magnetic 4', 8', and 8'HO T12 ballasts from being manufactured in the future:
- April 2005 - eliminates production for new fixtures
- July 2010 - eliminates all production including for replacement

The Pollution Impact

One Kilowatt-hour saved

- = 682 Grams of Carbon Dioxide not emitted
- = 5.8 Grams of Sulfur Dioxide not emitted
- = 2.5 Grams of Nitrogen Dioxide not emitted

Next Steps - "How to Get Started"

- Determine if a project exists from a preliminary energy savings and operating cost reduction standpoint
- Find a reputable vendor specializing in Energy Efficient Lighting Upgrades
- Confirm the organizations financial and technical hurdles that will need to be satisfied *up front*.
- have an investment grade lighting audit performed, with engineered solutions for upgrade
- Agree to a method of verifying savings through sampling as a condition of Approval

Questions

Or

Discussion

Ohio Department of Development Office of Energy Efficiency

Ohio EPA Energy Efficiency Workshop
June 29, 2004

OHIO DEPARTMENT OF DEVELOPMENT

Ohio Department of Development

Office of Energy Efficiency

EnVinta One-2-Five Diagnostic Assessment Software

OHIO DEPARTMENT OF DEVELOPMENT

What is EnVinta One-2-Five?

- Software based program for senior managers
- Takes a business approach to energy management
- Examines how energy is integrated with your business management systems.

What EnVinta One-2-Five is NOT…..

- Not a technical tool
- Focuses on management systems
- Designed to be used by the managers in an organization

What Happens at a Session?

- Management team follows a structured process which examines how the business thinks about energy.
- Identifies opportunities to improve business systems to achieve sustainable energy cost savings.

Key Features of the Diagnostic

- A focus on management issues rather than technical issues.
- The opportunity to discuss issues within an organization and gain a consensus on future action
- A critical review of current practices to help identify areas that require attention
- The identification of the top 5 critical actions to be first addressed

Customer Selection Process

- $350K/yr +/- Energy Spend
- Key Personnel at the Facility MUST Attend Diagnostic Session

Implementation Phase

- 3 Certified Facilitators-Two in training
- 50 Diagnostic Licenses
- ODOD Follow-up Services Incentives Program
  - Planning Services
    - Develop An Energy Management Plan based upon the Assessment Outcomes
    - Identify (from a macro perspective) Major Energy Use and Potential Areas for Opportunity
    - ODOD Incentive of Dollar for Dollar Match up to $7500

Implementation Phase

- ODOD Follow-up Services Incentives Program
  - Technical Opportunities Assessment Services
    - Develop An In-Depth Assessment of Technical Opportunities Within the Facility
    - ODOD Incentive of Dollar for Dollar Match up to $7500

Demonstrated Benefits

- A great tool to initiate customer contact
- Provides immediate feedback
- Provides benchmarking vs. peer companies
- Similarity to ISO or other quality/environmental management tools for those companies that have pursued those certifications

Demonstrated Benefits

- Ease of use
- The tool is set up so that continued improvement can be achieved by utilizing the tool at regular intervals

Future Use of EnVinta

- Continue to Fund Incentives for Planning and Technical Assessment
- Consider Funding Plan for Metering/Measurement Within Facilities
- Use of the Challenger Program for Facilities with Energy Spend $50K-350K/yr
- 25 Challenger Licenses Purchased
- Follow-up Data Collection After One year to Determine any Energy Efficiency Improvements/Energy Use Reduction

Future Use of EnVinta

- Regional Customer Workshops
- Case Study Development When Data Becomes Available
- Removal of Subsidy in Year 2/3
- Turn Over Program to Our Facilitation Partners After Year 3

Office of Energy Efficiency

Your Door into State Government

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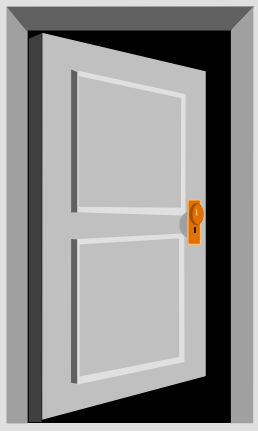
- **www.odod.state.oh.us/cdd/oee**