U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Most Commonly Identified Recommendations

DOE ITP *In Depth ITP Energy Assessment Webcast*

IAC Missouri

Missouri Industrial Assessment Center

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College of Engineering, University of Missouri. **April 16, 2009**

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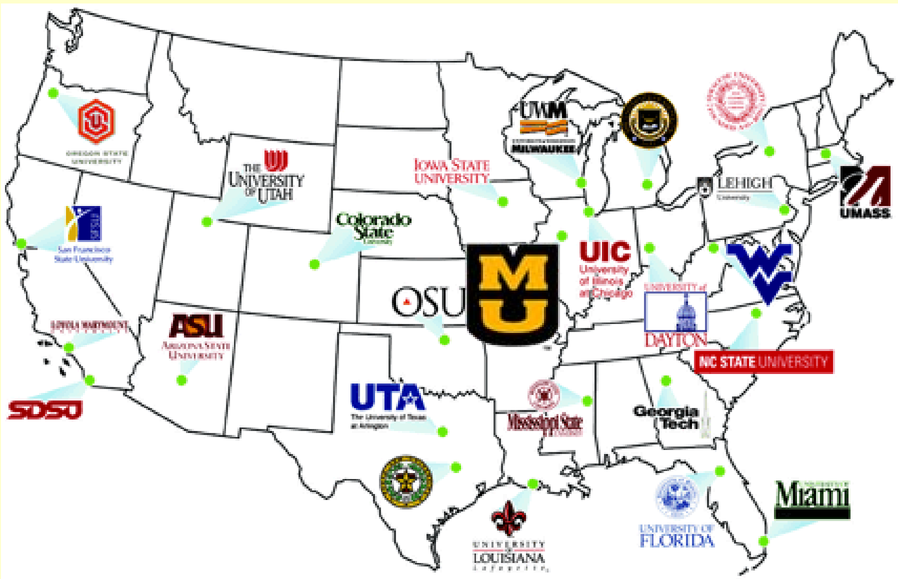
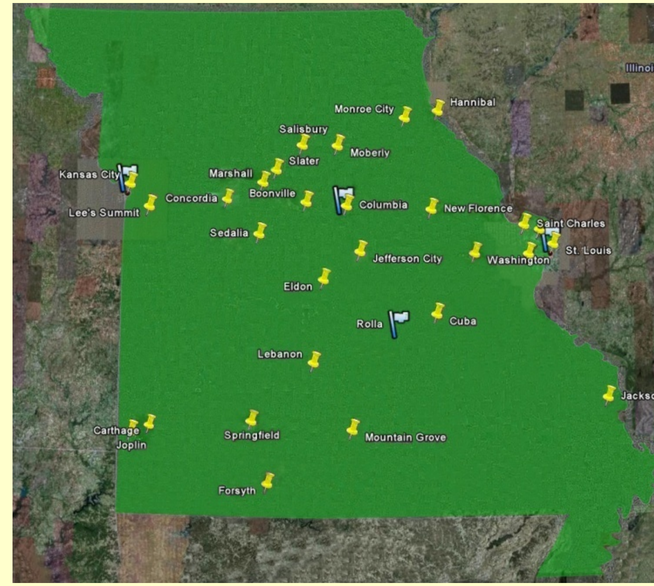




Missouri IAC is one of the 26 centers founded by the U.S. DOE in the nation. Since its establishment in 2005, we have been working closely with the MoDNR, the MU University Extension, utility providers in the state, etc, to provide education, development and services in industrial energy efficiency. Our services (audits, workshops, etc), have already covered many locations across the state of Missouri.

More information about the Missouri IAC, the IAC Program and the others (such as ITP, EERE, Save Energy Now) can be found on IAC and DOE websites:

Missouri IAC:	http://iac.missouri.edu
Department of Energy:	http://www.energy.gov
Energy Efficienct and Renewable Energy Network (EERE):	http://www.eere.energy.gov
IAC Program Field Manager's website:	http://iac.rutgers.edu
IAC Database website:	http://iac.rutgers.edu/database

STRUCTURE OF PRESENTATION

1. Overview – Importance & Key Messages
2. IAC Database - Top Recommendations
3. Top Recommendations: Considerations, Analysis and Case Studies
4. MO IAC's Web-based Learning & Auditing Tool
5. Conclusions

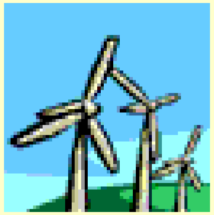
1. Overview – Importance & Key Messages

From a Global Perspective:

When it's gone – **It is GONE!**

So we have to:

- ***Find sustainable alternatives – as quickly as we can in the future***

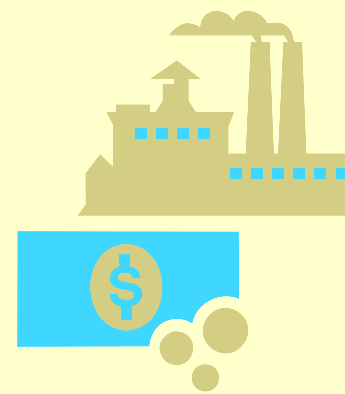


- ***Become energy efficient - TODAY***

We have two KEY messages which we wish to pass on to our industrial organizations:

From an Organization's Business Perspective: Every Dollar Saved Is a Profit of One Dollar to the Organization – 100%!

> ***For example: if a manufacturer saves $100k/Year on its utility costs and assumes it has a profit margin of 10%, the saving is then equivalent to an annual sale of $1 million to the company (That is – the company will have to generate a $1 million value in product/service sales in order to achieve the same profit).***



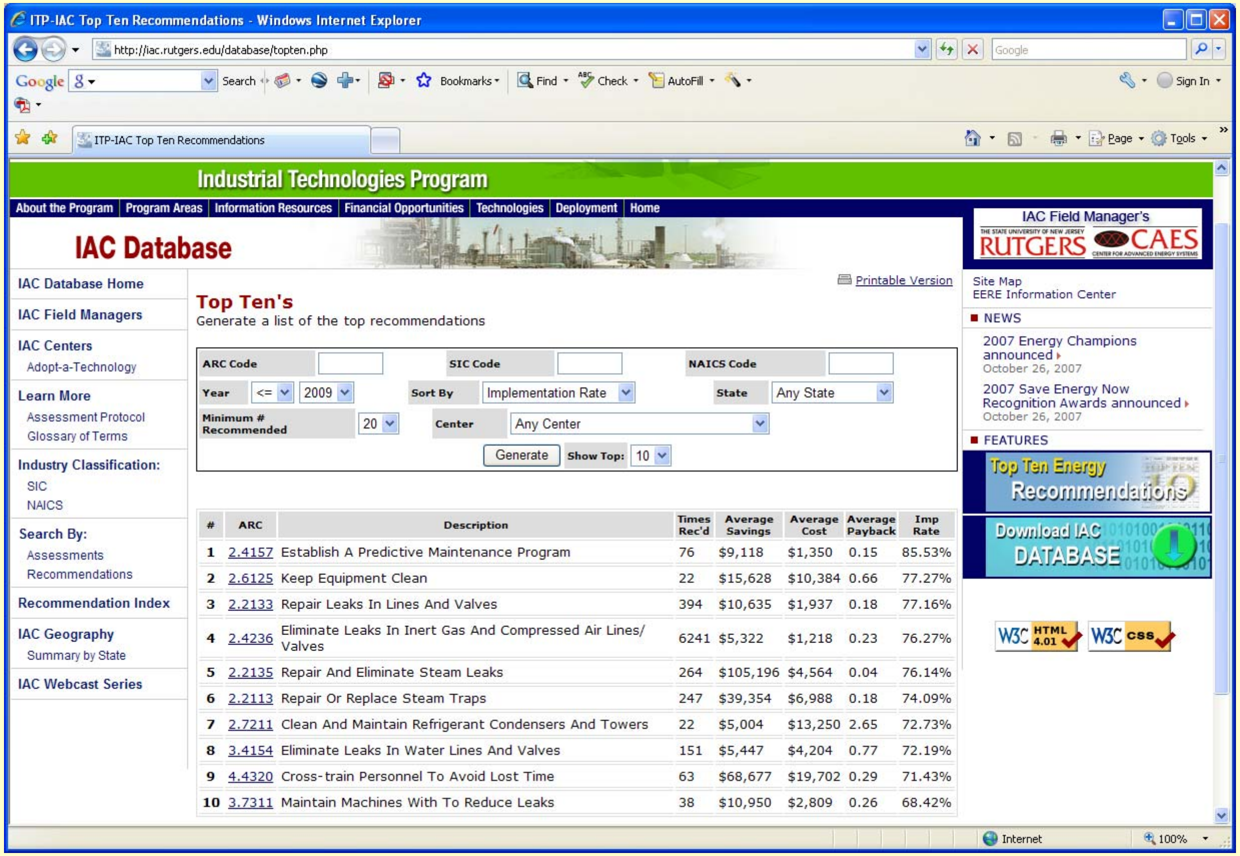
Our Previous Experiences Have Frequently Encountered "Low-Hanging Fruits" in the Industries.

> ***Significant savings are possible with minimum amount of investments/efforts.***

2. IAC Database – Top Recommendations

List of top Recommendations can be found at the IAC's database online at:

http://iac.rutgers.edu/database/topten.php



ITP-IAC Top Ten Recommendations - Windows Internet Explorer

http://iac.rutgers.edu/database/topten.php

Industrial Technologies Program

About the Program | Program Areas | Information Resources | Financial Opportunities | Technologies | Deployment | Home

IAC Database

IAC Field Manager's RUTGERS CAES

IAC Database Home

IAC Field Managers

IAC Centers

Adopt-a-Technology

Learn More

Assessment Protocol

Glossary of Terms

Industry Classification:

SIC

NAICS

Search By:

Assessments

Recommendations

Recommendation Index

IAC Geography

Summary by State

IAC Webcast Series

Printable Version

Top Ten's

Generate a list of the top recommendations

ARC Code | SIC Code | NAICS Code

Year <= 2009 | Sort By Implementation Rate | State Any State

Minimum # Recommended 20 | Center Any Center

Generate | Show Top: 10

#	ARC	Description	Times Rec'd	Average Savings	Average Cost	Average Payback	Imp Rate
1	2.4157	Establish A Predictive Maintenance Program	76	$9,118	$1,350	0.15	85.53%
2	2.6125	Keep Equipment Clean	22	$15,628	$10,384	0.66	77.27%
3	2.2133	Repair Leaks In Lines And Valves	394	$10,635	$1,937	0.18	77.16%
4	2.4236	Eliminate Leaks In Inert Gas And Compressed Air Lines/ Valves	6241	$5,322	$1,218	0.23	76.27%
5	2.2135	Repair And Eliminate Steam Leaks	264	$105,196	$4,564	0.04	76.14%
6	2.2113	Repair Or Replace Steam Traps	247	$39,354	$6,988	0.18	74.09%
7	2.7211	Clean And Maintain Refrigerant Condensers And Towers	22	$5,004	$13,250	2.65	72.73%
8	3.4154	Eliminate Leaks In Water Lines And Valves	151	$5,447	$4,204	0.77	72.19%
9	4.4320	Cross-train Personnel To Avoid Lost Time	63	$68,677	$19,702	0.29	71.43%
10	3.7311	Maintain Machines With To Reduce Leaks	38	$10,950	$2,809	0.26	68.42%

Site Map

EERE Information Center

NEWS

2007 Energy Champions announced

October 26, 2007

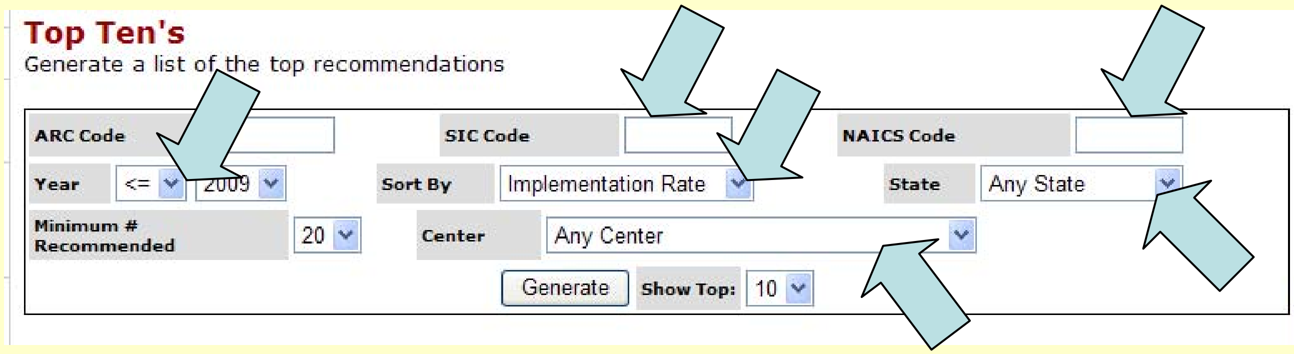
2007 Save Energy Now Recognition Awards announced

October 26, 2007

FEATURES

Top Ten Energy Recommendations

Download IAC DATABASE



The top recommendations can be found by:

- ❖ Type of industry (SIC or NAICS code)
- ❖ Time period
- ❖ According to: implementation rate, average savings, times recommended
- ❖ Location (state by state, or center by center)

Example: list of top 10 most recommended

Top Ten's

Generate a list of the top recommendations

ARC Code | SIC Code | NAICS Code

Year <= 2009 | Sort By Times Recommended | State Any State

Minimum # Recommended 20 | Center Any Center

Generate | Show Top: 10

#	ARC	Description	Times Rec'd	Average Savings	Average Cost	Average Payback	Imp Rate
1	2.7142	Utilize Higher Efficiency Lamps And/or Ballasts	10026	$5,170	$10,151	1.96	53.06%
2	2.4236	Eliminate Leaks In Inert Gas And Compressed Air Lines/ Valves	6241	$5,322	$1,218	0.23	76.27%
3	2.4133	Use Most Efficient Type Of Electric Motors	4877	$4,539	$10,391	2.29	62.05%
4	2.4221	Install Compressor Air Intakes In Coolest Locations	4469	$1,697	$740	0.44	46.48%
5	2.4111	Utilize Energy-efficient Belts And Other Improved Mechanisms	3723	$3,108	$2,279	0.73	53.16%
6	2.4231	Reduce The Pressure Of Compressed Air To The Minimum Required	3210	$3,373	$1,061	0.31	45.05%
7	2.2511	Insulate Bare Equipment	3052	$6,106	$3,483	0.57	45.94%
8	2.7143	Use More Efficient Light Source	2892	$4,702	$8,204	1.74	50.28%
9	2.7135	Install Occupancy Sensors	2813	$1,878	$1,798	0.96	30.71%
10	2.1233	Analyze Flue Gas For Proper Air/fuel Ratio	2108	$7,803	$2,247	0.29	66.56%

Example: list of top 10 recommendations with highest implementation rate

Top Ten's

Generate a list of the top recommendations

ARC Code		SIC Code		NAICS Code	
Year	<= 2009	Sort By	Implementation Rate	State	Any State
Minimum # Recommended	20	Center	Any Center		

Generate | Show Top: 10

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9	4.4320	Cross-train Personnel To Avoid Lost Time	63	$68,677	$19,702	0.29	71.43%
10	3.7311	Maintain Machines With To Reduce Leaks	38	$10,950	$2,809	0.26	68.42%

Example: list of top 10 recommendations with highest average savings

Top Ten's

Generate a list of the top recommendations

ARC Code | SIC Code | NAICS Code

Year <= 2009 | Sort By Average Savings | State Any State

Minimum # Recommended 20 | Center Any Center

Generate | Show Top: 10

#	ARC	Description	Times Rec'd	Average Savings	Average Cost	Average Payback	Imp Rate
1	2.3412	Use Waste Heat To Produce Steam To Drive A Steam Turbine-generator	53	$565,914	$1,902,455	3.36	11.32%
2	2.3417	Use Waste Heat With A Closed-cycle Gas Turbine-generator Set To Cogenerate Electricity And Heat	34	$538,153	$2,209,653	4.11	8.82%
3	2.3416	Use Combined Cycle Gas Turbine Generator Sets With Waste Heat Boilers Connected To Turbine Exhaust	35	$387,948	$1,078,761	2.78	11.43%
4	2.3414	Burn Waste To Produce Steam To Drive A Steam Turbine Generator Set And Use Steam Exhaust For Heat	40	$374,282	$1,240,120	3.31	12.50%
5	4.6310	Install An Uninteruptable Power Supply	32	$342,188	$238,636	0.70	21.88%
6	4.1130	Install Refrigeration System To Cool Product	23	$309,784	$153,557	0.50	39.13%
7	3.1182	Make A New By-product	34	$305,137	$388,688	1.27	20.59%
8	4.5120	Condense Operation Into One Building	38	$280,156	$369,721	1.32	36.84%
9	2.3415	Use A Fossil Fuel Engine To Cogenerate Electricity Or Motive Power; And Utilize Heat	164	$255,229	$1,146,859	4.49	9.15%
10	2.3413	Burn Fossil Fuel To Produce Steam To Drive A Steam Turbine-generator And Use Steam Exhaust For Heat	40	$245,933	$729,427	2.97	5.00%

In the rest of today's presentation, we will provide more details for each in the following list of top recommendations

Description
Utilize Higher Efficiency Lamps And/or Ballasts
Eliminate Leaks In Inert Gas And Compressed Air Lines/ Valves
Use Most Efficient Type Of Electric Motors
Install Compressor Air Intakes In Coolest Locations
Utilize Energy-efficient Belts And Other Improved Mechanisms
Reduce The Pressure Of Compressed Air To The Minimum Required
Insulate Bare Equipment
Use More Efficient Light Source
Install Occupancy Sensors
Analyze Flue Gas For Proper Air/fuel Ratio

Plus:

Waste Heat Recovery
Production Process Improvements
Demand management

3. Top Recommendations: Considerations, Analysis and Case Studies

3.a Electricity Demand Management

First, it is important to understand how your business is being charged by its utility providers:

Date	Consumption	Consumption Cost	Peak Demand	Demand Cost
(months)	kWh	($)	kW	($)
Jan	198,800	$12,975	948	$8,759
Feb	331,200	$20,374	912	$8,427
Mar	245,000	$13,951	710	$6,560
Apr	305,600	$18,902	948	$8,759
May	368,000	$22,621	1,222	$11,290
Jun	318,400	$19,651	888	$8,205
Jul	289,200	$18,855	890	$8,223
Aug	335,600	$21,720	964	$8,907
Sep	367,600	$23,638	952	$8,796
Oct	387,200	$25,384	1,144	$10,570
Nov	350,000	$22,583	824	$7,613
Dec	374,400	$24,701	1,105	$10,210
Totals	3,871,000	$245,355	11,507	$106,319

Date	Consumption	Consumption Cost	Peak Demand	Demand Cost
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Totals	3,871,000	$245,355	11,507	$106,319

- **Energy Consumption - the total amount of electricity used by a system over a period of time, measured in Kilowatt-hour (kWh). For example, If a motor uses 50 kW of power for 8600 hrs in a year, then the energy consumption of the motor would be:**

  50 kW x 8600 hrs/year = 430,000 kWh

  Energy Consumption Charge is then based:

  Amount of Consumption (kWh) X Rate ($/kWh)

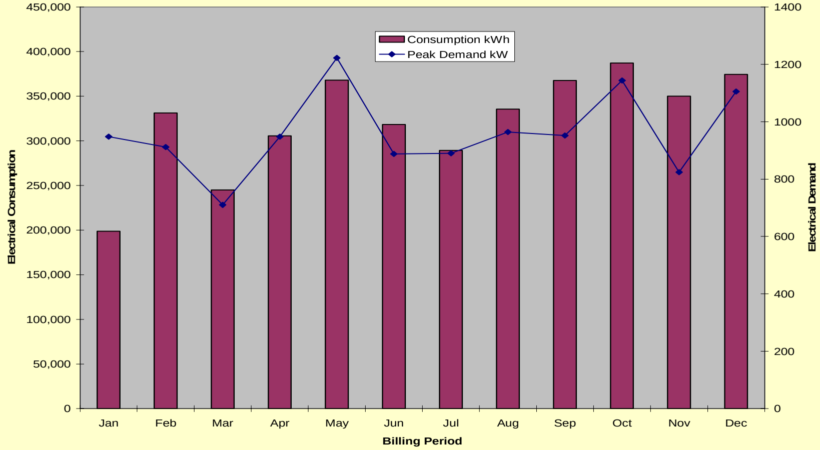
  Rate will be dependant on location and supplier.

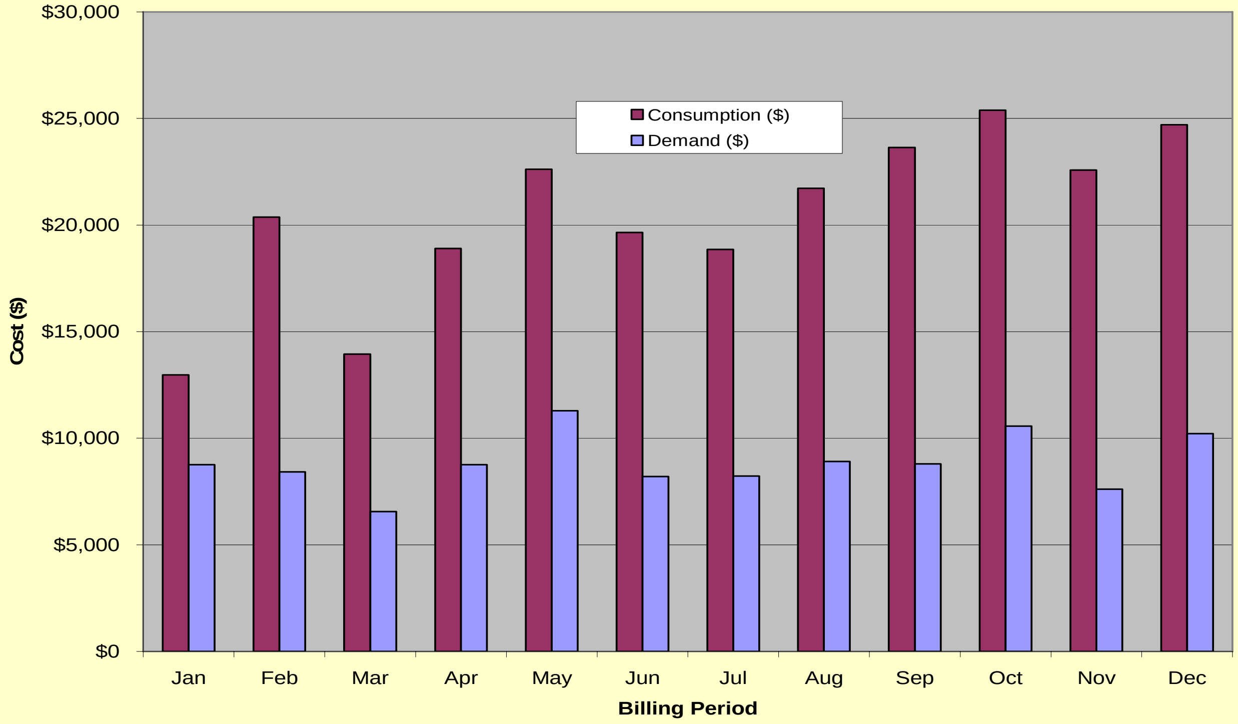
- **Demand - the instantaneous power draw by the company, measured in Kilowatt (kW). Demand is measured over a period of time – many utility providers measure a company's demand level at 15 intervals over a month, and Demand Charge is then based on highest kW used in the facility during this month:**

  Peak Demand Level (kW) X Rate ($/kW)

  Again, rate will be dependant on location and supplier.

  However, in some cases this is based on an yearly basis!





Since the total cost is the sum of assumption AND demand costs, the demand cost can easily increase the bill by 50%!

Identify causes of peaks

❑ ❑ Does the rate schedule of the plant show a demand charge?

❑ ❑ If there is a demand charge on the bill, is there information on what time of day or part of the month demand maximum occurs?

If not, get a printout of the hourly variation of the demand for an average month where production is fairly uniform. With this information:

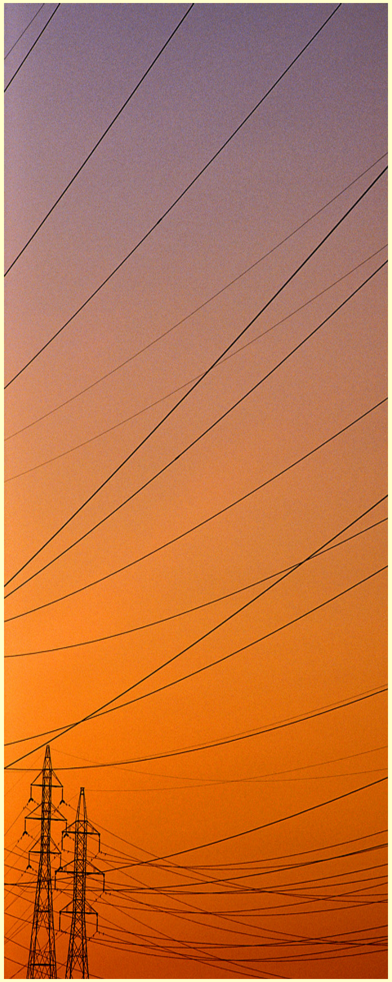
❑ ❑ (a) Is the demand maximum significantly greater at one time of day each day?

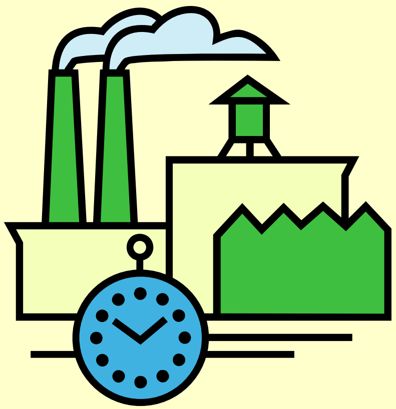
❑ ❑ (b) Is the maximum demand significantly greater than the average demand during each day?

❑ ❑ (c) Is the monthly maximum demand significantly greater on one day than any other?

Things to do to avoid demand charge

- **Use thermal energy storage to take advantage of low off-peak rates**
- **Use power factor controllers and optimize plant power factor**
- **Shift operation off-peak to benefit from lower energy prices**
- **“Sequence start” major equipments**
- **Reduce lighting to recommended levels**
- **…**

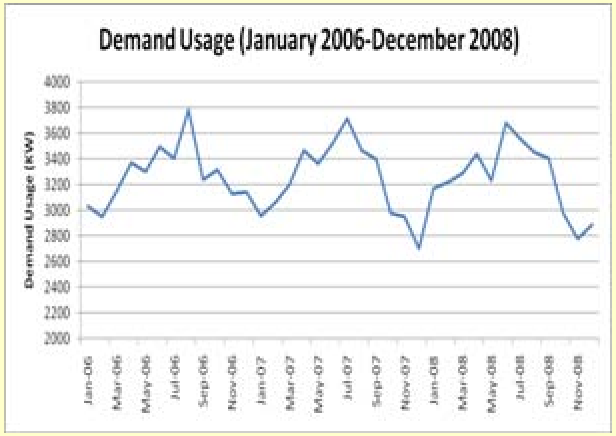




Case 1: Shift operation off-peak

Problem: **Company was metered by the utility provider over a period of one year and, based on the highest level of demand reached, and paid for a demand charge over the whole year.**

Recommendation: **After analyzing the consumption profile, it was realized that the peak occurs some time at 2pm in August. The company made arrangements so that in the summer months the shifts hours avoid the "peak hours", and hence significantly reduced its utility costs over the year.**



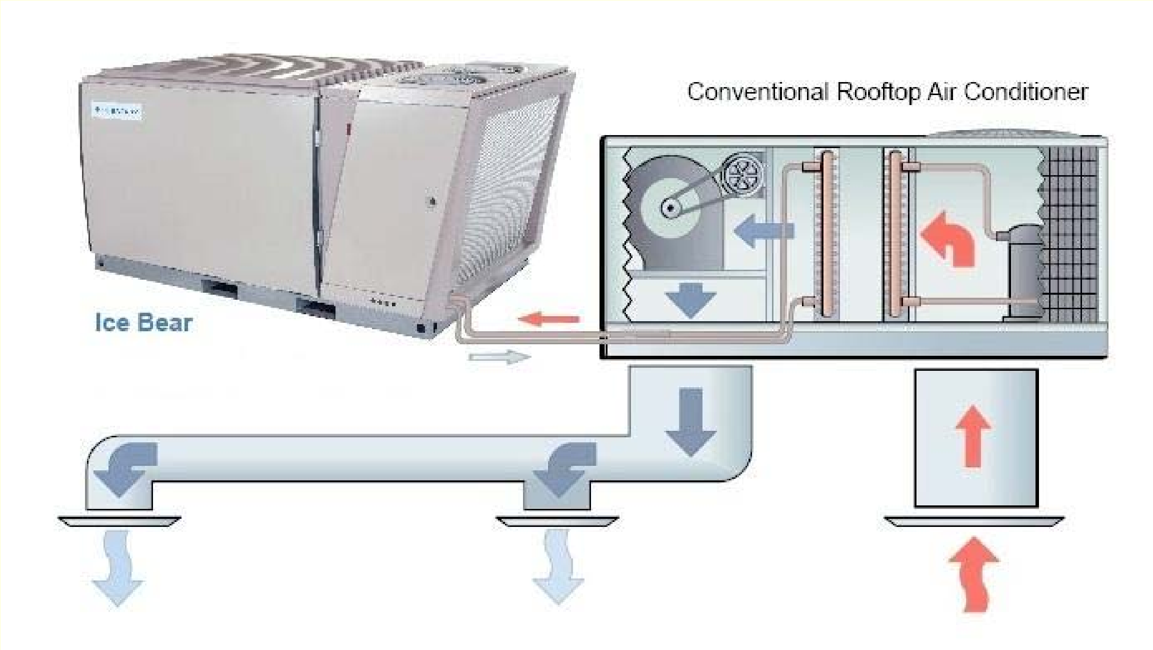
Case 2: Use Real-Time Demand Usage Monitoring Device

Problem: **The company was not monitoring its power usage, while its usage profile clearly indicated very high demand penalties.**

Recommendation: **Invest in a real-time demand charge monitoring system, and constantly monitor the plant's electricity consumption. Such a system can be used to either send an alert or shut off electricity to a certain area of the plant when the kilowatt usage reaches a certain level.**

Estimated Demand Kilowatt Usage Savings = 249.5 kW
Estimated Cost Savings = $39,780/Year
Estimated Implementation Cost = $3,000
Simple Payback Period = 0.075 Years

For example: many facilities are engaged in processes that require a controlled temperature environment. The administrative areas of facilities must also be kept temperature controlled. The usage of HVAC occurs during the day when energy demand and prices are at their peak. By utilizing lower cost off-peak energy to create ice for use the following day a facility may be able to reduce its demand peak and energy usage.



Ice Bear Energy Storage Module

Source: http://www.ice-energy.com/products/howitworks/tabid/163/Default.aspx

3.b Production Process Improvement & Energy Efficiency - Lean^2

Let us remember that, in general, the design, implementation, operation and improvement of a production facility must take energy efficiency into consideration, so that:

Lean^2 = Lean production processes & Lean energy consumption

The key here is systems approach and continuous improvement.

Education is important and the concept of Lean^2 needs to become part of cooperative culture within an industrial organization.

Conceptually, all techniques, considerations and tools that have been applied to continuous system improvement are relevant here (such as lean manufacturing, just-in-time, TQM, six-sigma), to improve productivity and eliminate wastes through:

Bottleneck elimination

Product quality assurance

Optimization of space, facility and labor utilization

Scheduling

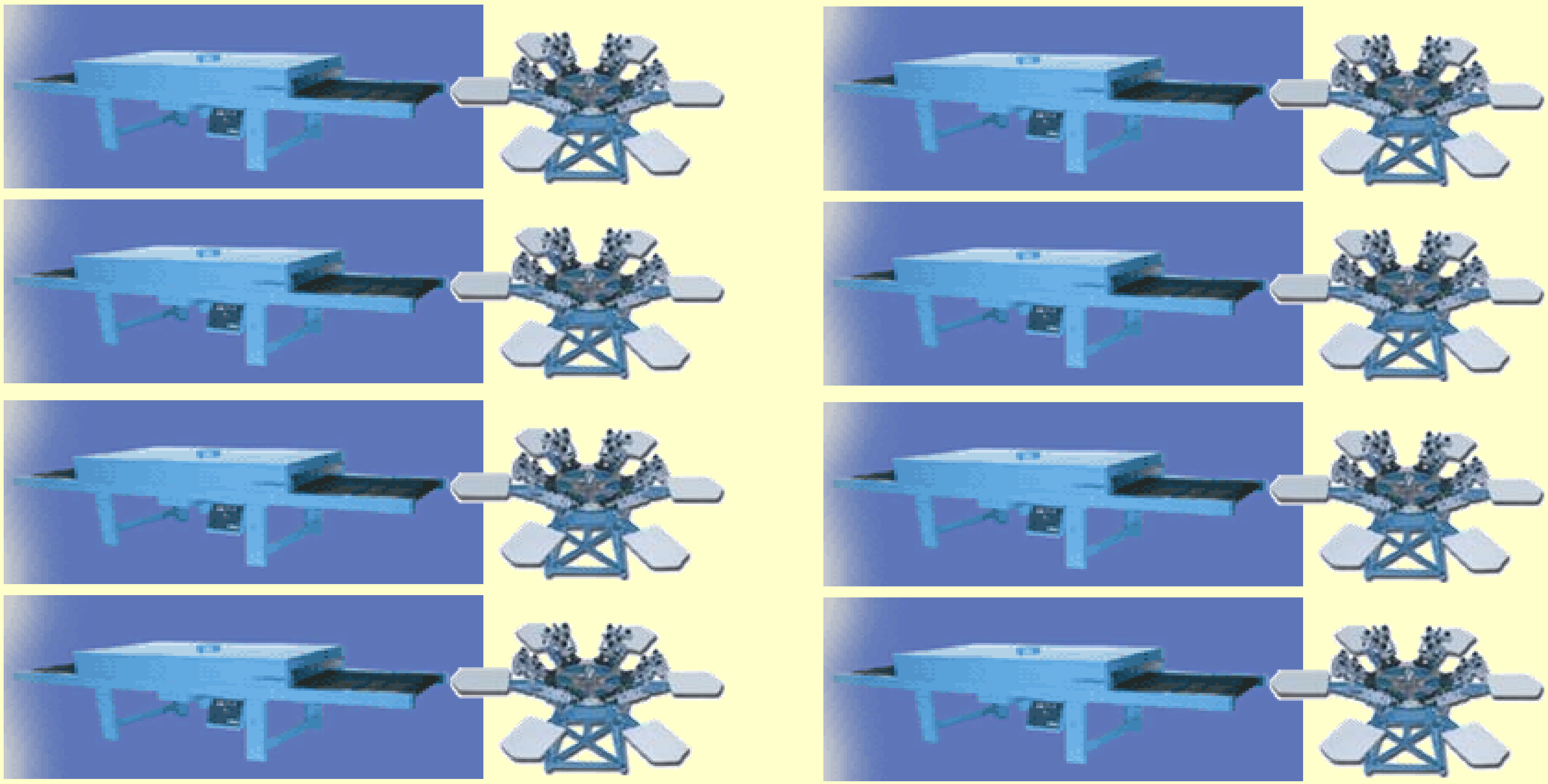
Process optimization

Preventive/predictive maintenance…

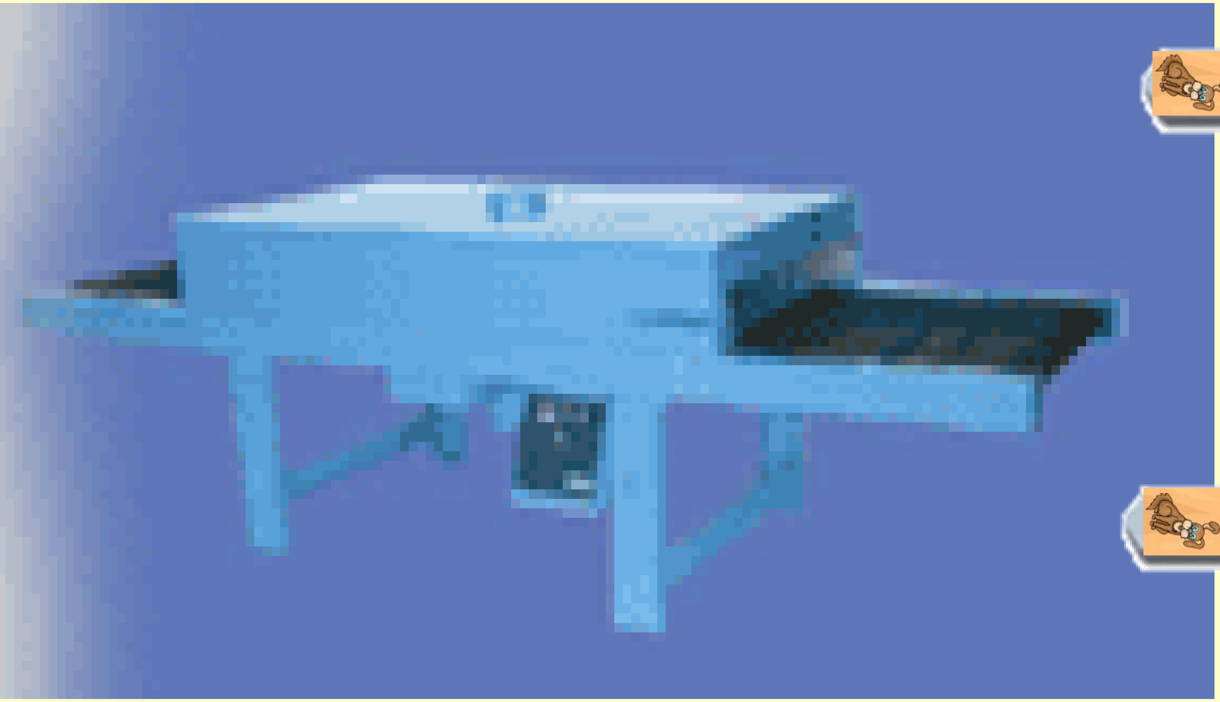
All above will have significant energy saving implications, which need to be taken explicitly into consideration.

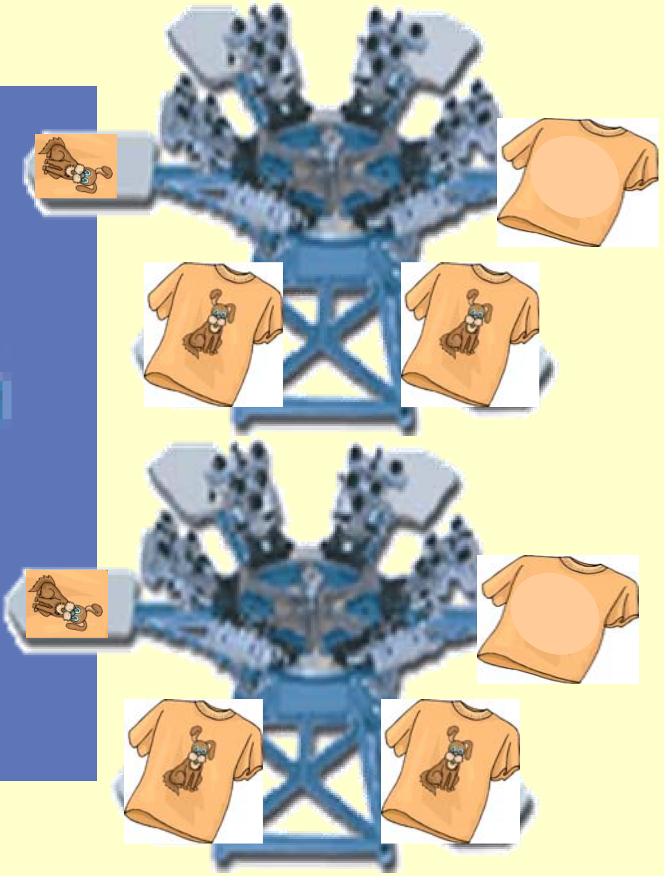
Case 1: The T-Shirt Printing Shop

BIG ENERGY EATER!

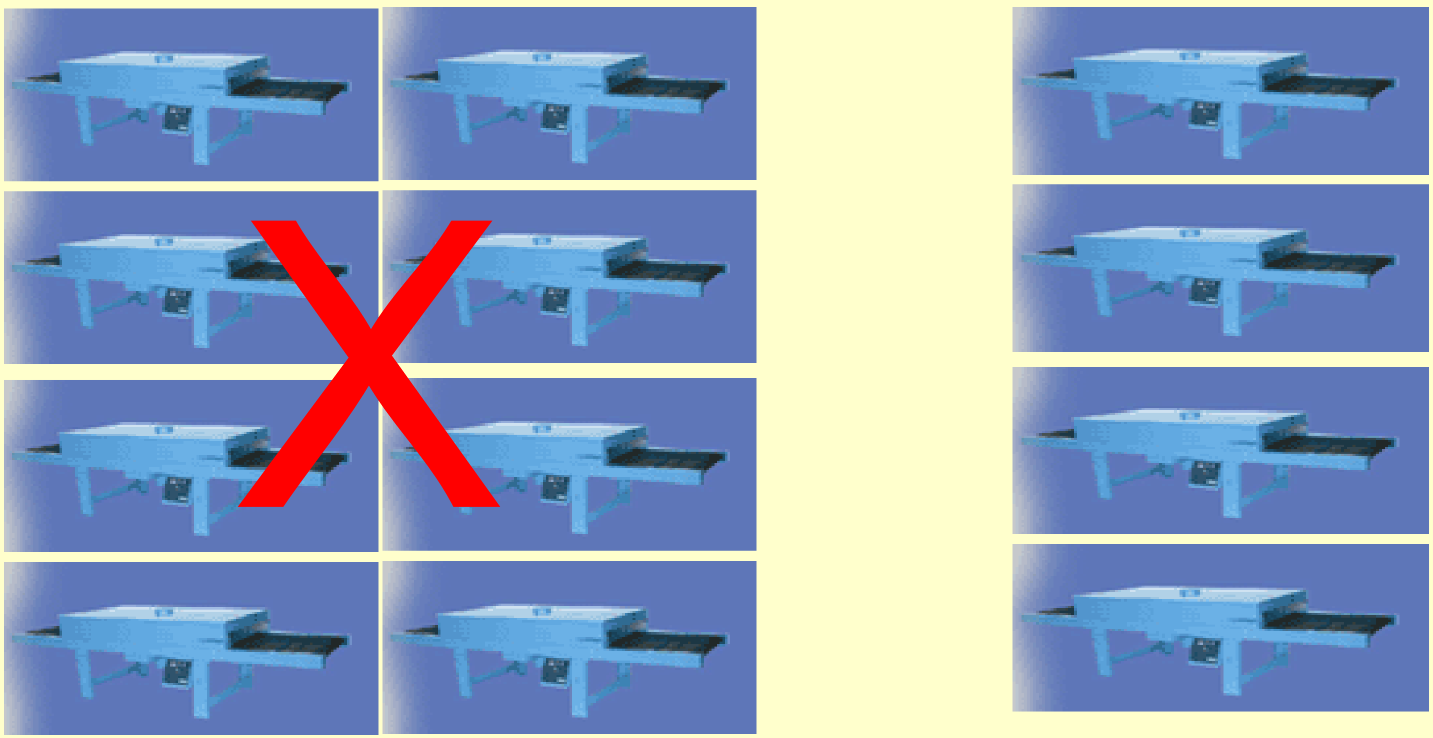


Recommendation…





Traditionally, this would be viewed as an equipment utilization issue. However, it results in an immediate saving of 50% on the drying process.



Examples like this are abundant in the industries……

Case 2: Eliminate Banks of Small Fans

The plant operates a few production lines, with a total of 120 1.5 HP fans for cooling that operate full time (estimated at 6000 hrs/year).

Recommendation:
Encase each line in way that would ensure that there is minimal wasted cooling and replace the small fans with a combination of outside air and 4 bigger fans.

Estimated Electricity Usage Savings = 126,938 kWh/year
Estimated Cost Savings = $13,376.13/year
Estimated Implementation Cost = = $20,000
Simple Payback Period = 1.50 year

Case 3: Use a different pump

Factory uses 12 diaphragm pumps on one of its lines: compressed air operated pumps can be much more expensive to operate than electric motor driven for general purpose operation.

Vs.

Case 4: Cooling the products instead of the whole room

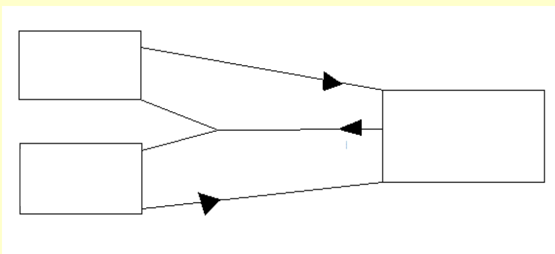
Factory uses a huge heating oven as part of production line, generating tremendous amount of heat in the building. The entire building is cooled to 65 F because this is the temperature needed for the end product. Solution: use local cooling at the end of the line.

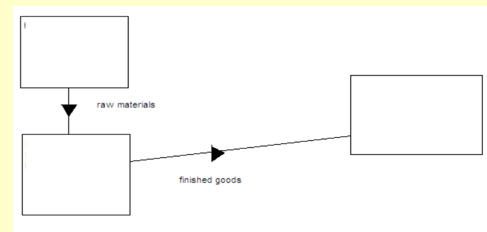
Case 5: Eliminate energy wastes in unused space

Factory uses a huge area as a locker room for its employees, with an estimated utility costs at $250k/year. Consolidate space usage on site - move to another building where enough space are available for the purpose.

Case 7: Eliminate unnecessary material movements

Factory is located in a number of buildings on a couple of different sites, with materials/parts transported amongst them by truck.
Improve: simplify materials flow by rearranging the location of different production processes.



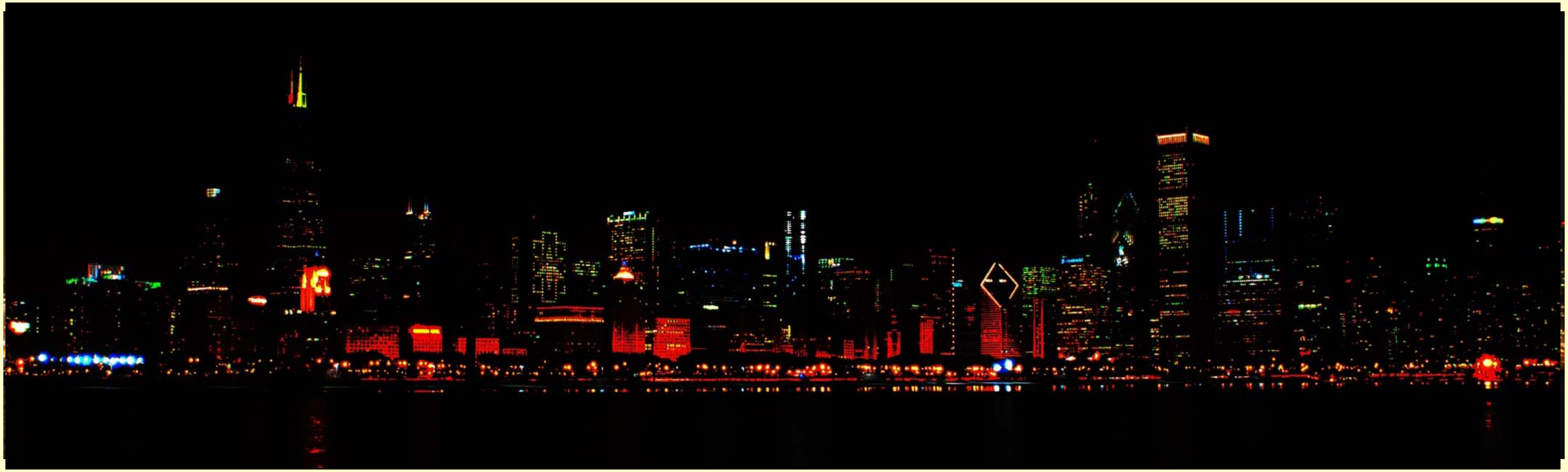


Estimated Gas Usage Savings = 1,364 Gallon/Year
Estimated Cost Savings = $5,460/yr
Estimated Implementation Cost = minimal
Simple Payback Period = immediately

Case 8: Watch that huge hot-water tank outside

Required to store hot water to prevent freezing in winter.
Need to monitor its temperature setting very carefully!

3.c Utilize higher efficiency lamps and/or ballasts



In general, lighting is an area that we have seen a lot of potentials. Reducing lighting energy consumption will reduce not only consumption costs, but also demand charges.

Before we go into the technical aspects of lighting efficiency, it needs to be pointed out that the simplest and frequently the most effective way to save here is:

SWITCH OFF!!!

Under-utilized area with excessive lighting

An area top of the roof where no one hardly ever goes into

Rarely occupied storage area

Before we go into the technical aspects of lighting efficiency, it needs to be point out that the simplest and frequently the most effective way to save here is:

SWITCH OFF!!!

26 x 400W MH fixtures:

(26 fixtures) x (0.4kW/fixture)
= 10.4 kW

Consumption costs
(10.4 kW) x (8,000 annual operating hours)
= 83,200 kWh/yr

(83,200 kWh/yr) x ($0.07735/kWh)
= $6,435.52 /yr

An area no one hardly ever goes into

Demand Charge
(10.4 kW) x ($15 /kW-Month) x (12 Months)
= $1,872.00 /yr

Total Savings
$6,435.52 /yr + $1,872.00 /yr
= $8,307.52 /yr

By simply SWITCHING OFF/using timer: an equivalent of approximately $80,000 sales for the company (assuming 10% profit margin)!!!

3.c Utilize higher efficiency lamps and/or ballasts

Recommendation Overview

Old type lighting are less efficient.

For instance, typical ratings for mercury vapor lamps range from only about 25 to 50 lumens/watt, as against the over 90 lumens/watt ratings that are the norm of today's energy efficient fluorescent lighting systems.

Recommendation

In many cases, older type of fixtures can be replaced with the higher efficiency lamps and ballasts such as T5 lamps, which draw up to 80% less power than mercury vapor fixtures for the same level of lighting.

Additional Benefits

- Readiness for occupancy sensor
- Readiness for dimming
- Better color rendering
- Better distribution of light
- Longer life expectancy
- Greater heat resistance

Data Collection

Count number of metal halides or old type fixtures and find the wattage output . If necessary, collecting the data of lighting level to compare with industry standards.

Calculation and Example

Assume that the plant has 100 fixtures of 400 watt metal halides. The 400 Watt metal halide fixture can consume 465 W/fixture. The plant operates 8,000 hours per year. The 4 tubes 4-feet T5 fixture which gives approximately the same lumen output is rated at 234 W. The cost of electricity is \$0.075/kWh for a usage charge and \$4.50/kW for a demand charge. Therefore, a simple calculation can be calculated below:

Energy usage savings = (465W – 234W)/1000 x 100 fixtures x 8,000 Hours x \$0.075/kWh
= \$13,860.00/Year

Demand charge savings = (465W – 234W)/1000 x 100 fixtures x \$4.50/kW x 12 months
= \$1,247.40/Year

Total Energy Cost Savings = \$13,860.00 + \$1,247.40 = \$15,107.40/Year

Utilize higher efficiency lamps and/or ballasts

Simple payback period

A T5 lamp high-bay fluorescent fixture as listed above, with electronic ballasts, costs typically around $210 (lamps, electronic ballasts and material). Therefore the material costs should be approximately: $210/fixture x 100 fixtures = $21,000

If a total of 120 hours are required for installation, with a rate of $25 per hour, this will result in a labor cost of: 120 hours x $25/hour = $3,000

Therefore the total implementation costs will be approximately: $21,000 + $3,000 = $24,000

The simple pay back period is therefore: $24,000/$15,107.40 = 1.59 Years

3.d Install Occupancy Sensors

Recommendation Overview

In areas such as warehouse, maintenance room, compressed air room, rest room, cafeteria, office rooms, conference room, etc., sometimes lights are kept on when they are not occupied, resulting in wasted energy consumption.

Recommended action

Since the best way to save energy on lighting is to switch off when it is not needed, installing occupancy sensors will help to improve the situation so that lighting is on ONLY WHEN AND WHERE NEEDED.

Benefits of installing occupancy sensors

- Turns lights on and off based on occupancy
- Has user-adjustable time delay and sensitivity
- Can provide choice of different coverage patterns
- Can have built-in light level sensor

Data Collection

Identify the number of lighting fixtures, types and energy consumed that are not occupied. Estimate the hours that are not occupied. Identify a possible number of occupancy sensors can be installed.

Calculation and Example

Assume that the total power drawn by the lighting fixtures are estimated as:

144 fixtures x 0.190 W/fixture = 27.36 kW

For the purpose of illustration, assume a saving of just over 50% on average. Therefore the electrical usage savings from installing sensors will be approximately 15 kW. If the lighting is on for about 8,000 hours per year, annual electrical energy savings will be approximately:

15 kW x 8,000 hours/year x $0.075/kWh = $9,000/year

Simple pay back

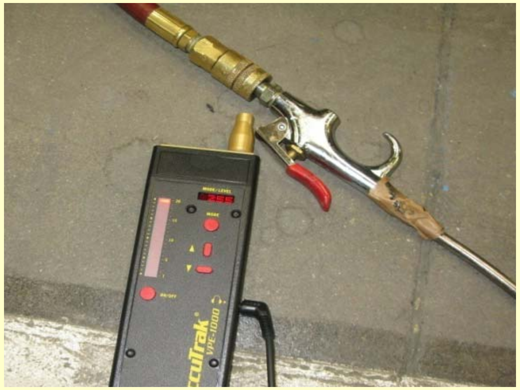
Assuming that 8 sensors are needed for an office environment and 12 sensors for the industrial floor area. The cost of the office and the industrial environment is $50 and $150 respectively. It is also estimated that 30 hours are required to install sensors with a labor cost of $25/Hour. Therefore, the implementation cost is ($50 x 8) + ($150 x 12) + (30 x $25) = $2,950

A simple pay back period for this recommendation will be $2,950/$9,000 = 0.32 Years

3.e Eliminate leaks in inert gas and compressed air lines/valves

Recommendation Overview

- **Compressed air is an integral part of many facilities – it is very expensive to operate!**
- **Leaks are a significant source of wasted energy in a compressed air system, often wasting as much as 20-30% of the compressor's output (A ¼-in diameter leak in a 100 psi compressed air line can cost over $7000 per year).**
- **Leaks can also contribute to problems with system operations, such as fluctuating system pressure, which can cause air tools and other air-operated equipment to function less efficiently.**
- **Our Center utilizes an ultrasonic detector to identify leaks that are not easily heard. A facility that employs a leak detection program can significantly reduce compressor energy usage and save thousands of dollars each year.**



Leaks can occur anywhere in the system though are commonly found in couplings, hoses, tubes, fittings, pipe joints and quick disconnects in the compressed air piping.

It is also common to find air lines that are open when not being used and compressed air being used improperly for personnel cooling, parts drying and other applications.

Tools: An ultrasonic leak detector

Source: http://img.directindustry.com/images_di/photo-g/ultrasonic-detector-for-locating-leak-and-mechanical-malfunction-264834.jpg

Data Collection: During an on site assessment our Center has a team member check for leaks using the ultrasonic leak detector. We catalog the number of leaks identified, the respective dimensions and shape and the pressure (PSI) of the system.

Energy Savings and Payback

Leakage rates[a] (cfm) for different supply pressures and approximately equivalent orifice sizes[b]						
Pressure (psig)	**Orifice Diameter (inches)**					
	1/64	**1/32**	**1/16**	**1/8**	**1/4**	**3/8**
70	0.29	1.16	4.66	18.62	74.4	167.8
80	0.32	1.26	5.24	20.76	83.1	187.2
90	0.36	1.46	5.72	23.1	92	206.6
100	0.40	1.55	6.31	25.22	100.9	227
125	0.48	1.94	7.66	30.65	122.2	275.5

a. For well-rounded orifices, values should be multiplied by 0.97 and by 0.61 for sharp ones
b. US DOE Compressed Air Tip Sheets, and is originally from Fundamentals of Compressed Air Systems Training offered by the Compressed Air Challenge®.

Example:

- 5 1/32 inch leaks were detected on a line operating at, leading to a leakage rate of 1.55 (from table).
- The assumed compressed air generation requirement is approximately 18 kilowatts (kW) per 100 cfm.
- Assumed 6,000 annual operating hours.
- Aggregate electric rate of $0.077 per kWh as determined by the utility calculator.
- Correction factor of 0.97 used for round holes.

Then:

# of leaks	x	leakage rate (cfm)	x	kW/cfm	x	# of hours	x	$/kWh	x	Correction factor	Saving
5	x	1.55	x	0.18	x	6,000	x	0.077	x	0.97	= $625.15

It is not uncommon to find hundreds of leaks in a thorough leak checking. It is therefore easy to understand why, according to the IAC Database, it is frequently possible to achieve more than $5,000 in energy savings by fixing air leaks. The low costs to fix these leaks contribute to an average payback of 3 months.

3.f Install compressor air intakes from coolest locations

Recommendation overview

As the temperature of intake air increases, the air density and the mass flow and pressure capability decrease, which will cost more energy to compress the air.

So in many cases it is desirable to install the air intake in the coolest location in order to get the air having the highest density. (Source: US Department of Energy Compressed Air Tip Sheet).

(It is important that the entry to the inlet pipe is as free as possible from contaminants, such as rain and dirt, and that all intake air is properly filtered).

Air intake inside

Calculation

Data such as horsepower (HP) of compressors, operating hours (HY), load factor (LF) and efficiency (η)of the compressors should be collected on site. The annual energy savings (AES) can be calculated as:

$$AES = \frac{HP \times HY \times FS \times LF \times 0.7465}{\eta}$$

Here, FS is called fractional savings, and can be calculated using this formula:

$$FS = (T_{hi} - T_{low}) / T_{hi}$$

This will also result in demand savings (DS) which is calculated as follows: DS = AES/HY $\times$ BDC (demand charge per month) $\times$ M (month)

Example:

A compressor with 30HP runs 5800h annually, load factor is 1.25 and the efficiency 90%. The ambient temperature is about 86° F, and the average temperature outside is about 56.7° F. Then the fractional savings is

$$FS = [(86+273)-(56.7+273)]/(86+273) = 8.2\ \%$$

The annual energy savings are

$$AES = \frac{30 \times 5800 \times 0.082 \times 1.25 \times 0.7465}{0.90} = 14{,}793.14\text{kWh/y}$$

If elec. price is \$0.07/kWh, then the usage saving is: US = 14,793.14X0.07 = \$1035 /yr

Assuming that the demand charge is \$5.00, so the demand savings is: DS = 14,793.14/5,800 × 5 × 12 = \$153.00/y

Resulting in a total saving of: \$1188/yr

3.g Reduce pressure of compressed air to minimum required

Recommendation Overview

In some cases, the facility has set the pressure of the compressed air system above the minimum required by the operations. This is usually done to ensure that an operation at the far end of the facility has the pressure required. By reducing the system pressure to the proper level the facility can reduce energy consumption and lower costs.

Example

A large printing facility, and a major compressed air user.

Through continuously improvement, reduced operation pressure from 110 psi to around 85 psi plant-wide.

Large storage tank will also help improve the on-off cycle of the compressors.!

3.h Use most efficient type of electric motors

Problems identification

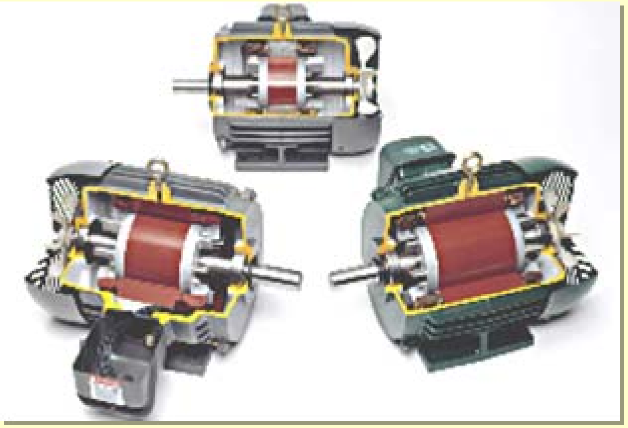
Running standard efficiency motors is more costly than running premium efficiency motor. The standard efficiency motors can gain 2 to 8 percent if replaced by more efficient motors.

Benefits

- Longer insulation and bearing lives
- Lower heat output and less vibration
- Extended winding life
- Increased tolerance of overload conditions
- Higher tolerance for increased voltage rates or phase imbalance
- Lower failure rates and extended manufacturer warranties

Key to identify the savings:

1. Motor efficiency
2. Load factor
3. Hours of operation
4. Possible premium efficiency ~ 95%



Three different efficiencies for the same horsepower rating. Top: standard-efficiency pre-EPAct motor; lower left: EPAct-level motor; lower right: NEMA Premium efficiency motor. Source: http://www.copper.org

Calculation:

$$0.746(W/HP)\times HP\times HRS\times\left(\frac{1}{Eff_{OLD}}-\frac{1}{Eff_{NEW}}\right)\times EC = Savings/Year$$

HP = Horse Power
HRS = Hours of operation
Eff(old) = Efficiency of a current motor
Eff(new) = Efficiency of a propose motor
EC = Electricity Cost ($/kWh)

Example:

Assuming that a 5 HP standard-efficiency is in service. The motor operates 8,000 hours per year at full load. The efficiency rating would be around 84%. The average cost of electricity is at $0.075/kWh (National average). Replacing the motor with a premium efficiency that has a efficiency rating of 90% at full load would save you as calculated below:

$$0.746(W/HP)\times 5\times 8000\times\left(\frac{1}{0.84}-\frac{1}{0.90}\right)\times \$0.075/kWh = \$177.62/Year$$

In this example, the premium efficiency motor would cost approximately $302 after discount. A simple payback period is:

$302/$177.62 = 1.7 years

HP	Premium Efficiency (1800 RPM)
5	90.0%
10	93.0%
15	93.0%
20	93.6%
30	94.1%
40	95.0%
50	95.0%
60	95.4%
75	95.4%
100	95.4%
125	95.4%

Example of Premium efficiency ratings gathered from MotorMaster+ 4.0

The calculation, motor database including types, efficiency and cost, and motor comparison can be carried out by using MotorMaster+ Software from DOE website: http://www1.eere.energy.gov/industry/bestpractices/software.html

Additional Resource:
For more tips on how to save energy for motors and other energy systems, go to http://www1.eere.energy.gov/industry/bestpractices/technical.html

3.i Analyze flue gas for proper air/fuel ratio

Recommendation Overview

Ambient and atmospheric conditions can affect oxygen/air supply. Savings can be obtained by increasing combustion efficiency of the boiler through a proper air/fuel ratio.

Recommended action

Monitor the air/fuel ratio and adjust to the proper portion to achieve the best performance out of the boiler.

The recommended percentage of oxygen is at 3.0% with a corresponding of 15% of excess air.

It is also recommended to initiate maintenance programs to analyze flue gas frequently , and/or install an O2 trim controller system for an automated continuous adjustment.

Fire tube boiler with O2 Trim system.
Source:
http://www.energysolutioncenter.org

Data Collection:

Use gas analyzer to measure air/fuel ratio (flue gas oxygen %, excess air % and efficiency%).

Calculation:

1. Use the oxygen%, excess air% and net stack temperature to estimate boiler efficiency (see table).
2. Use the following equation for energy savings estimation:

$$\textit{Energy Cost Savings} = IG \times H \times (1 - (E_1/E_2)) \times FC$$

IG = Input gas of the fuel-based system MMBtu/year
H = Hours of operation per year
E_1 = Current fuel-based system combustion efficiency
E_2 = Proposed fuel-based system combustion efficiency
FC = Fuel Cost $/MMBtu

Combustion gas analyzer model PCA II.
Source: http://www.bacharach-inc.com

Excess Air	O2 %	CO2 %	Net Stack Temperature						
			220	230	240	246	250	260	270
0.0	0.0	11.8	85.3	85.1	84.9	84.8	84.7	84.5	84.2
2.2	0.5	11.5	85.2	85.0	84.8	84.7	84.6	84.4	84.1
4.5	1.0	11.2	85.1	84.9	84.7	84.6	84.5	84.2	84.0
6.9	1.5	11.0	85.0	84.8	84.6	84.5	84.4	84.1	83.9
9.5	2.0	10.7	84.9	84.7	84.5	84.3	84.2	84.0	83.8
12.1	2.5	10.4	84.8	84.6	84.4	84.2	84.1	83.9	83.7
15.0	3.0	10.1	84.7	84.5	84.2	84.1	84.0	83.8	83.5
18.0	3.5	9.8	84.6	84.4	84.1	84.0	83.9	83.6	83.4
21.1	4.0	9.6	84.5	84.2	84.0	83.8	83.7	83.5	83.2
24.5	4.5	9.3	84.3	84.1	83.8	83.7	83.6	83.3	83.1
28.1	5.0	9.0	84.2	83.9	83.7	83.5	83.4	83.2	82.9
31.9	5.5	8.7	84.1	83.8	83.5	83.4	83.3	83.0	82.7
35.9	6.0	8.4	83.9	83.6	83.3	83.2	83.1	82.8	82.5
40.3	6.5	8.2	83.7	83.4	83.2	83.0	82.9	82.6	82.3

Example:

A 200 HP steam boiler has a capacity of 6,00 lbs/hour at 212 F. The Natural gas input at full load is 8.165 MMBtu.
Efficiency reading:82.5%, 35.9% of excess air and 6.0% flue gas oxygen.

If adjustment of air/fuel ratio can be achieved at 3.0% of flue gas oxygen and15% excess air, then from the table the improved efficiency will be 83.5%.

Assume energy cost at $10/MMBtu, the energy cost savings can be calculated as:

Energy Cost Savings = 8.165 MMBtu x 8,000 Hours x (1 – (82.5/83.5)) x $10/MMBtu
= $7,822.75/Year

Simple payback period

If the plant installs automatic adjustment. The O2 Trim system for 200 HP boiler can cost around $10,000. Installation cost is $5,000, totaling $15,000. A simple payback period will therefore be:

$15,000/$7,822.75 = 1.9 years

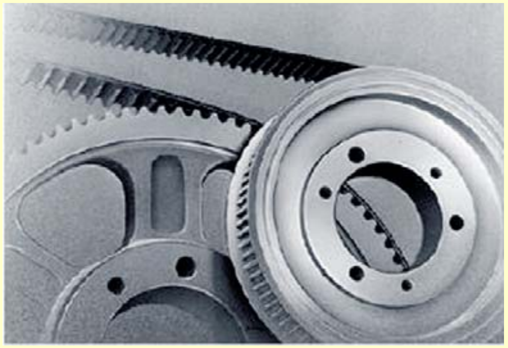
PHAST software can help you do all calculations of the process heating in your plant as well as the adjustment of the air/fuel ratio. This software can be downloaded at: http://www1.eere.energy.gov/industry/bestpractices/software.html

Additional Resource:
For more tips on how to save energy for process heating and other energy systems, go to http://www1.eere.energy.gov/industry/bestpractices/technical.html

3.j Utilize energy-efficient belts and other improved mechanisms

Recommendation Overview

❖The efficiency of V-belts will slowly degrade to about 90% or lower (from an initial 95%) due to wear.
❖To reduce the loss, energy-efficient cog/synchronous belts which have gains in efficiency from 2.9% to 5% are recommended to transfer power.
❖Even a conservative value of 1.0% is used in actual calculation, a considerable savings will be gained.



Calculation

It is easy to identify such a problem when the plants are using low energy-efficient belts other than cog belts.
Data such as the total horsepower (HP) of equipments, average efficiency of the equipments (η), average load factor (LF), annual operating time (H) are then needed for the following calculation:

Power Saving $PS = HP/\eta \times LF \times S$ (Here, S= % in efficiency gain)
Energy Saving $ES = PS \times H$

Example

650HP motors with V-belts with average efficiencies at 0.85, load factor 80%, and annual running 8,400 hours. Replacing V-belts with cog belts will result in:

ES = (650/0.8)X0.7459X0.8X0.01X8,400 = 38,330kWh/yr

With $0.05/kWh, usage savings is: US = 38,330X0.05 = $1,916.5/y
With demand charge of $5.00/kW: demand saving is: DS = 38,330/8,400X$5X12 = $273.79
Totaling: $1,916.5+ $273.79 = $2,190.29 /year.

Case

Lines	Motor (HP)	Average load
Line 1	2000	46%
Line 2	1500	23%
Line 3	1000	38%
Line 4	1500	66%
Total	**6000HP**	**1635HP**

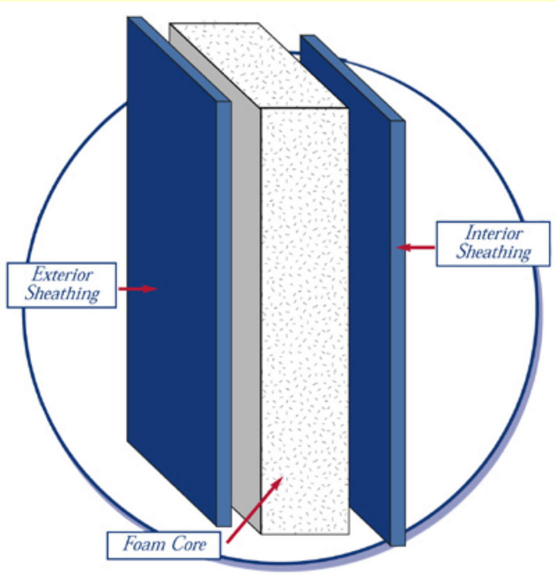
At a 1.0% efficiency gain:
Estimated Electricity Usage Savings = 51,660 kWh annually
Estimated Cost Savings = $3,995.90 annually
Estimated Implementation Cost = $0
Simple Payback Period = Immediately

Large motors using V-belts running 4,500 hours/year

3.k Insulate bare equipments

Recommendation Overview

A big part of heat loss is from the surface of heating equipments. So it is desirable to have good insulation on heating equipments, especially for the high temperature and big capacity units.

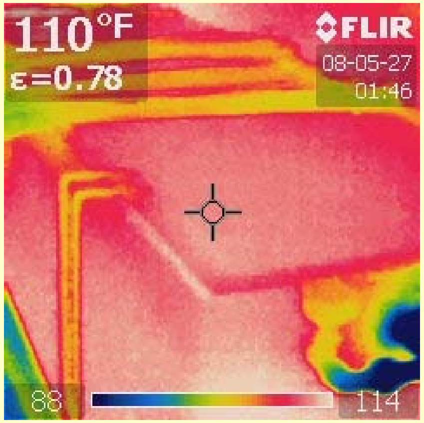


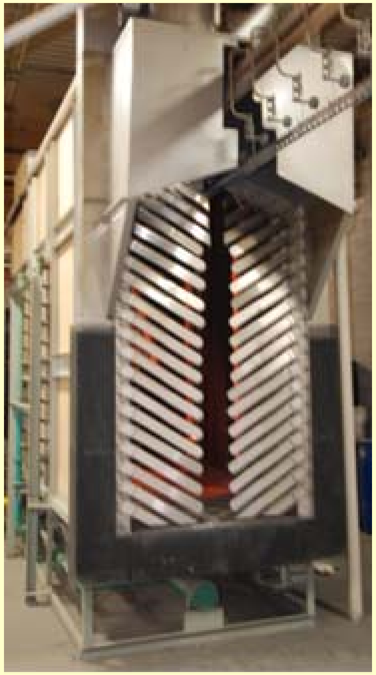
Calculation

Thermal imaging (Infrared camera) is a useful tool to measure the surface temperature. Calculation can be done as follows:

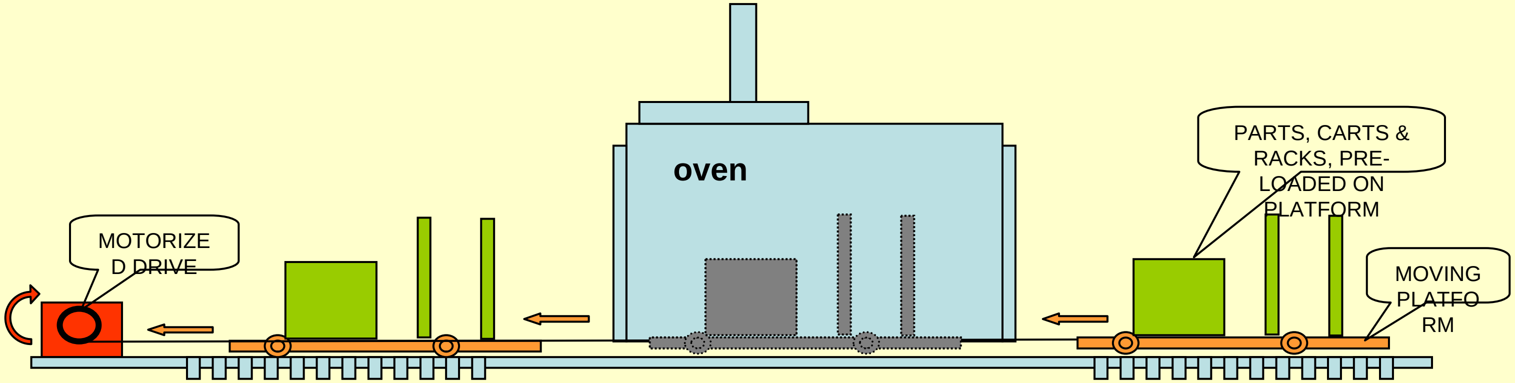
$$Q = \frac{A \times (T_{inside} - T_{outside})}{R - value}$$

A is the area across which heat is being lost, T is temperature, and R-value is a constant depending on building materials (1=poor insulation, 7=good)

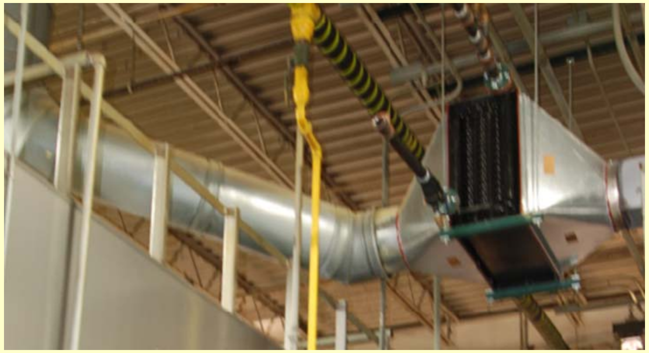




In general, it is good to keep the heat in.



3.I Waste Heat Recovery



4. MO IAC’s Web-based Learning & Auditing Tool

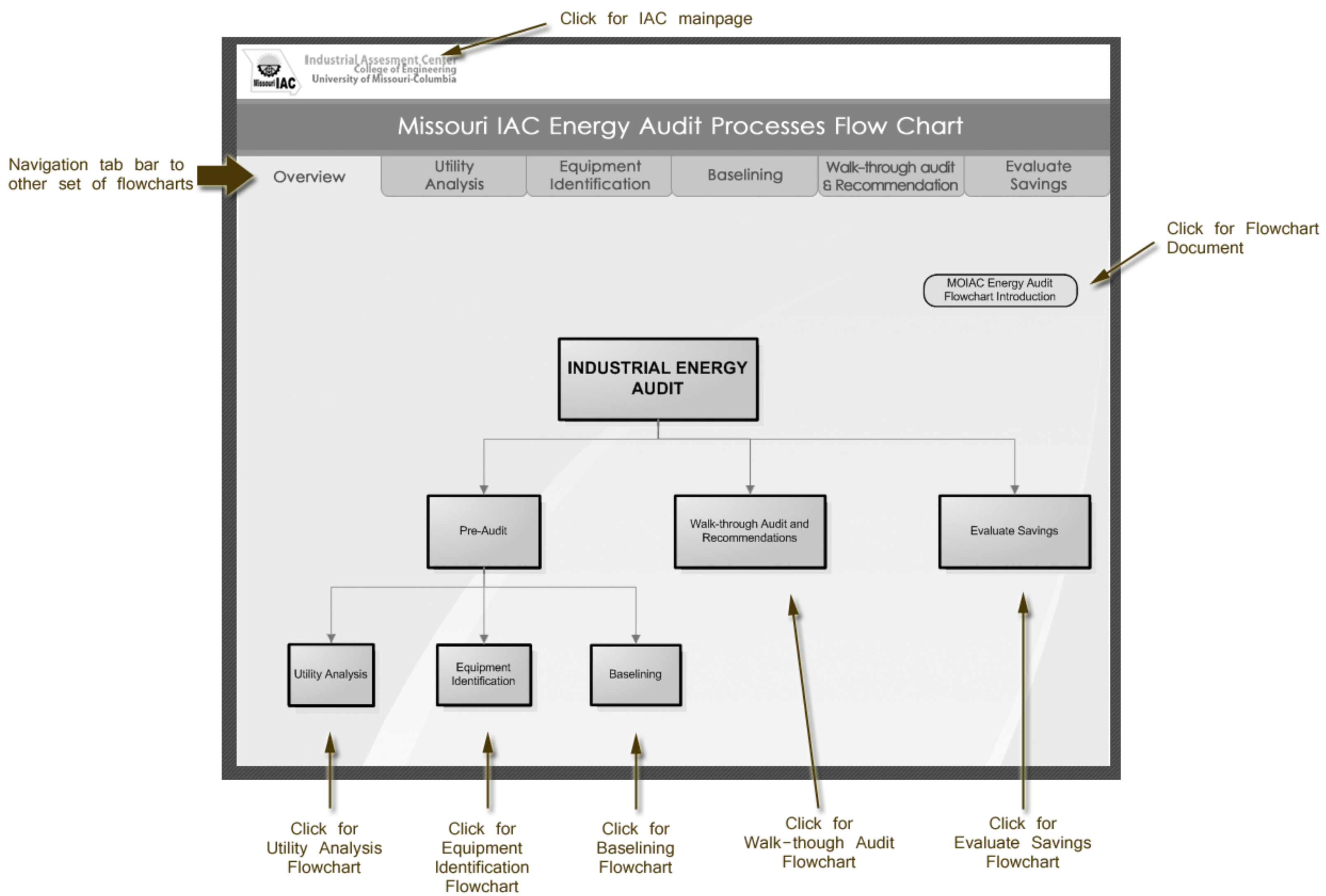
Objectives

To establish an integrated computer-aided training/audit tool for industrial energy audits in a structured, logical and practical way.

To support the kind of diagnosis-solution problem solving required to perform a competent energy audit.

The concept is based on the integration of necessary components of tasks (flowcharts, documents, datasheets, tools), providing a single platform that will allow users to navigate throughout relevant processes in a task-centered way, see:

http://iac.missouri.edu/tools/Flowchart/flowchart.html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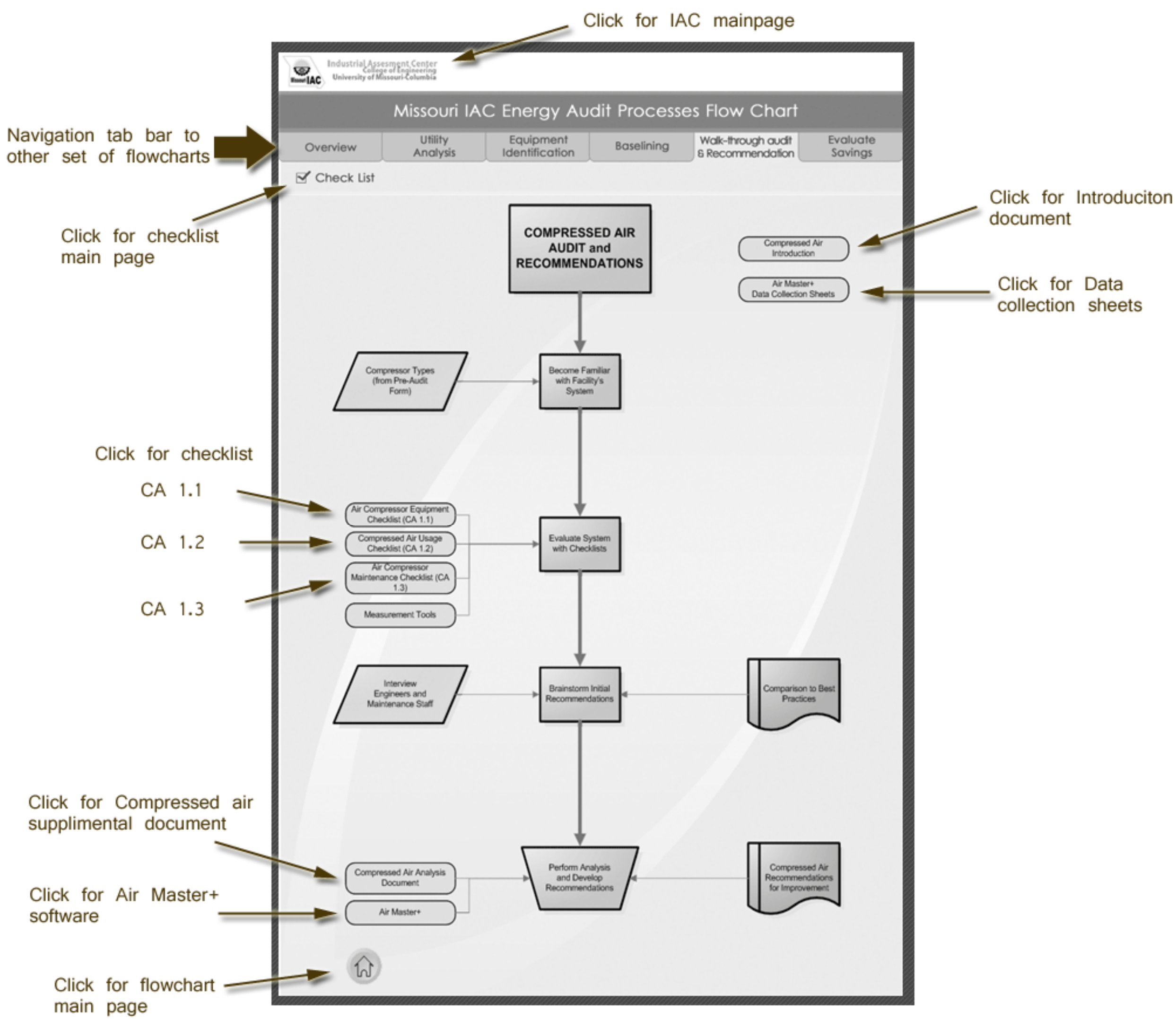
Click for Evaluate Savings Flowchart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Compressed Air Introduction
Air Master+ Data Collection Sheets
Click for Introduciton document
Click for Data collection sheets
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Become Familiar with Facility's System
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CA 1.2
CA 1.3
Air Compressor Equipment Checklist (CA 1.1)
Compressed Air Usage Checklist (CA 1.2)
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Measurement Tools
Evaluate System with Checklists
Interview Engineers and Maintenance Staff
Brainstorm Initial Recommendations
Comparison to Best Practices
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Perform Analysis and Develop Recommendations
Compressed Air Recommendations for Improvement
Click for flowchart main page

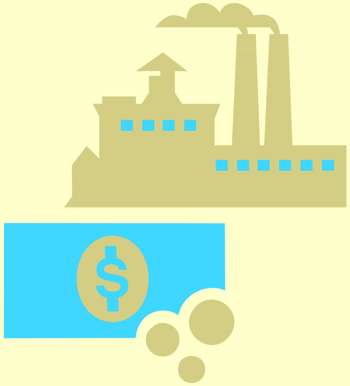
5. Conclusions

We repeat our two KEY messages:

- ***Every Dollar Saved Is a Profit of One Dollar to the Organization – 100%!***
- ***There are many "Low-Hanging Fruits" to be picked in energy efficiency.***

Becoming energy efficient is good:

For the environment and for your business



For ourselves and for our future generations

SO LET'S PLEASE MAKE AN EFFORT

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Questions?

IAC Missouri

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