Tips for Starting an Energy Management Program

NEWMOA Web Conference on Energy Efficiency
June 3, 2008

John S. Raschko, Ph.D.
Mass. Office of Technical Assistance
www.mass.gov/envir/ota
(617) 626-1093

Developing an Energy Management Strategy

- Use of formal energy management programs becoming more popular
- Number of resources available –
  - DOE *Corporate Energy Management (CEM)* program –
    - Modeled on quality management systems
    - Moves accountability for energy outcomes to upper levels of the firm; involves many areas of business activity (not just production)
    - Measure current performance, set goals, track savings, and reward improvements
    - *http://www1.eere.energy.gov/industry/bestpractices/corporate_energy.html*

Developing an Energy Management Strategy

- Resources (cont.) –
  - EPA/DOE ENERGY STAR® program –
    - Guidelines for Energy Management - measure current performance, set goals, track savings, and reward improvements; benchmarking
    - Assessment tools – for both corporate and facility levels
    - Other tools available – energy mgt. guidance, improving system performance (lighting, fans, etc.), financial evaluation, computer power mgt.
    - Training – webinars, pre-recorded training, self-guided presentations
    - Partnerships with industry
    - *http://www.energystar.gov/index.cfm?c=guidelines.guidelines_index*

DOER 7-Step Energy Action Plan

1. Assign Responsibility
2. Assemble Data
3. First Cut Analysis
4. More Complex Analysis
5. Short and Long Term Plans
6. Examine Procurement
7. Monitor, Monitor, Monitor

Identifying and Evaluating Energy Efficiency Opportunities

- DOE Industrial Technology Program (ITP) tools –
  - *Quick Plant Energy Profiler (QuickPEP)* - run online at DOE's website; meant to be a broad overview of the energy profile for a plant. *http://www1.eere.energy.gov/industry/bestpractices/software.html*

DOE QuickPEP Tool

Inputs

- Average utility bill information
- Average production information
- Major energy-using systems
- Score cards (optional)*
- Average energy usage information

Quick PEP

Outputs

- Energy use & cost per unit of production
- Annual purchased energy graphs and tables
- Annual consumed energy graphs and tables
- Potential annual energy savings graphs and tables
- Customized list of next steps

*Before presenting your results, Quick PEP requests information about the energy efficiency of your major plant systems. You can determine this yourself or fill out an optional "score card" to obtain efficiency information for selected systems.

Identifying and Evaluating Energy Efficiency Opportunities

- DOE Industrial Technology Program (ITP) tools (cont'd) –
  – *Energy Use and Loss Footprints* - developed for a number of manufacturing industries; map the flow of energy supply, demand, and losses in manufacturing facilities.
  – *Software tools* - evaluate energy saving opportunities in variety of systems, e.g., steam, motors, pumps, compressed air, fans, process heating, CHP
    - Massachusetts Energy Efficiency Partnership (MAEEP) conducts trainings on these tools

Identifying and Evaluating Energy Efficiency Opportunities

- Energy Audits (gas and electric) –
  - Comprehensive assessment for determining the best energy measures –
    - Detailed evaluation of energy use, including load profile
  - Providers –
    - *DOE Save Energy Now program* – 3 day assessment involving training on DOE software tools; 0.3 trillion Btu/yr *total* energy use; typically no cost; apply online *http://www1.eere.energy.gov/industry/saveenergynow/assessments.html*
    - *Industrial Assessment Center (IAC) audits* – 1 day, no cost, energy costs $100,000 to $1.75 million/year, SIC 20 – 39 (Dr. Beka Kosanovic (413) 545-0684 *http://www.ceere.org/iac/index.html*)
    - Consultants

Identifying and Evaluating Energy Efficiency Opportunities

- Energy Audits (cont'd) –
  - Often subsidized by utilities through their energy efficiency programs –
    - Contact your utility account representatives for detailed information on your provider's programs
    - All investor owned utilities (IOUs) have programs (e.g., NSTAR, NGRID, WMECO, Keyspan, Bay State Gas)
    - Municipal utility programs vary – links to many at MA Division of Energy Resources (DOER) website
    - Utilities can also assist with load management

Other Resources

- MA DOER –
  - information on energy resources, including energy procurement, fuel prices, conservation, and renewables
  - *http://www.mass.gov/doer/*
- Combined heat and power (CHP) -
  - Northeast CHP Application Center (@ CEERE) –
    - provides assessments and detailed information on CHP
    - *http://www.northeastchp.org/nac/index.cfm*
  - EPA CHP Partnership –
    - Info on technologies, emissions, $$, decision tool
    - *http://www.epa.gov/chp/*

Other Resources

- Energy Service Companies (ESCOs) –
  - develops, installs, and finances projects designed to improve the energy efficiency and maintenance costs for facilities over a seven to 10 year time period.
  - assume the technical and performance risk associated with the project
  - National Association of Energy Service Companies (NAESCO) *http://www.naesco.org/about/esco.htm*

Useful Publications

- Rutgers Self-Assessment Workbook for Small Manufacturers *http://iac.rutgers.edu/database/technicaldocs/IAC_Manualsselfassessment.pdf*
- Wulfinghoff, Donald R., Energy Efficiency Manual, Energy Institute Press, 1999
- Mull, Thomas E., Practical Guide to Energy Management for Facilities Engineers and Plant Managers, ASME Press, 2001

Contact

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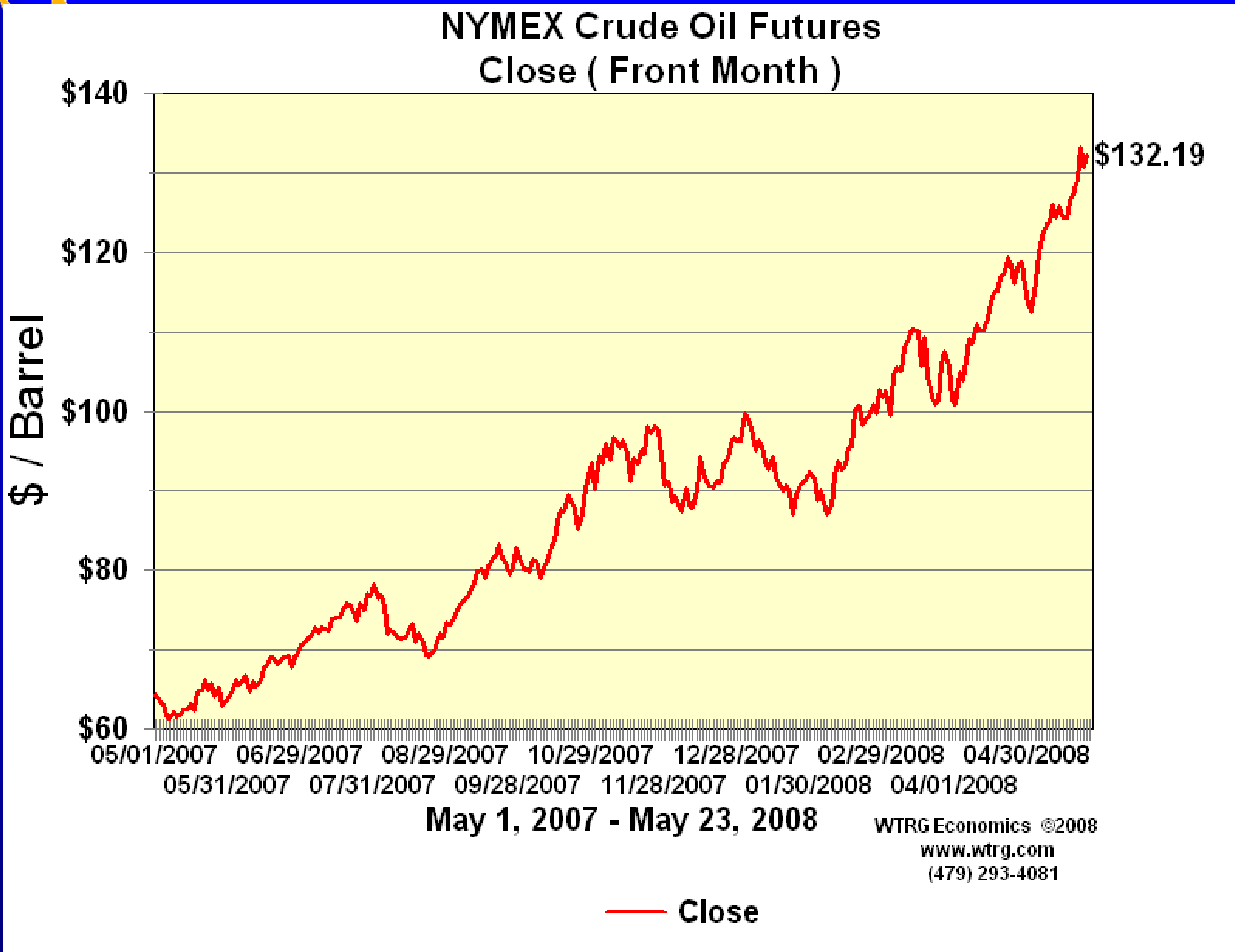
Energy Efficient Buildings

by Jim Cain, OTA

June 3, 2008 Webinar

20 Minute Snapshot
Buildings and Energy

- Energy is Becoming Costly
- Building Function and Business Type
- Energy Use Categories
- Environmental Factors
- Useful Literature
- OTA Fact Sheet
- Energy Predictions and Software


NYMEX Crude Oil Futures
Close (Front Month)
$ / Barrel
$140
$120
$100
$80
$60
$132.19
05/01/2007
06/29/2007
08/29/2007
10/29/2007
12/28/2007
02/29/2008
04/30/2008
05/31/2007
07/31/2007
09/28/2007
11/28/2007
01/30/2008
04/01/2008
May 1, 2007 - May 23, 2008
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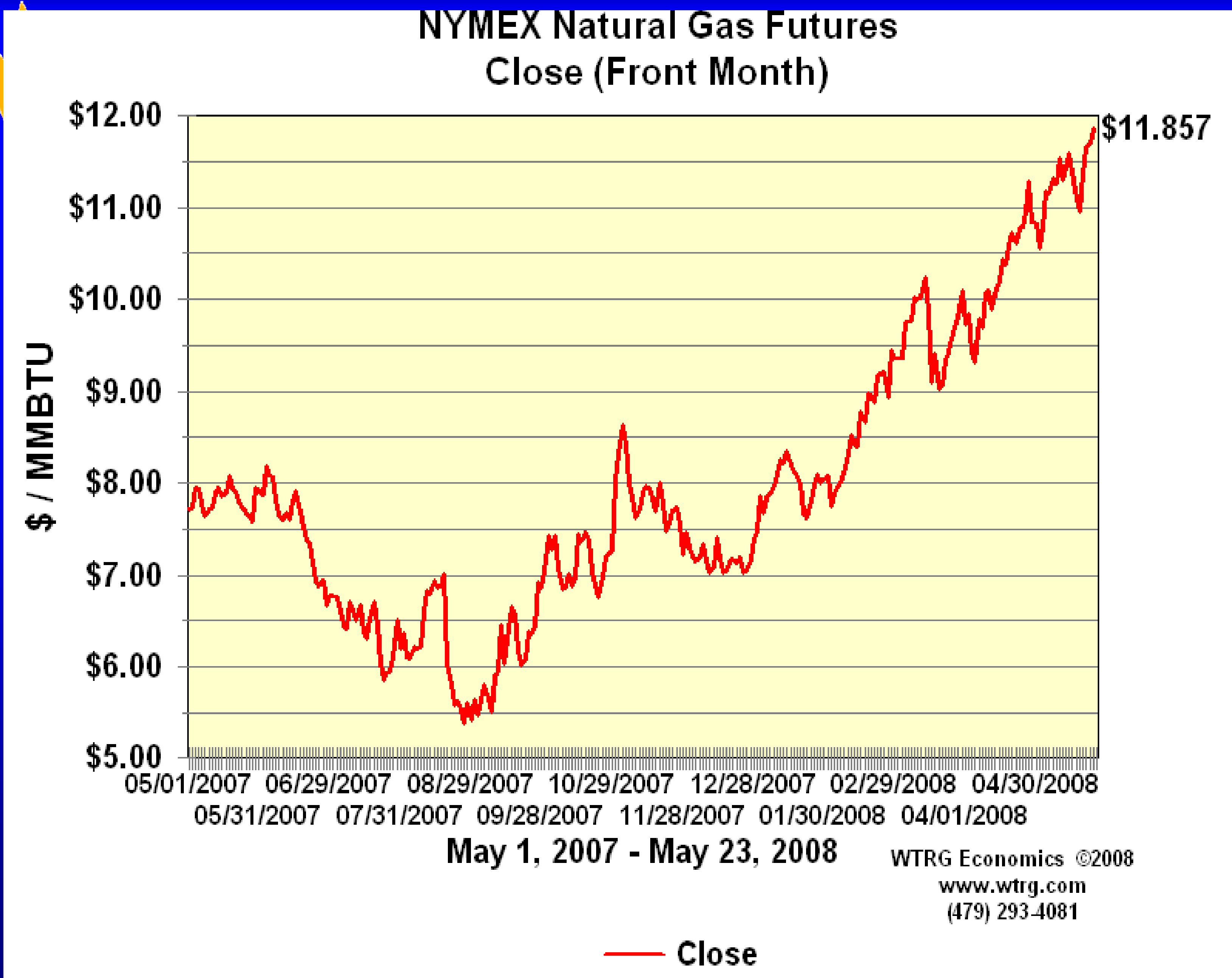
Close


NYMEX Natural Gas Futures
Close (Front Month)
$12.00
$11.00
$10.00
$9.00
$8.00
$7.00
$6.00
$5.00
$11.857
$ / MMBTU
05/01/2007 06/29/2007 08/29/2007 10/29/2007 12/28/2007 02/29/2008 04/30/2008
05/31/2007 07/31/2007 09/28/2007 11/28/2007 01/30/2008 04/01/2008
May 1, 2007 - May 23, 2008
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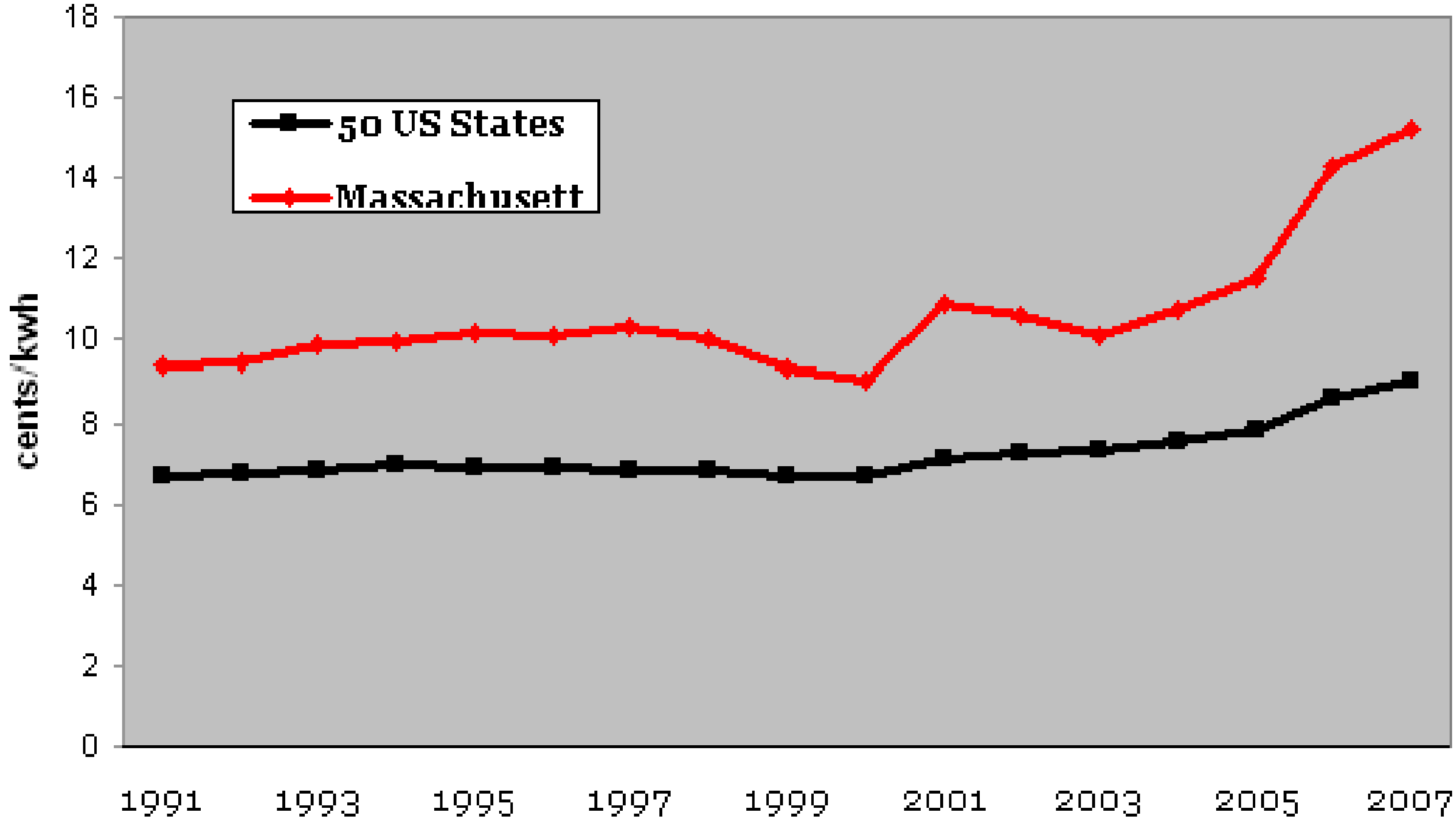
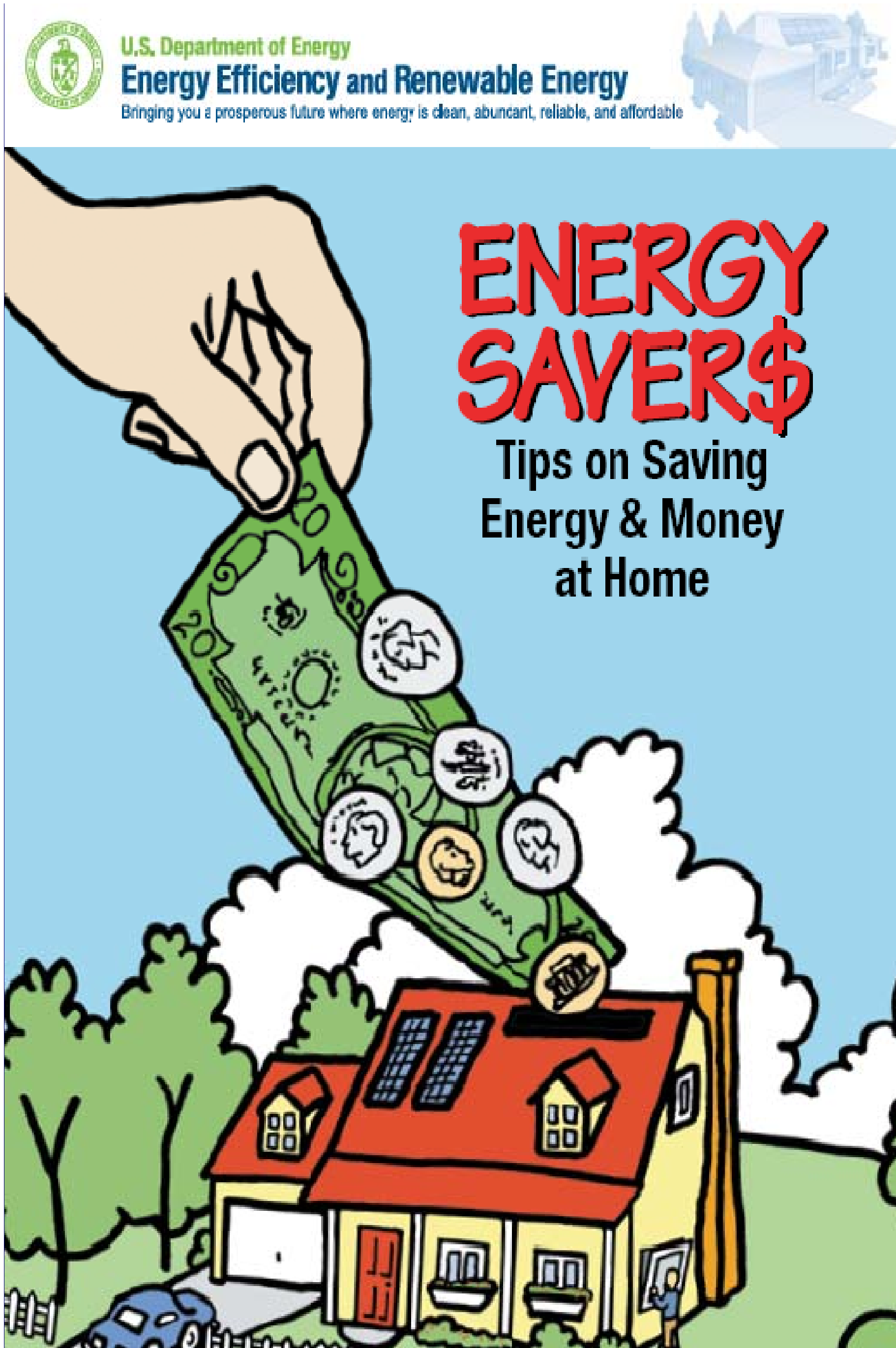
PPI

TOTAL Average Delivered Retail Electricity Price: Massachusetts vs All States



For the 12 months ending in July of each year, through July 2007, EIA Data.

Dec. 2007 Mass. Average = 14.6 cents (all sectors) ; 13.2 cents (industrial)
EIA report 3-13-08


U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable
ENERGY SAVER$
Tips on Saving Energy & Money at Home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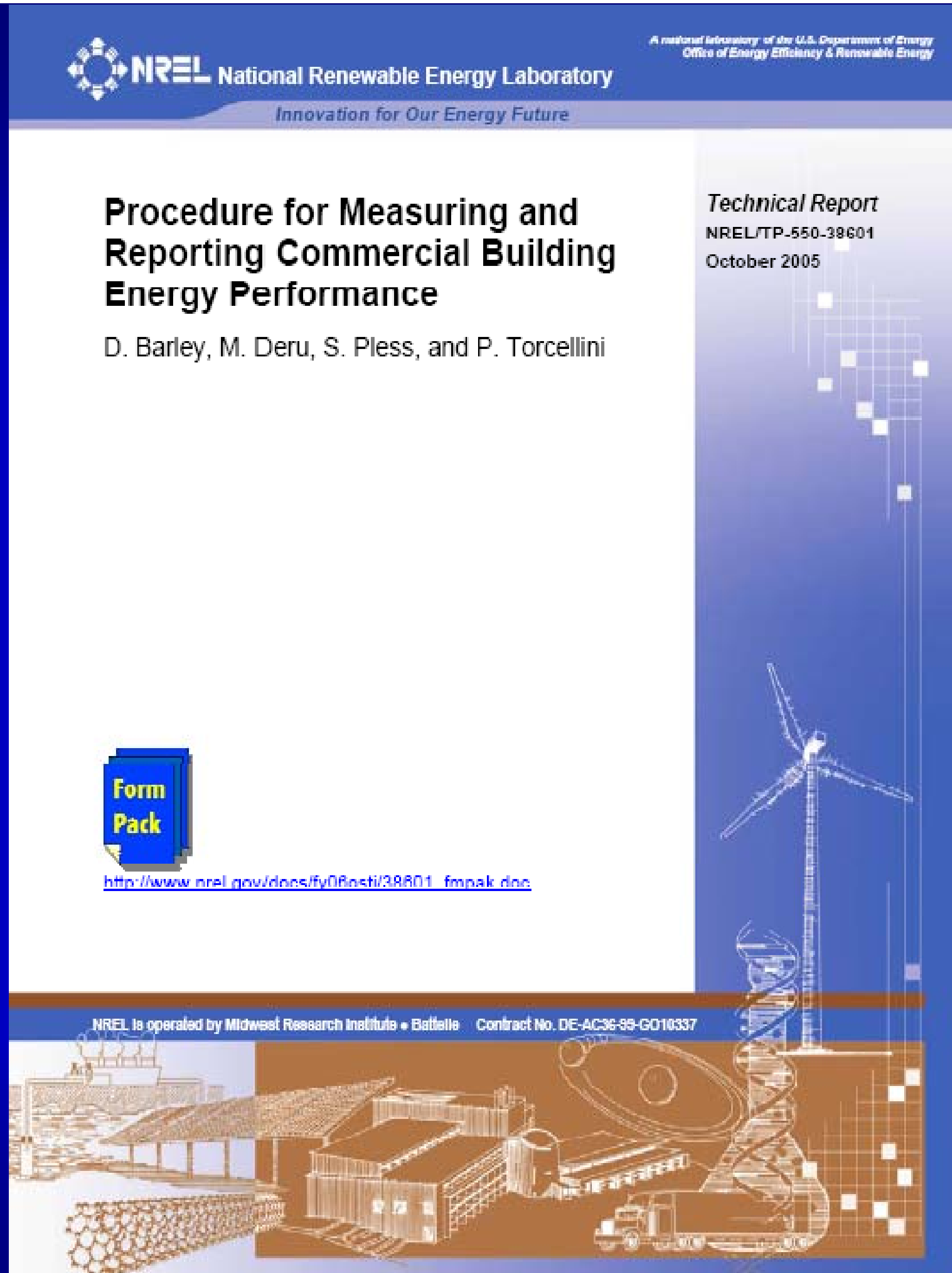
A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

NREL National Renewable Energy Laboratory

Innovation for Our Energy Future

Procedure for Measuring and Reporting Commercial Building Energy Performance

D. Barley, M. Deru, S. Pless, and P. Torcellini

Technical Report
NREL/TP-550-38601
October 2005

Form Pack

http://www.nrel.gov/docs/fy06osti/38601_fmpak.doc

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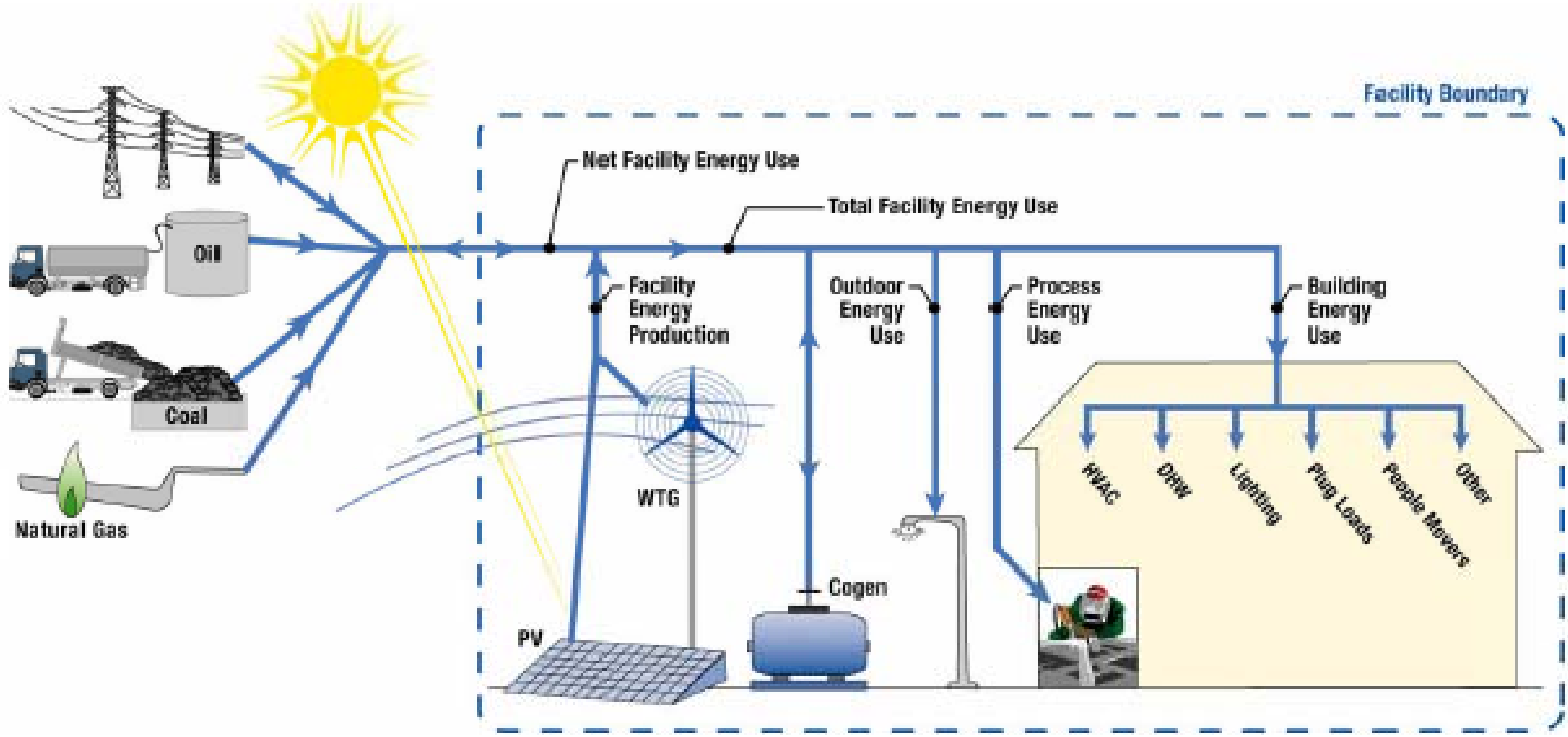
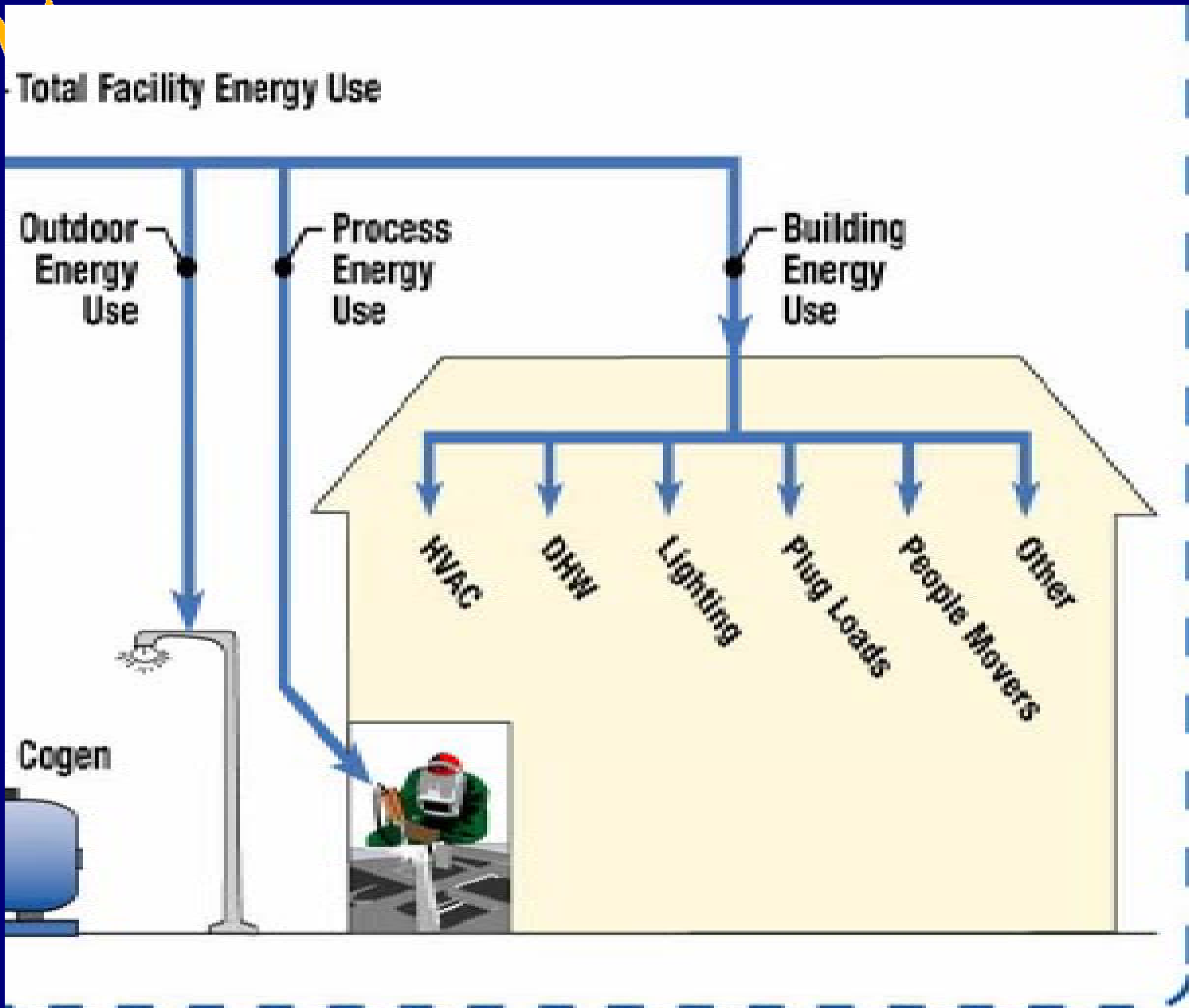


Energy flow diagram providing an overview of this procedure
Figure 4-1 shows a more detailed diagram of the relationships among metrics.

Facility Energy Flow Diagram
(waste heat and emissions not shown)


Total Facility Energy Use
Outdoor Energy Use
Process Energy Use
Building Energy Use
HVAC
DHW
Lighting
Plug Loads
People Movers
Other
Cogen

EIA National Energy Surveys Show Wide Variation in a Facility's Proportionate Use By Business, Function, Region, Site factors, etc

Facility Energy Use	Low	High
Heating: Process and Space	25%	35%
Cooling: Process and Space	2%	7%
Machine Drives and Fans	3%	11%
Lighting	1%	22%
Office Equipment	2%	7%

Massachusetts Office of Technical Assistance and Technology

Energy Conservation Fact Sheet

Energy Saving Tips for Industrial and Commercial Buildings

Introduction

Energy is a significant and growing cost for most businesses. A review of how energy is used in buildings and then targeting improvements in equipment and procedures can lead to big cost savings. Furthermore, many corporate and government programs now strongly encourage energy conservation. The purpose of this fact sheet is to provide useful examples of energy saving tips that relate to the general categories of building energy use, that would apply to most facilities. (Examples of potential savings in direct process uses, which may dominate energy consumption in heavy industry, can be found in the OTA energy efficiency fact sheet).

Facility Energy Use	Low	High
Heating: Process and Space	25%	35%
Cooling: Process and Space	1%	7%
Machine Drives and Fans	3%	11%
Lighting	1%	22%
Office Equipment	1%	7%

Businesses vary greatly in size and purpose, and this will be reflected in the proportionate energy consumption for each category of end use. The accompanying table is derived from national surveys[1] of industrial and commercial facilities. Most Massachusetts manufacturers, with a few exceptions, have energy uses within the ranges of this table. A manufacturer of basic materials would have proportionately more process heating and an assembly facility would have more space heating, lighting, etc. A large facility from heavy industry may have large boilers and even electrical cogeneration while a smaller facility in one of the light industries may have proportionally more energy use for auxiliary food services, domestic hot water, etc.

Devising an energy strategy with the greatest potential savings involves identifying the major energy end uses within the facility. Capital costs and operating costs are also needed for ranking various conservation measures. Note that the payback periods will be affected by hours of operation and load profiles. Avoided peak demand surcharges and other energy pricing variability can be important in planning your energy strategy.

Energy Conservation

Many criteria can be used in decisions whether to install energy-saving equipment or implement new procedures. The most frequently considered are total costs, rate of return, ease of implementation, and certainty of the desired outcome. The following four categories are examples of how your facility can make changes to achieve energy conservation.

HVAC

A big category for light industrial operations is HVAC. Waste heat from processes, lighting, air compressors, etc. can contribute in winter but may not be well distributed. Waste heat at some facilities can create additional cooling loads not only in summer, but to a lesser degree in the other seasons as well.

- Waste heat from compressors can frequently be captured for space heating or other uses.
- Supply air for the compressors and boilers should be from the outside, not indoor air.
- Seal leaks and increase insulation, at least up to recommended R-values.
- Add economizers to the A/C system (a useful technique except on hot, humid days).
- Identify and correct unwanted drafts and unwanted air movement from one area to another.
- Use ceiling fans where appropriate.
- Adjacent rooms that are maintained at different temperatures should be separated by doors or flexible transparent barriers.
- Heating and cooling ducts should be insulated.
- Use automatic controls such as programmable thermostats, time clocks, bypass timers, weather sensors, and activity sensors, where appropriate.
- Areas of building prone to solar heat gain should be shaded in summer and exposed in winter.
- Thermostats should be set cooler in winter and warmer in summer.

Additional Energy Conservation Services

Many electric and gas utilities provide financial assistance for energy audits and energy efficient equipment. Web links to many of these can be found on the OTA Energy Web Page http://www.mass.gov/envir/ota/resources/energyconserv.htm

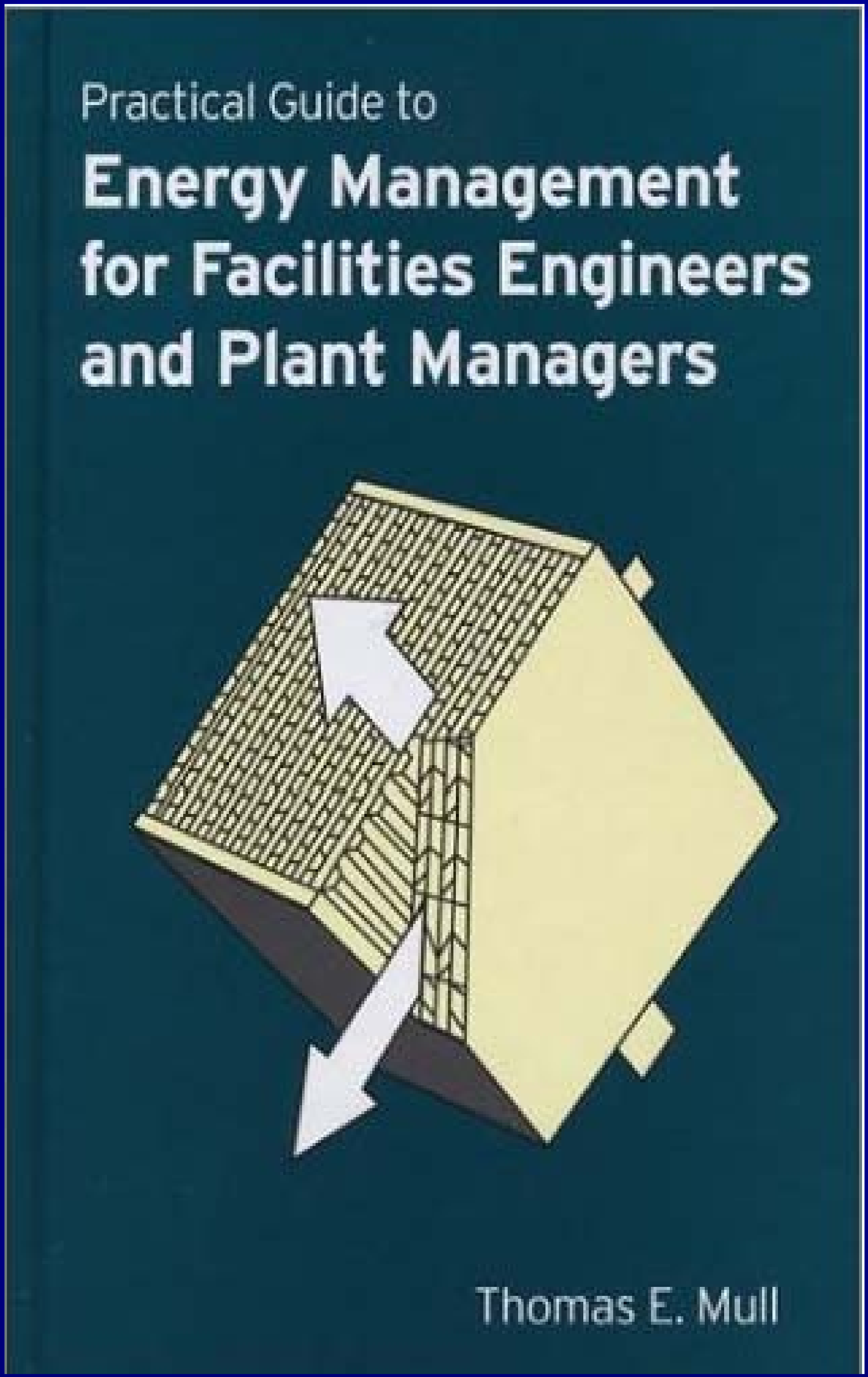
1. Energy Information Administration: U.S. Department of Energy

Executive Office of Energy and Environmental Affairs
Office of Technical Assistance and Technology

Energy Conservation Fact Sheet

HVAC (Heating, Ventilating, and Air Conditioning)

1. Capture **waste heat**
2. **Supply air** to equipment directly from outside
3. Reduce **infiltration** and increase **insulation**
4. Add **economizers** to A/C system (except when humid)
5. Identify and correct unwanted **drafts** through building
6. Use **ceiling fans** where appropriate
7. Separate / **isolate** adjacent rooms , if at different climates
8. **Insulate** heating and cooling ducts when economical
9. Use automatic and/or programmable **controls**
10. **Shade** east / west windows of building in summer and **expose** south windows (winter
11. Set **thermostats** cooler in winter and warmer in summer



600 pages c. 2001 ASME

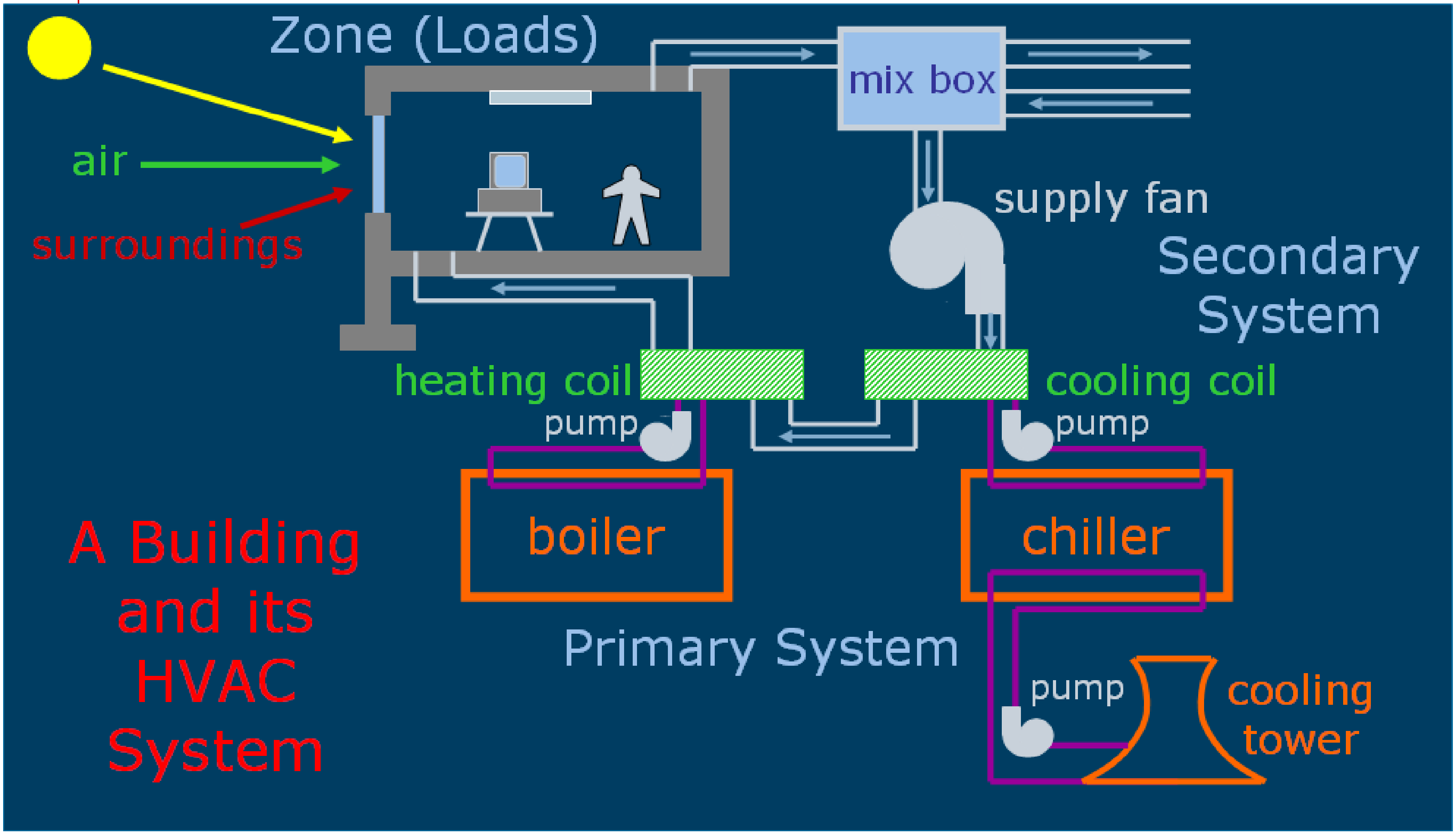
- Introduction to Energy Management
- Basic Scientific Principles
- Economics for Energy Management
- Combustion Systems and Boilers
- Steam Systems
- Hydronic and Pumping Systems
- Chillers and Chilled Water Systems
- Cooling Towers and Fluid Coolers
- Air Distribution and HVAC Systems
- Electrical and Lighting Systems
- Compressed Air Systems
- Refrigeration Systems
- Heat Recovery and Waste Heat Mgt
- Thermal Energy Storage Systems
- Energy Mgt and Control Systems

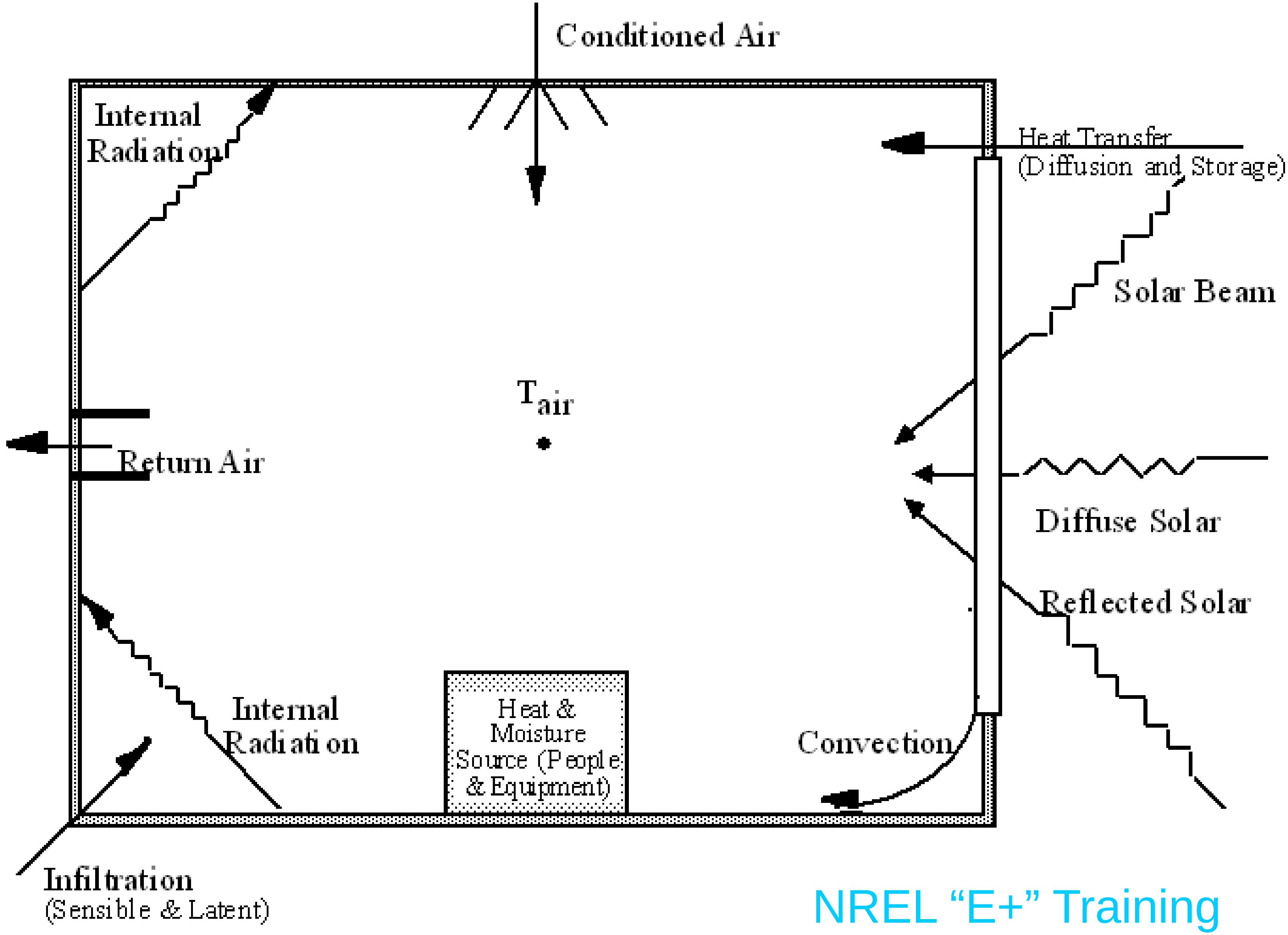
Building Energy: 345 Software Tools

http://www.eere.energy.gov/buildings/tools_directory/

- Whole Building Analysis
  - Energy Simulation
  - Load Calculation
  - Renewable Energy
  - Retrofit Analysis
  - Sustainability / Green Buildings
- Codes & Standards
- Materials, Components, Equipment, & Systems
  - Envelope Systems
  - HVAC Equipment and Systems
  - Lighting Systems
- Other Applications
  - Energy Economics, Atmospheric Pollution, Indoor Air, Training, Ventilation / Airflow, Multibuilding Facilities, Utility Evaluation, Solar/Climate Analysis, Water Conservation, Validation Tools, Misc.

from EnergyPlus Training
by NREL / DOE and
GARD Analytics / Univ of Illinois

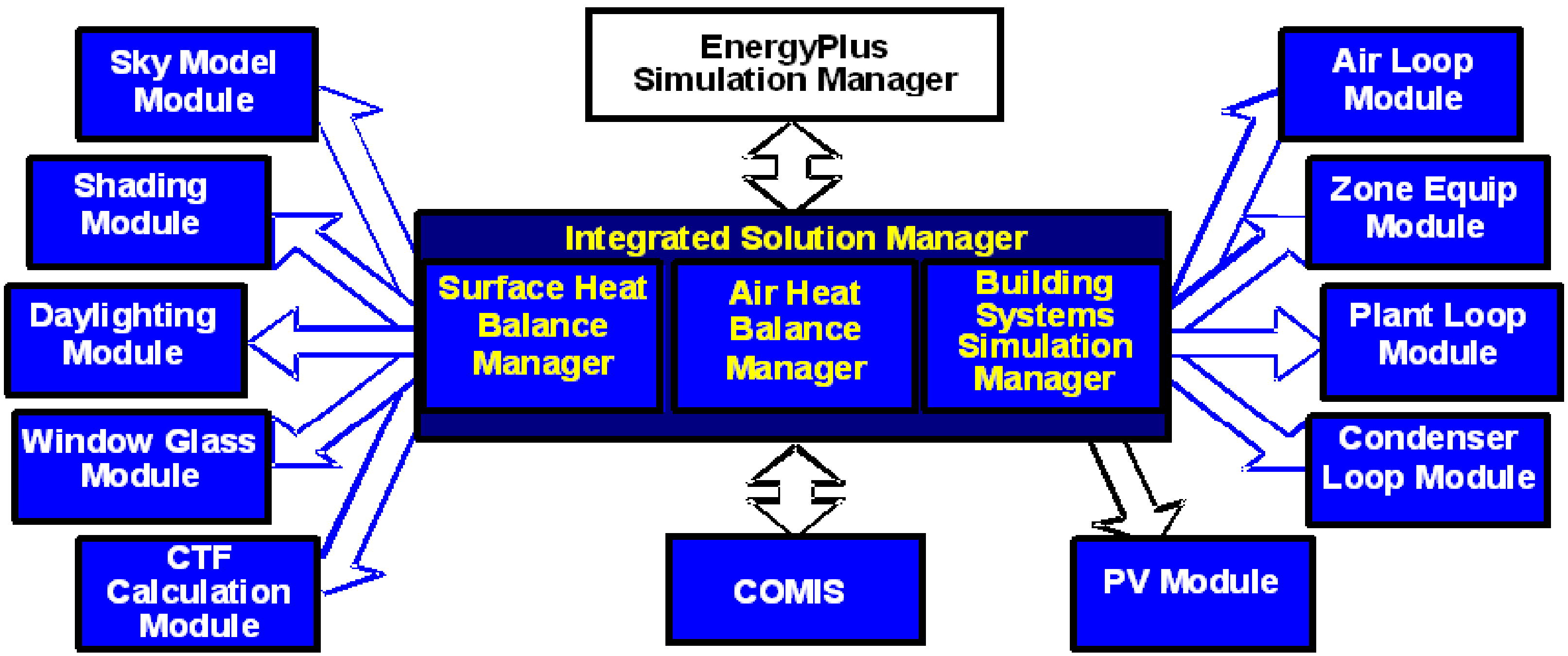




NREL "E+" Training

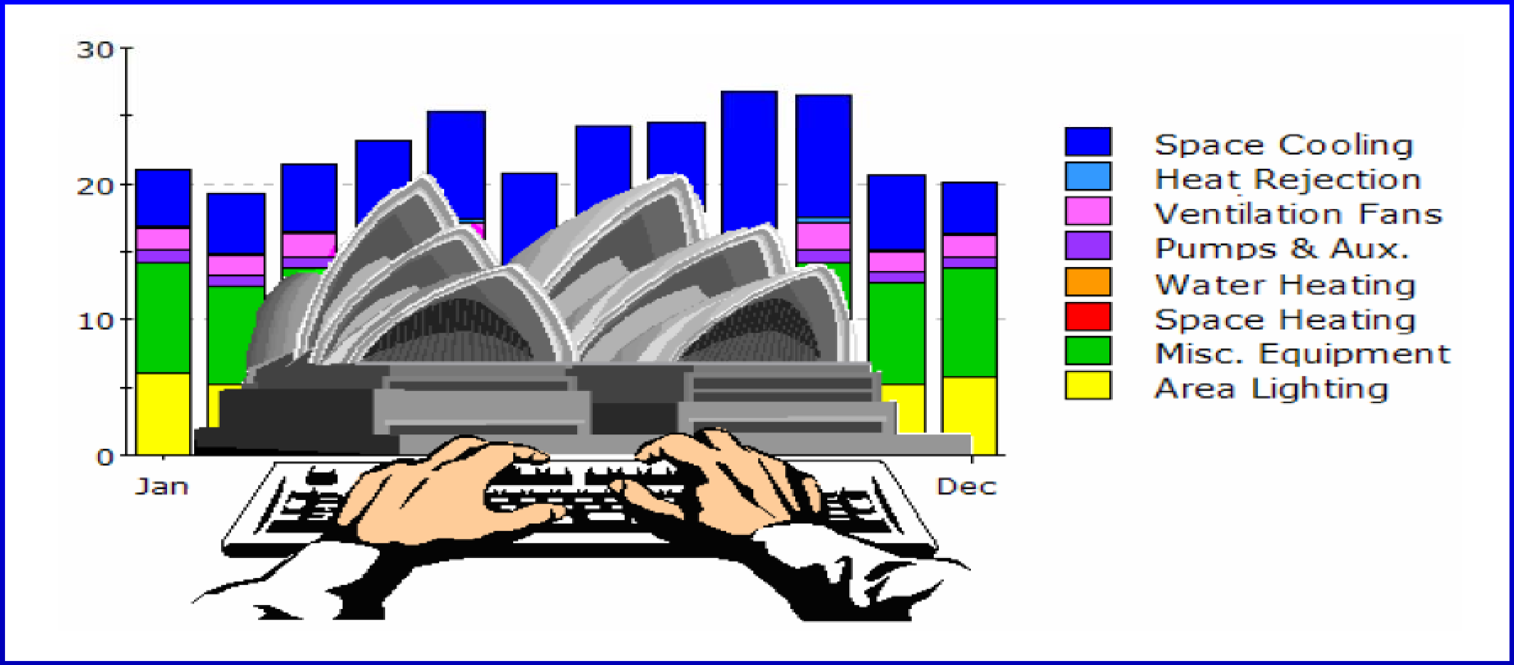
Digital images on this slide courtesy of:
Lisa Fricker, Graduate Student, UIUC

Integrated Simulation Manager (cont'd)



eQUEST from doe.gov

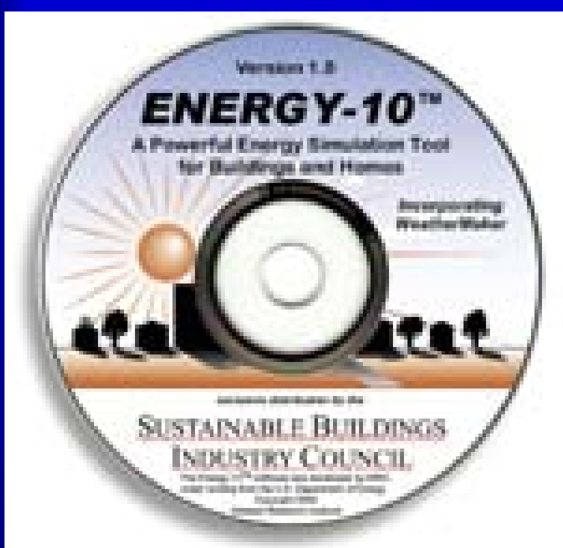
Whole Building Integrated Energy Design



Input: Building Site Info and Weather
Building Shell, Structure, Materials, Shades
Building Operations and Scheduling
Internal Loads
HVAC Equipment and Performance
Utility Rates
Economic Parameters

http://www.sbicouncil.org/store/e10.php

- *ENERGY-10*™ calculates integrated energy performance and is best suited to buildings with one or two thermal zones. The interface is simple, the analysis thorough, and the results accurate and quick. Building types that are most frequently simulated using this software include retail and office buildings, warehouses, schools, restaurants, residences, lodging facilities, and more.



Verification of Energy-10 Simulations

Thesis by Justin Ng Hsing Aik, NCSU 2005

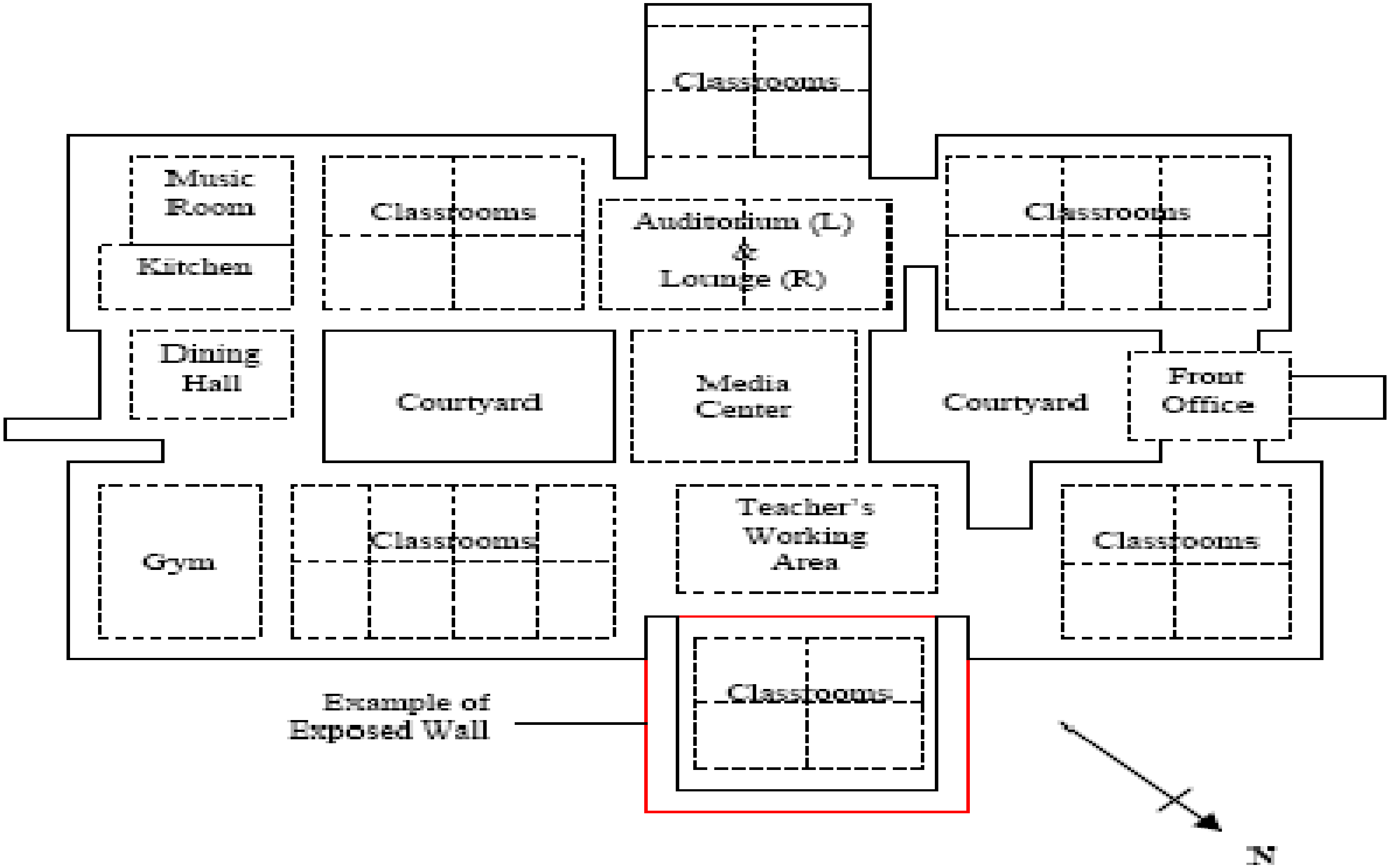


Figure 4.5.1: Current School Design with Exposed Wall

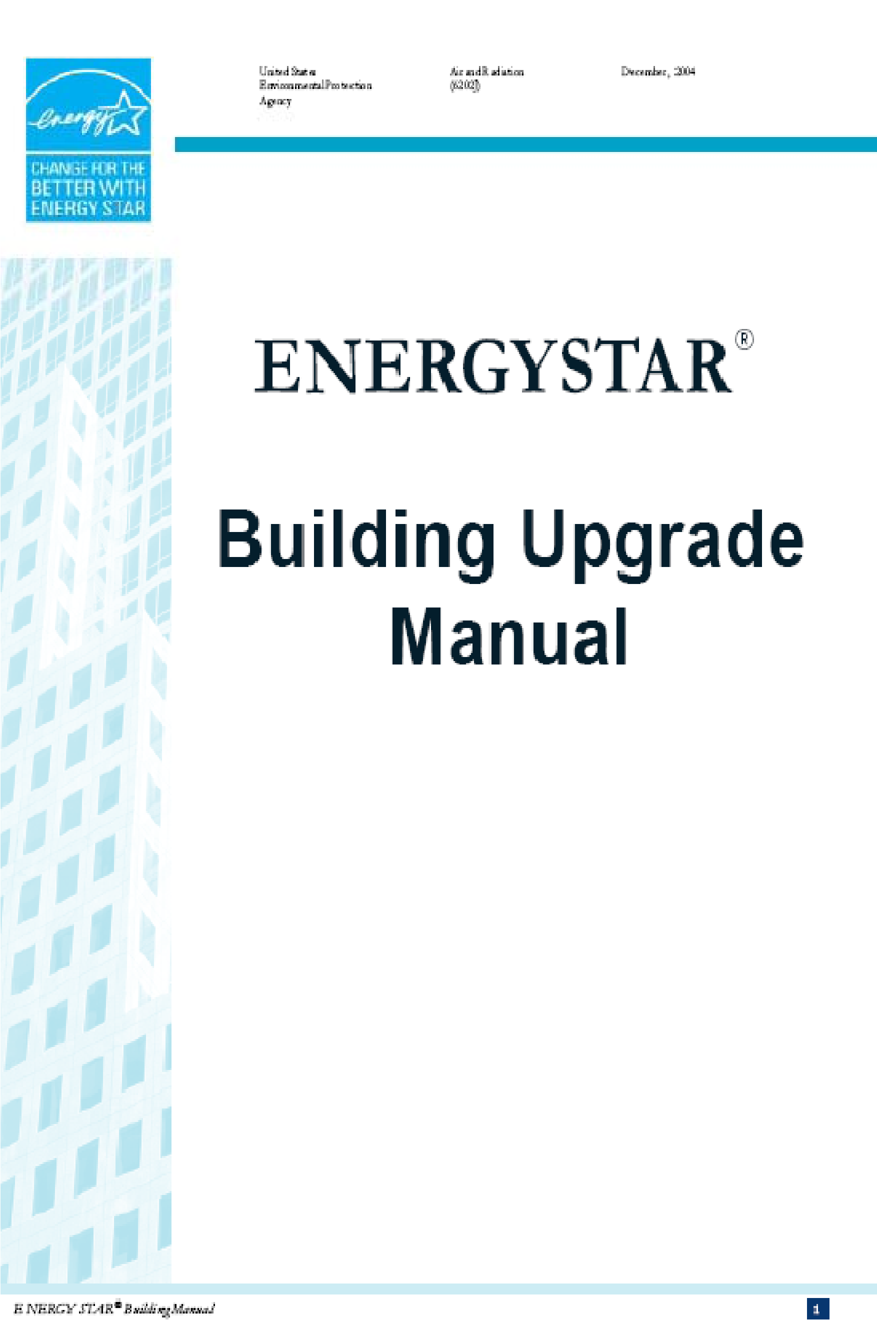
Table 7.0.1: Effects of Various Energy Conservation Measures on Overall School Energy Performance

Energy Conservation Measures	Annual Savings (kWh) / ($)			Implementation Cost	Payback (Months – Unless Noted)	Comments
	For Classrooms 303 and 304	For All 28 Classrooms	For the Entire School			
1. Install high efficiency water source heat pumps	5,669 kWh / $354	79,366 kWh / $4,953	N/A	$97,650 [14]	20 years	Focus of study was primarily on classroom heat pumps. To evaluate all the heat pumps was beyond the scope of this study.
2. Replace T12 fluorescent fixtures with T8 fluorescent fixtures and electronic ballasts	2,178 kWh / $136	30,492 kWh / $1,903	66,792 kWh / $4,168	$9,866	28	These savings represent lighting costs only. An additional 28% can be saved in summer cooling costs.
3. Install an economizer on the heat pump	596 kWh / $37	8,344 kWh / $521	N/A	-	-	Not cost effective.
4. Improved building insulation and envelope sealing	517 kWh / $32	7,238 kWh / $448	N/A	-	-	Not cost effective.
5. Change building design to reduce exterior exposure	451 kWh / $28	6,314 kWh / $394	N/A	-	-	Not cost effective.
6. Utilize temperature setback during the cooling months of April to October	849 kWh / $53	11,886 kWh / $742	27,044 kWh / $1,688	$2,800 [13]	20	This energy conservation measure may be cost effective. Evaluation of other heat pumps is required.
7. Increase ventilation in classrooms to 15 cfm per person (as per ASHRAE Standard 62-2001)	-1,453 kWh / -$91	-20,342 kWh / -$1,269	N/A	Cost prohibitive	An energy loser	Before taking any further action, check the indoor air quality (i.e. check indoor air temperature, relative humidity, CO_2 and CO levels). Consider having an industrial hygienist conduct the first check, before replicating the procedures.

Energy Conservation Measures	Annual Savings (kWh) / ($)			Implementation Cost	Payback (Months – Unless Noted)	Comments
	For Classrooms 303 and 304	For All 28 Classrooms	For the Entire School			
8. Utilize clerestories to provide some daylighting	-32 kWh / -$2	N/A	N/A	-	-	Classrooms 303 and 304 were not oriented to take advantage of daylighting. In general, daylighting is not a technology that can be retrofitted.
9. Eliminate the need for annual carpet cleaning by replacing the existing carpet with alternate flooring	N/A	N/A	95,600 kWh / $5,358	-	-	Carpet cleaning in July requires the school to operate the heat pumps an unusually long period to insure that the carpets are dry and not subject to mold and mildew. In light of increasing energy costs, it is recommended that this drying cost be eliminated by using a different floor covering.
10. Place heat pumps on a timer to eliminate fan and heat pump power during unoccupied periods	6,937 kWh / $433	97,118 kWh / $6,060	N/A	Negligible, since timer is already on-site	Immediate	The savings calculation is based on one mistake per week when the heat pump is left inadvertently operating 24 hours per day.
11. Relocate the computer away from the front of the return air duct	N/A	N/A	N/A	Negligible	Immediate	Placement of the computer in front of the return air duct will affect the volumetric flow rate of the return air, and places an additional load on the heat pump to condition the supply air.

Proposed Measures (School)

Measure	
Upgrade Heat Pumps	No
Install Economizer on Heat Pumps	No
Upgrade T-12 Fluorescents	Yes
Insulate Building Envelope	No
Setback Temp. April-October	Yes
Timer Fan / Heat Pumps - Winter	Yes
Increase Ventilation (15 cfm/person)	Req
Move Computer from Return Air Duct	Yes


ENERGYSTAR®

Building Upgrade Manual

United States Environmental Protection Agency

Air and Radiation (6202J)

December, 2004

CHANGE FOR THE BETTER WITH ENERGY STAR

ENERGY STAR® Building Manual

1

http://www.energystar.gov/index.cfm?c=business.bus_upgrade_manual

(170 pages)

Introduction
Business Analysis
Financing
Recommissioning
Tune-up all systems:
- Lighting & Supplemental Loads
- Building Envelope
- Controls
- Testing, Adjusting, Balancing
- Heat Exchange Equipment
- Heating and Cooling System

Lighting
Supplemental Load Reductions
Fan System Upgrades
Heating & Cooling System Upgrades

The colors shown are approximate and symbolic, not colorimetrically accurate. A colorimetrically-accurate diagram is available.

Some common examples.

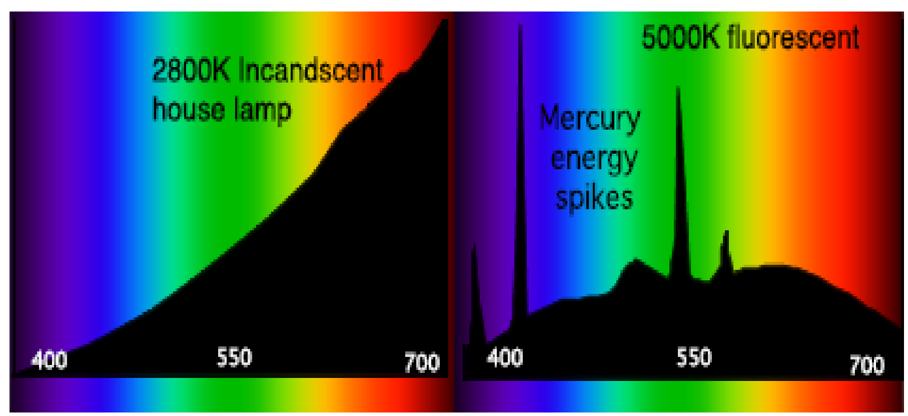
- 1700 K: Match flame
- 1850 K: Candle
- 2800 K: Tungsten lamp (incandescent lightbulb)
- 3350 K: Studio "CP" light
- 3400 K: Studio lamps, photofloods, etc...
- 4100 K: Moonlight
- 5000 K: Typical warm daylight
- 5500–6000 K: Typical cool daylight, electronic flash (can vary between manufacturers)
- 6420 K: Xenon arc lamp
- 6500 K: Daylight°
- 9300 K: TV screen (analog)

The colors of 5000 K and 6500 K black bodies are close to the colors of the standard illumininants called respectively D50 and D65, which are used in professions working with color reproduction (photographers, publishers, etc.).

Spectral power distribution plot

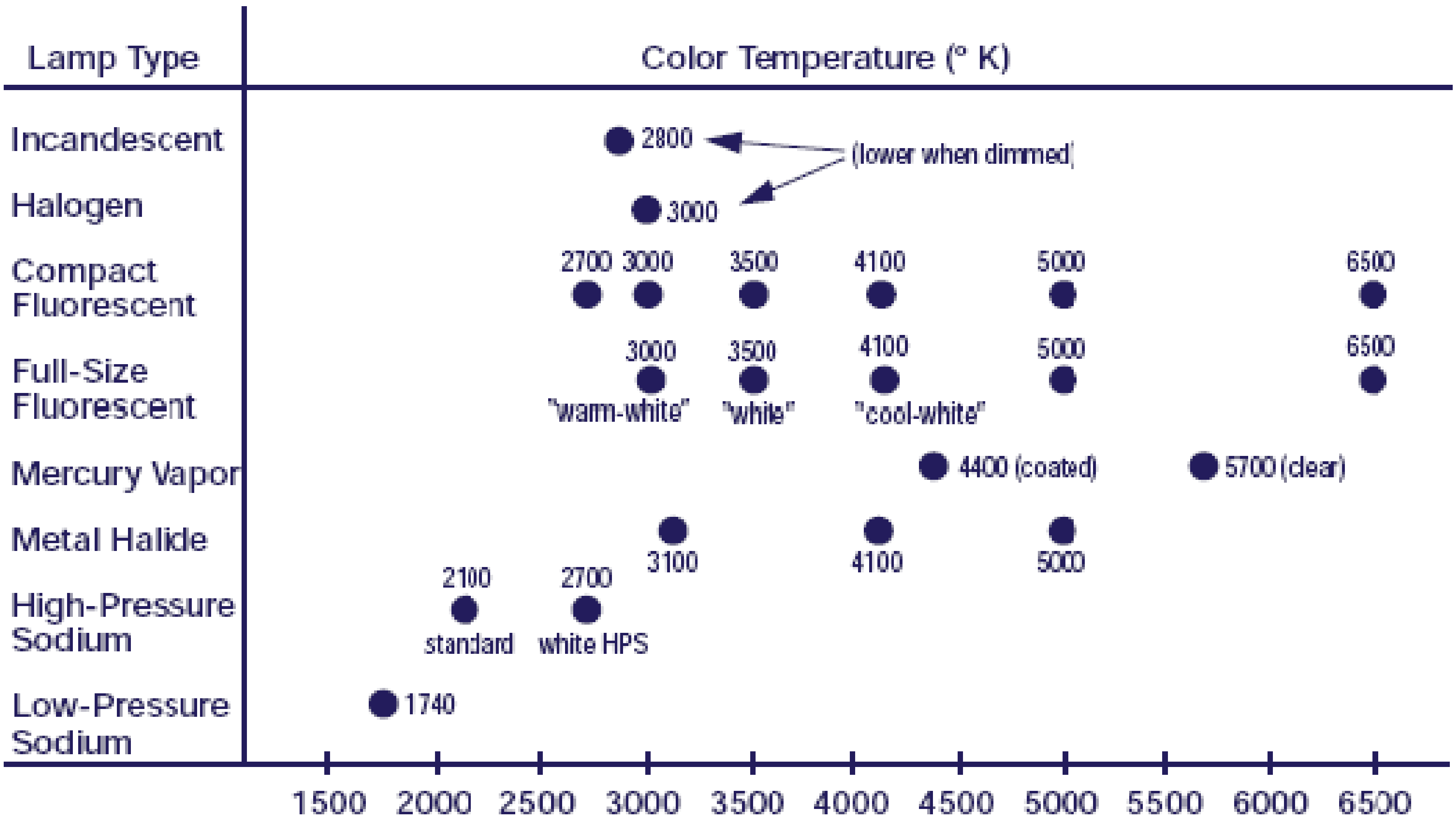
[edit]

The spectral power distributions provided by many manufacturers may have been produced using 10 nanometre increments or more on their spectroradiometer.[citation needed] The result is what would seem to be a smoother (fuller spectrum) power distribution than the lamp actually has. Increments of 2 nm are mandatory[citation needed] for taking measurements of fluorescent lights. Here is an example of just how different an incandescent lamp's SPD graphs compared to a fluorescent lamp.



Color Temperature of Various Light Sources

From Energystar Building Upgrade Manual



Lamp Characteristics

From Energystar Building Upgrade Manual

	Standard Incandescent	Full-Size Fluorescent	Mercury Vapor	Metal Halide	High-Pressure Sodium
Wattages	3–1,500	4–215	40–1,250	32–2,000	35–1,000
System Efficacy (lm/W)	4–24	49–89	19–43	38–86	22–115
Average Rated Life (hrs)	750–2,000	7,500–24,000	24,000+	6,000–20,000	16,000–24,000
Color Rendering Index	98+	49–85	15–50	65–70	22–85
Life Cycle Cost	High	Low	Moderate	Moderate	Low
Source Optics	Point	Diffuse	Point	Point	Point
Start-to-Full Brightness	Immediate	0–5 Seconds	3–9 Minutes	3–5 Minutes	3–4 Minutes
Restrike Time	Immediate	Immediate	10–20 Minutes	4–20 Minutes	1 Minute
Lumen Maintenance	Good/Excellent	Fair/Excellent	Poor/Fair	Good	Good/Excellent


Putting Energy Into Profits:
ENERGY STAR® Guide for Small Business
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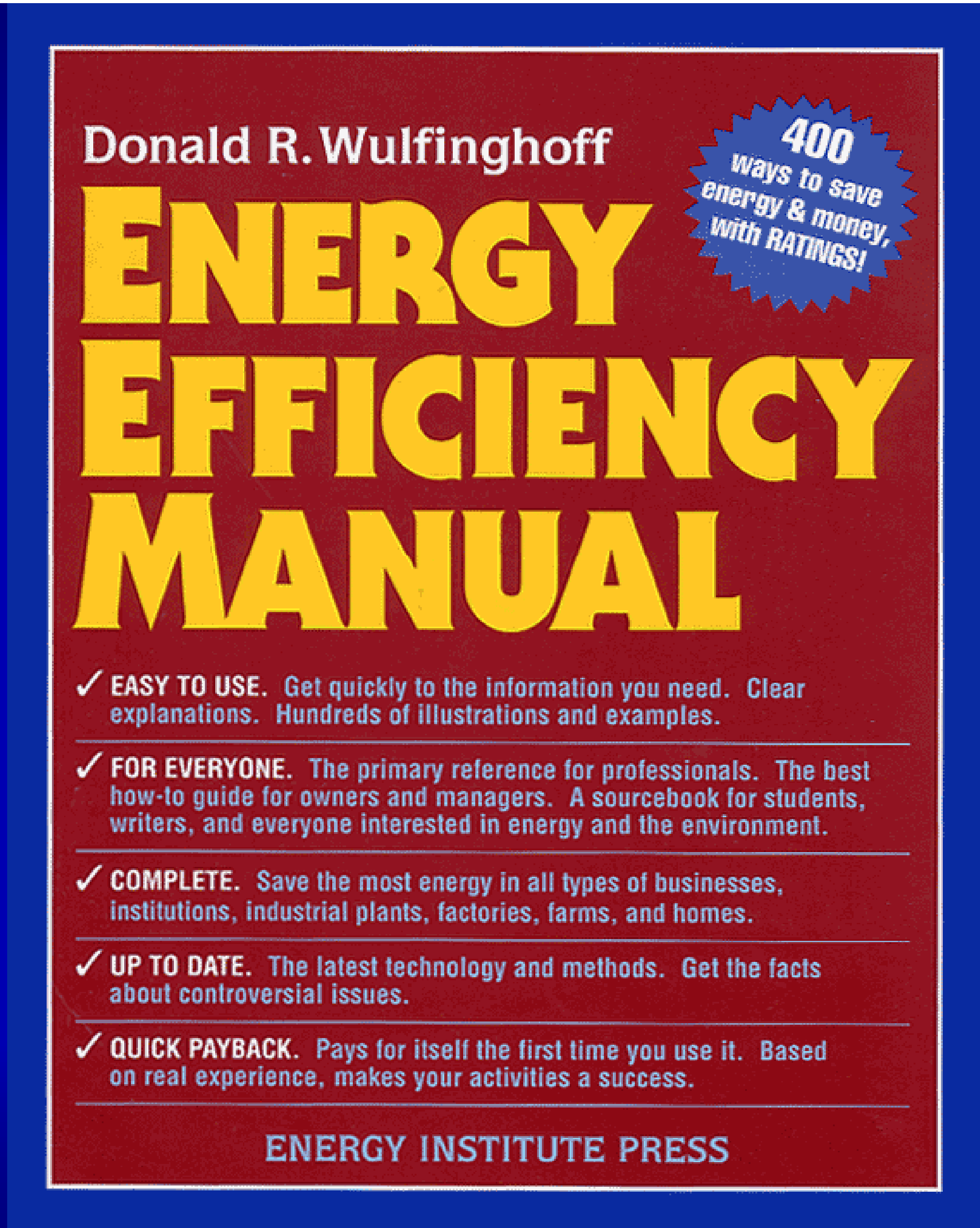
energystar.gov
ENERGY STAR®, a U.S. Environmental Protection Agency program helps us all save money and protect our environment through energy efficient products and practices. For more information, visit www.energystar.gov.


Donald R. Wulfinghoff
ENERGY EFFICIENCY MANUAL
400 ways to save energy & money, with RATINGS!
✓ EASY TO USE. Get quickly to the information you need. Clear explanations. Hundreds of illustrations and examples.
✓ FOR EVERYONE. The primary reference for professionals. The best how-to guide for owners and managers. A sourcebook for students, writers, and everyone interested in energy and the environment.
✓ COMPLETE. Save the most energy in all types of businesses, institutions, industrial plants, factories, farms, and homes.
✓ UP TO DATE. The latest technology and methods. Get the facts about controversial issues.
✓ QUICK PAYBACK. Pays for itself the first time you use it. Based on real experience, makes your activities a success.
ENERGY INSTITUTE PRESS

Wulfinghoff's Energy Manual

Contents — 1500 pages

Boiler Plant	12 topics	200 pages
Chiller Plant	12 topics	200 pages
Service Water Systems	3 topics	100 pages
Air Handling Systems,	9 topics	200 pages
Room Conditioning Units & Self-Contained HVAC Equipment -		100 pages
Building Air Leakage -		70 pages
Building Insulation -		30 pages
Control and Use of Sunlight -		100 pages
Artificial Lighting -		150 pages
Independent Energy-Using Components –		40 pages
Reference Notes -		160 pages

Energy Mgt Tools
Energy Sources
Mechanical Equipment
Building Envelope
Lighting

How Can OTA Help You ?

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Office of Technical Assistance and Technology

Executive Office of Energy and Environmental Affairs

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Improving Energy Efficiency In Motors And Compressor Systems

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Office of Technical Assistance and Technology

Electric Motors

- **According to the DOE process systems with electric motors account for 63% of electricity used in industry and 64% of total electricity consumption**
- **The Energy Policy Act of 1992 set minimum efficiency standards for certain classes of electric motors, which became effective in 1997**
- **In June 2001, The National Electrical Manufacturers Association (NEMA) designating "better-than-EPAct" motors as NEMA Premium™.**

Electric Motors

- **The DOE estimates 600,000 motors >l hp are replaced annually in US manufacturing facilities**
- **Using NEMA Premium motors as replacements could save 62 to 104 billion kWh per year, worth $5-15 billion**
- **Prevent the annual release of 30 million metri ctons of carbon emissions**

Premium Electric Motors

- **Replacing a failed motor with a Premium unit has a straightforward return on investment.**
- **Energy efficiency savings offset the price differential in a short period and continue as long as the motor remains in service. (10 years)**

Premium Electric Motors Economic Example

- **100 horsepower AC induction motor operating at standard SF 0.75 (56 kw)**
- **Two Shift Annual Operating Cost - 4000hr x 56 kw x $0.14/ kwh = $31360**

Premium Electric Motors Economic Example

- **Standard Motor costs approximately $8450   Baldor CM4400T**
- **Premium Motor costs approximately $10427 Baldor CEM4400T**
- **$1977 cost differential**

Engineering Data

Horsepower	Standard Efficiency	Premium Efficiency
5	84.0	89.6
10	**84.0**	**91.1**
15	87.5	91.7
25	90.2	93.0
50	91.7	94.1
100	91.7	95.0
250	94.1	95.8

Electric Motors
Failed 100 hp

- **95.0% - 91.7% = 3.3%**
- **.033 x $31360/yr = $1035/yr. Savings**
- **$1977 cost differential**
- **Premium Motor Payback 1.9 yr, cost savings persist for the life**

Electric Motors
Small Motor Example

- **Changing motors solely for energy conservation is more advantageous with smaller motors.**

- **Ventilation Fan 10 hp motor at SF 1.0 – 24/7 operation at 7.5 kw**

Electric Motors
Small Motor Example

- **Premium $1577 Standard Motor $1280 (OEM choice)**

Engineering Data

Horsepower	Standard Efficiency	Premium Efficiency
5	84.0	89.6
10	**84.0**	**91.1**
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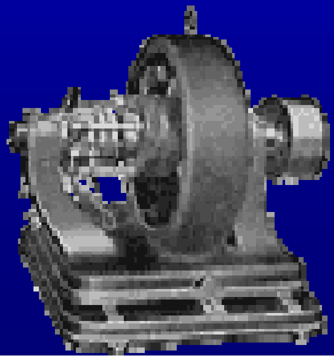
25	90.2	93.0
50	91.7	94.1
100	91.7	95.0
250	94.1	95.8

Electric Motors
Small Motor Example

- **6000 hr x 7.5 kw x $0.14 = $6300/YR**
- **7.1 % Premium efficiency differential saves $450/yr**
- **$1570 Cost, $450 annual savings**
- **Payback 3+ years with 10 year expected life.**
- **Perhaps $2700 cost avoidance over six additional years**

Which motors to Target

- Motors driving variable output where efficiency is often poor.
  - Centrifugal Pumps
  - Hydraulic systems
  - Fans and Blowers
- Motors scheduled for replacement or purchased as spares
- Motors greater than ten years old



Another Option

- **Variable Frequency Drives (VFD)**

- Control the speed and torque of an AC electric motor

- Vary the frequency and/or voltage of the electricity supply.

- AKA Variable Speed Drives (VSDs)

Another Option

- **VFDs** replace inefficient mechanical controls:
- belts and pulleys
- throttle valves
- fan dampers
- magnetic clutches

VFD Advantages

- No friction loss
- No moving parts.
- Instant and precise speed control
- Small size facilitates retrofit
- Gentle startups and gradual slowdowns
- “Soft-Starts” reduce peak loads

- Energy savings up to 20 percent

Compressed Air

- Very convenient and very inefficient utility
- Only 10-15% electrical to mechanical energy yield.
- Widespread use in industry offers potential energy conservation options associated with the motor.
- There are also substantial opportunities in system repair and maintenance.

100 Hp Compressor

- **Change to Premium Motor** Saves
  .033 x $31360/yr **= $1035/yr**

Compressed Air LEAKS

- Leaks are major source of wasted energy in compressed air systems.
- 1 hp yields about 3.5 SCFM at 100 psi
- A “small” leak at 1 scfm costs about **$0.75 a day** (< 1/32” dia = pencil point)
- For 24/7 activity costs $**250/year**
- A plant may have a leak rate of 20-30% of total compressed air production capacity.

100 HP Motor at 75% capacity

- **Change to Premium Motor** Saves
  .033 x $31360/yr **= $1035/yr**

- **A 20% leak reduction** saves
  0.2 x $31360/yr **= $6272 /yr**

- Limited capital investment !

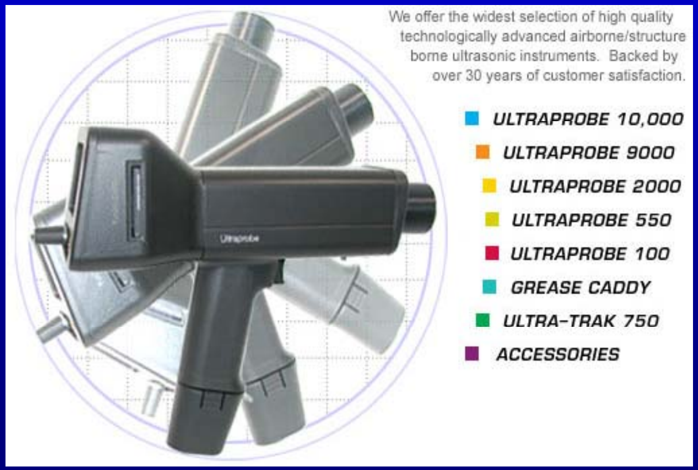
Repair and Maintenance Leaks

- Pipe and Fitting Leaks
- Flexible Hoses
- Condensate Drains- Float and Electric
- Hand tools and guns
- Valve seats and Seals

Leak Detection

- Tour the plant during down time
- Storage tank pressure decay

- Ultrasonic Leak Detectors



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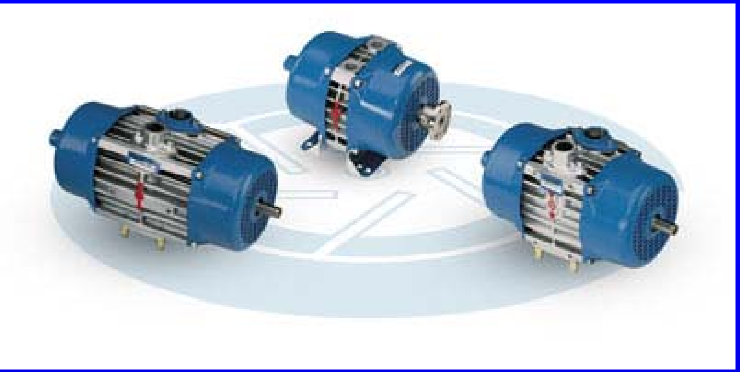
Pressure Drop Inefficiency

- For every 2 PSI above need energy costs rise 1%
- Filters/Separators- saturated or clogged elements cause pressure drop that costs energy
- Corrosion- roughness impedes the flow causing pressure drop.

- Consider other point of use equipment for low pressure applications

Low Pressure High Volume

- Vane Compressors

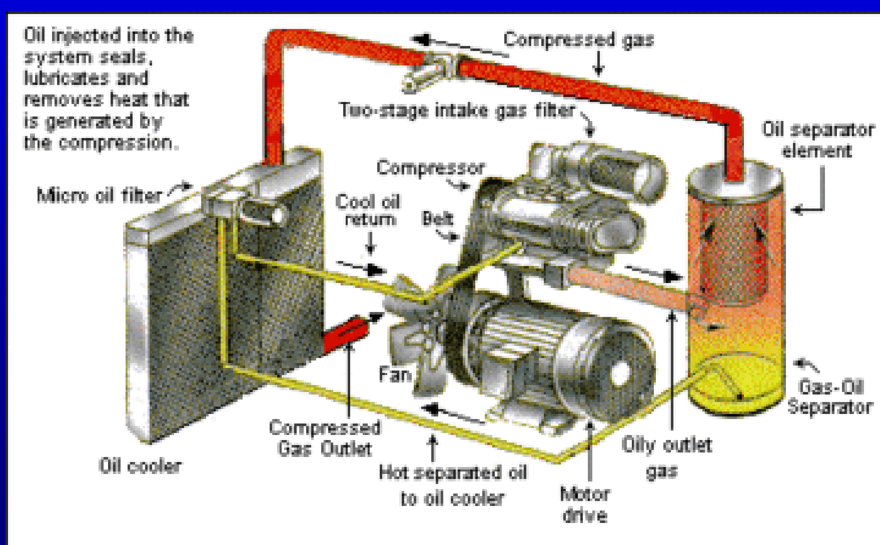


- Regenerative Blowers

- Low Pressure Guns and Nozzles.

Screw Compressors

- For medium pressure
- Load Matching through inlet throttling and VFD speed control



Resources

- U.S. Department of Energy's Motor Challenge Program
- http://www1.eere.energy.gov/industry/bestpractices/motor_challenge_national_strategy.html
- DOE MotorMaster – Retrofit Database (with pricing!)

- http://www.compressedairchallenge.org/

OTA is Here to **HELP YOU**!

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ENERGY EFFICIENCY PUMPS AND FANS

NEWMOA Web Conference on Energy Efficiency
June 3, 2008

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Energy Efficiency
Pumps

- Involve all levels of employees in suggesting pump efficiency improvements
- Conduct an In-Plant Pumping System Survey
- Maintain Pumping Systems Effectively
- Correct inefficiencies in the system

Energy Efficiency
Pumps

Involve all Levels of Employees

Management

Supervisors

Operators

PUMPING SYSTEM SURVEY

The Department of Energy provides a software tool to assess the efficiency of pumping systems called PSAT.

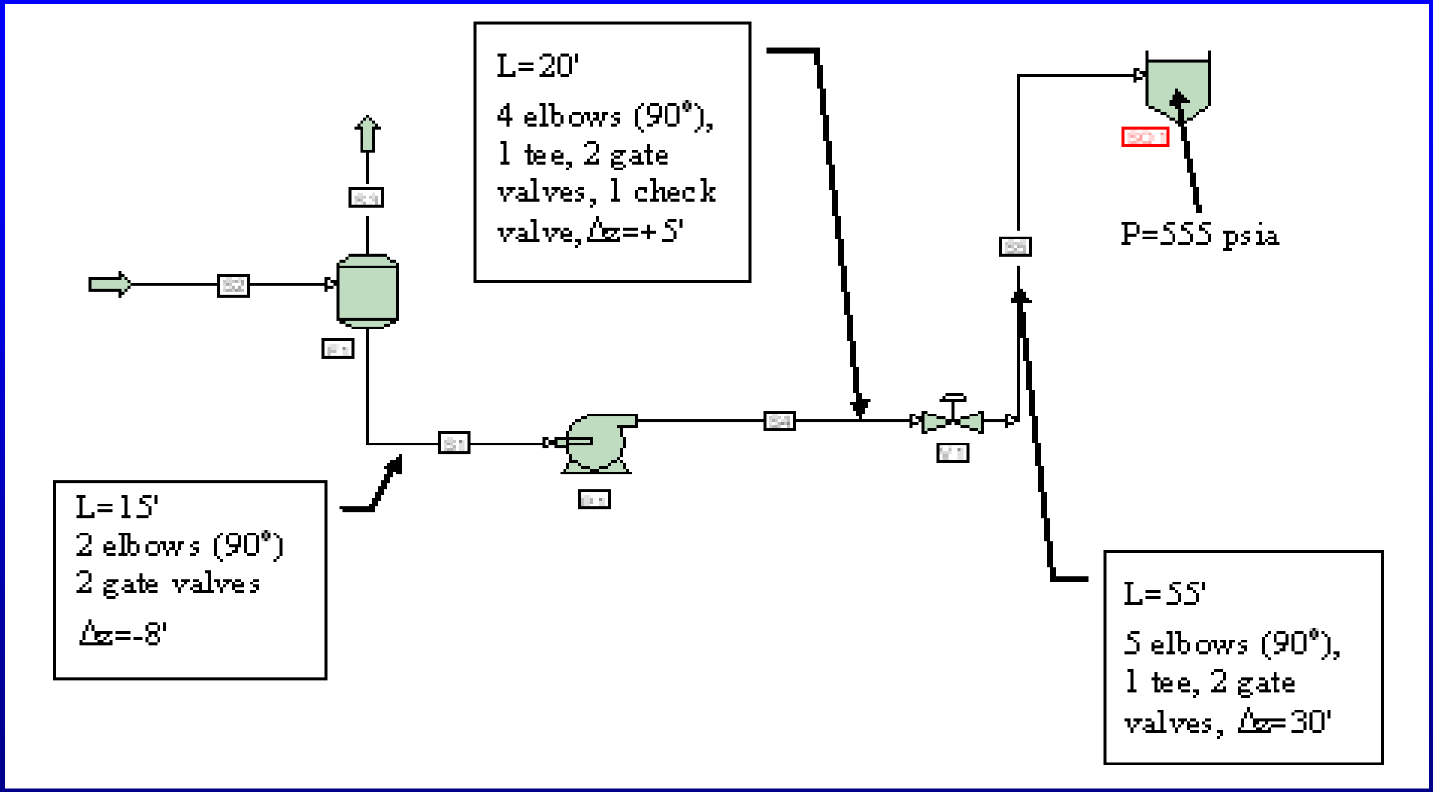
- The DOE has obtained savings using PSAT in the following industries, however, pumps are common to all industries

Industry # of Assessments	Average Energy savings Million BTU/year	Average Annual savings
• Aluminum (2)	1,882,500	$74,000
• Chemicals (1)	1,601,200	$106,000
• Forest Products	4,717,400	$186,500
Mining(7)	9,419,100	$410,700
• Petroleum (2)	1,150,000	$46,000
• Steel (2)	5,787,500	$231,500

Conduct an In-Plant Pumping System Survey, this includes:

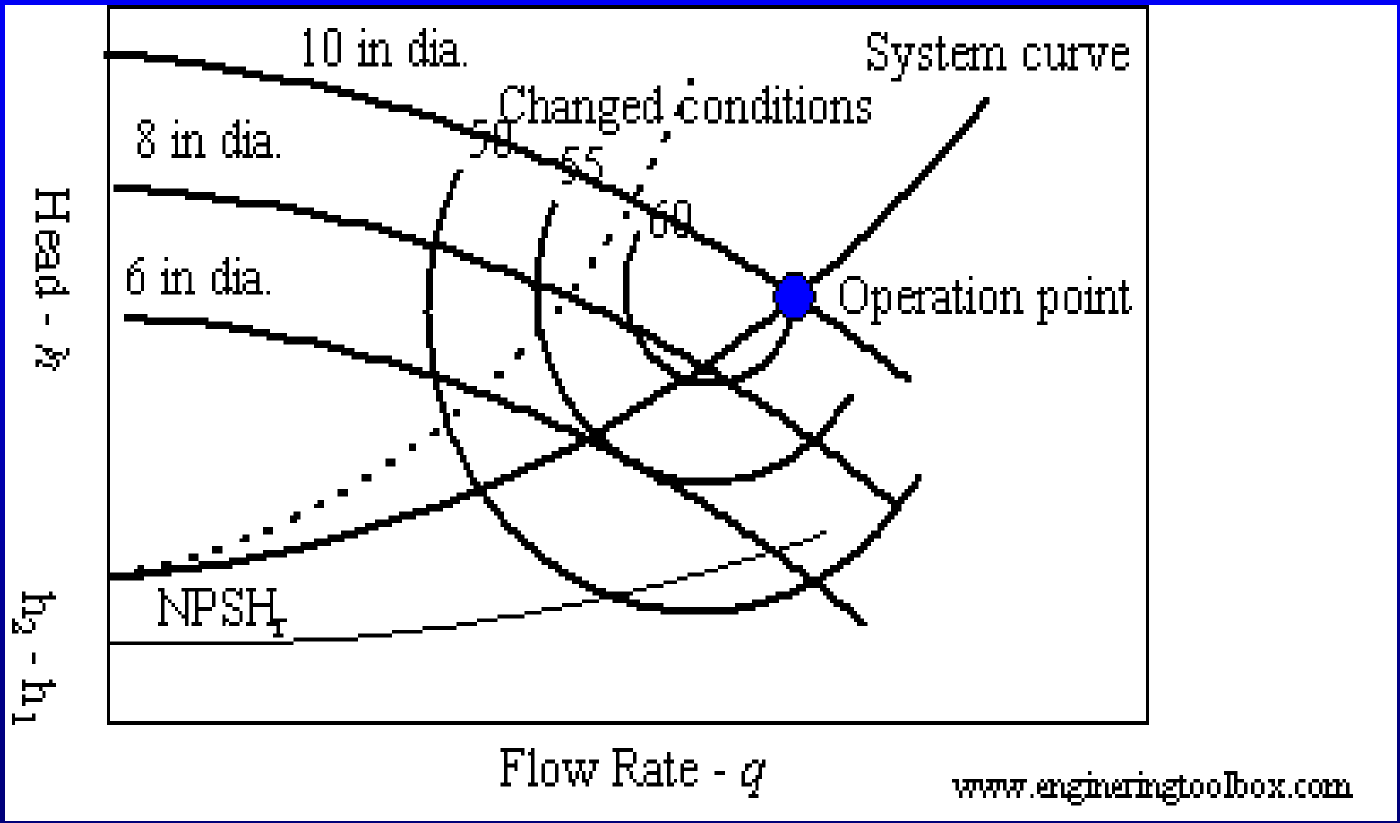
- Develop a system curve by measuring pressure at selected points in the pipe at different flows.
- The selected points include suction and discharge pressures.
- Obtain the performance curve of the pump from the manufacturer if you do not already have it.

SCHEMATIC OF A PUMPING SYSTEM



Energy Efficiency
Pumps

- In-Plant Pumping System Survey, cont'd



In-Plant Pumping System Survey, cont'd

- Find out where the system curve intersects the performance curve.
- This point should be within 20% of the pumps best efficiency point (BEP).
- Average operating flow – check control valve opening.

Energy Efficiency
Pumps

MAINTAIN PUMPING SYSTEMS EFFECTIVELY

- **Packing.**
- **Mechanical Seals.**
- **Bearings.**

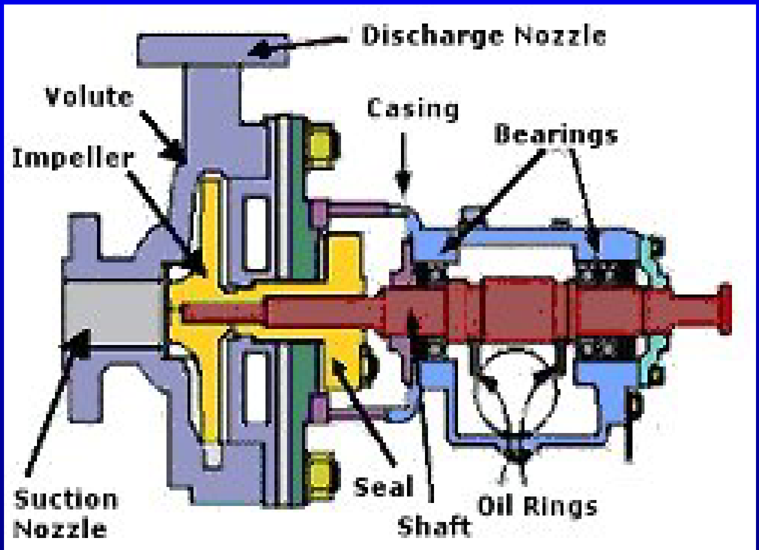


FIG 2

MAINTAIN PUMPING SYSTEMS EFFECTIVELY, cont'd

- **Motor/Pump Alignment.**
- **Motor Condition.**

CORRECT INEFFICIENCIES IN THE SYSTEM

Conduct a detailed review of your plants pumping system if:

- The imbalance between the designed system requirements and the actual (measured) discharged head and flow exceeds 20%

CORRECT INEFFICIENCIES IN THE SYSTEM

A pump may be incorrectly sized if:

- it operates under throttled conditions
- has a high bypass flow rate
- has a flow rate that varies more than 30% from its best efficiency point (BEP).

CORRECT INEFFICIENCIES IN THE SYSTEM

Efficient solutions include:

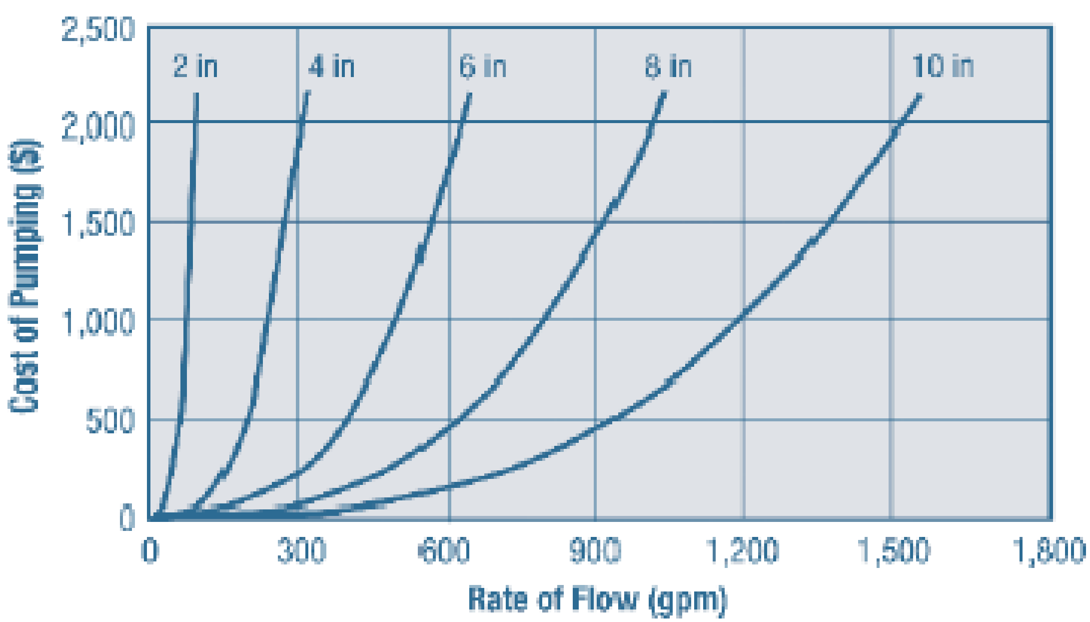
- using multiple pumps by adding smaller auxiliary (pony) pumps
- trimming impellers
- adding a variable speed drive.

Energy Efficiency

CORRECT INEFFICIENCIES IN THE SYSTEM

- Optimize pump sizing

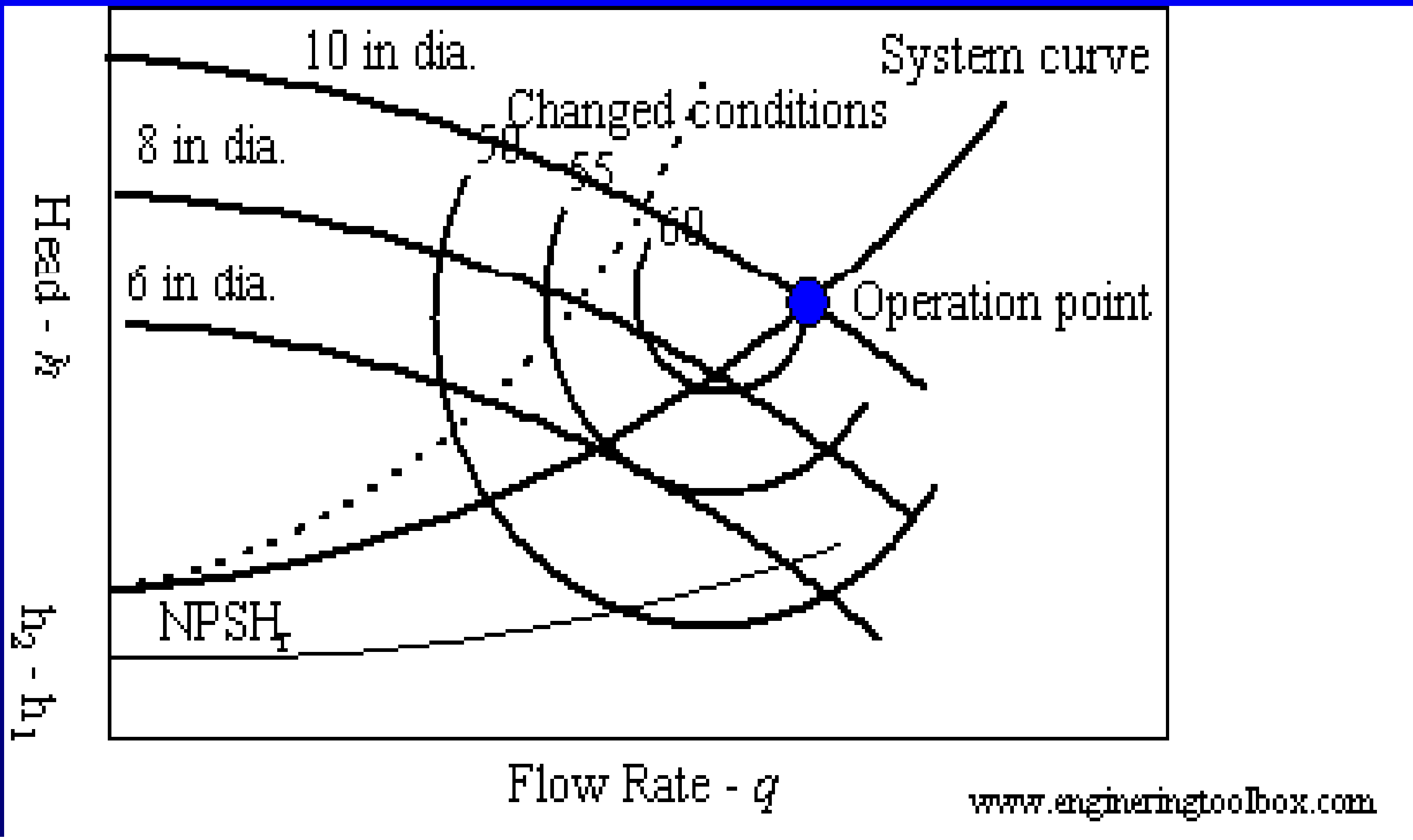
Figure 1. Annual water pumping cost for 1,000 feet of pipe of different sizes



Based on 1,000 ft. for clean iron and steel pipes (schedule 40) for pumping 70°F water. Electricity rate—0.05 $/kWh and 8,760 operating hours annually. Combined pump and motor efficiency—70%.

CORRECT INEFFICIENCIES IN THE SYSTEM

Trim or replace impellers



CORRECT INEFFICIENCIES IN THE SYSTEM

VARIABLE SPEED DRIVE

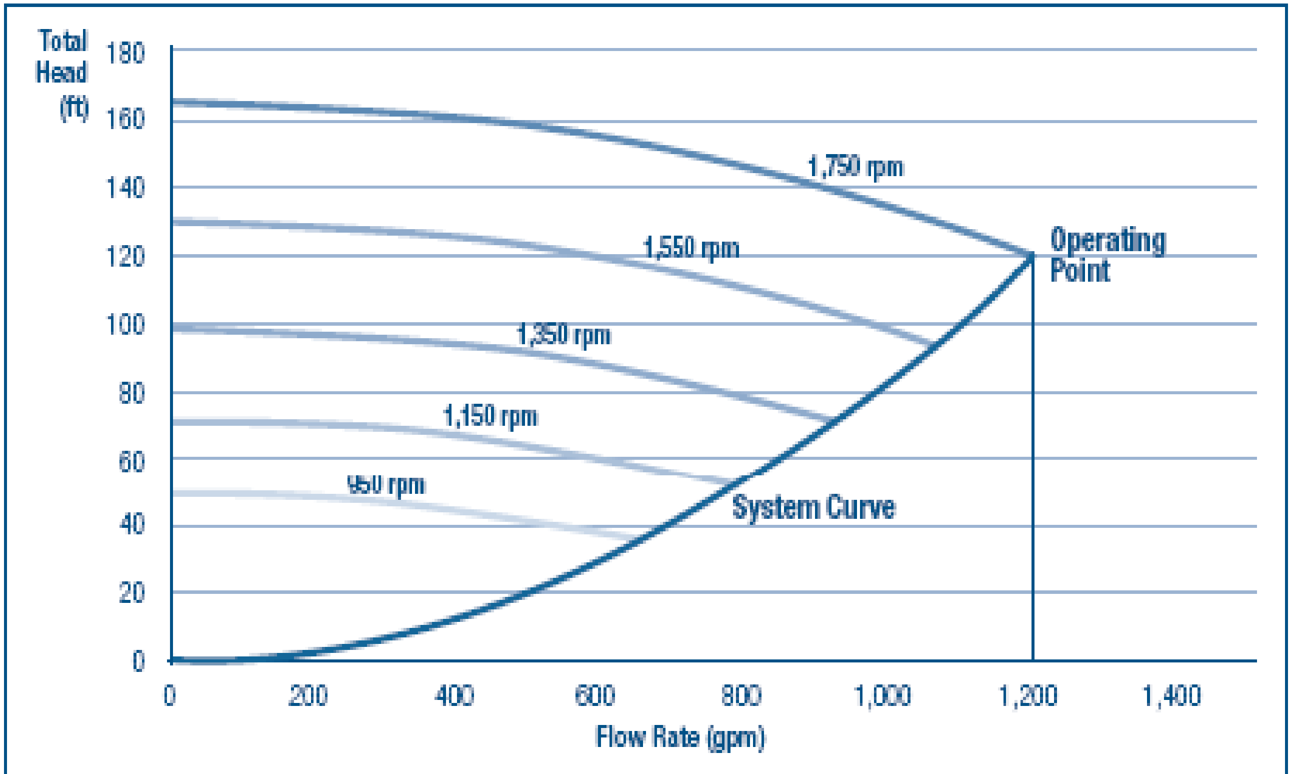


Figure 1. Variation in the centrifugal pump head capacity curve with pump speed

Energy Efficiency - Fans

The Fan System Assessment Tool (FSAT).

- A DOE software tool to assess fan system efficiency
- Quantifies energy consumption and savings opportunities
- Simple and Quick - requires only basic information
- Calculates the amount of energy used; determines system efficiency and savings potential.

Energy Efficiency - Fans

- Perform periodic maintenance
- Ensure proper fan sizing
- Design with inlet and outlet ducts as straight as possible

Energy Efficiency - Fans

- Consider Variable Frequency Drives (VFDs) to improve fan operating efficiency over a wide range of operating conditions
- Maintain proper belt tension and alignment
- Combine fans in parallel or in series where applicable to increase efficiency and reduce costs.

Common Maintenance Tasks Include:

- **Periodic inspection of all system units**
- **Bearing lubrication and replacement**
- **Belt tightening and replacement**
- **Motor repair and replacement**
- **Fan and system cleaning**
- **Check ductwork leaks**

Ensure Proper Fan Sizing
FAN AND SYSTEM CURVES

- **Generate a system curve to determine power consumption.**
- **Obtain the fan curve from the manufacturer.**
- **If the system curve intersects the fan curve at a point that is not near the best efficiency point (BEP), the fan is oversized.**

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Fan Performance and System Operating Point

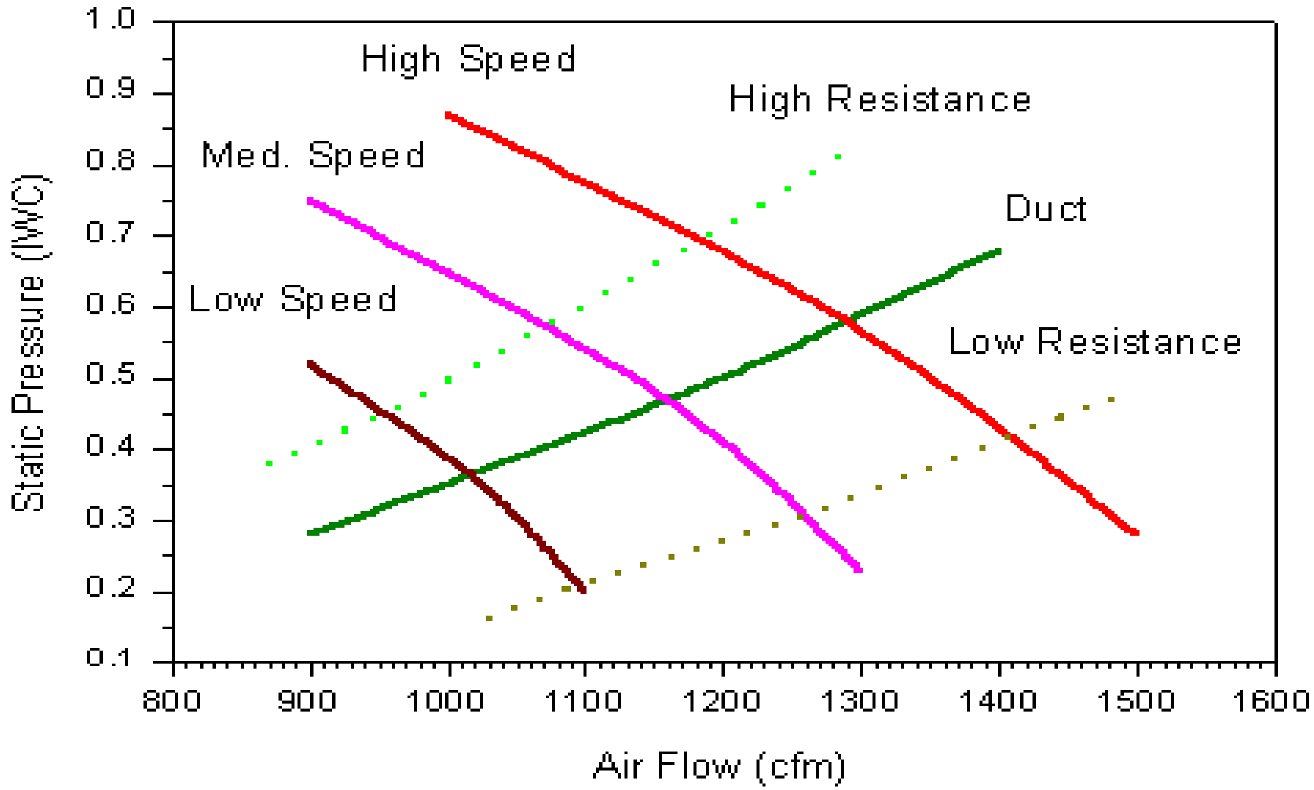


Figure 1. Influence of fan performance and duct flow resistance on system operating point.

Example of Fan System Components

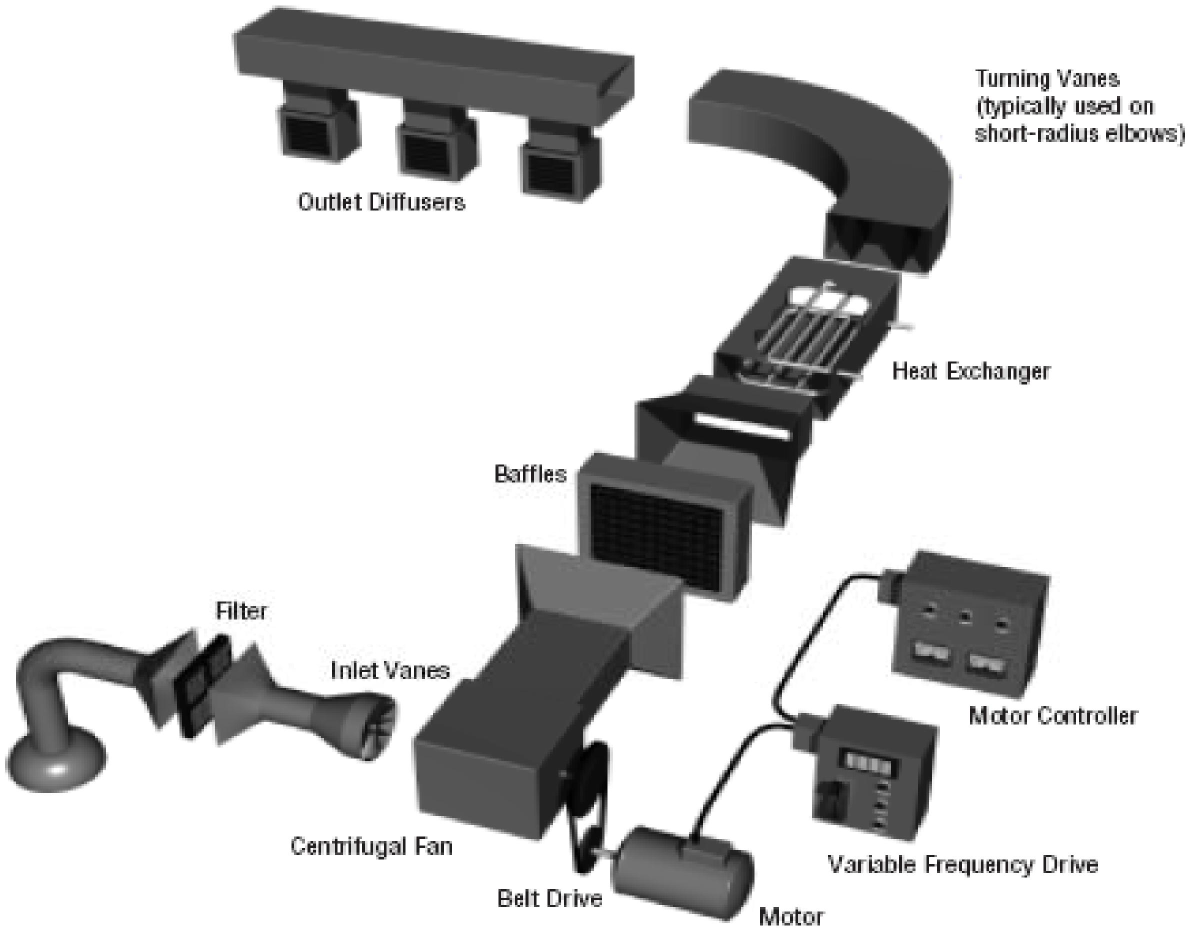


Figure 1-3. Example Fan System Components

VARIABLE FREQUENCY DRIVES

- improve fan operating efficiency over a wide range of operating conditions.
- provide an effective and easy method of controlling airflow.
- are able to retrofit to existing motors.
- eliminate fouling problems associated with mechanical control devices.
- One disadvantage is a low rotational speed risks unstable operation.

SUMMARY

- Energy Conservation for Pumps and Fans must involve all levels of employees.
- Conduct an In-Plant Pump or Fan System Survey
- Correct inefficiencies in the system
- Institute A Preventative Maintenance Program
- There are state and federal agencies that conduct free facility audits to identify areas where energy can be conserved.
- For more information contact OTA at: www.mass.gov/envir/ota or at 617-626-1060

References:

- DOE Pumping Systems TIP Sheets
- http://www1.eere.energy.gov/industry/bestpractices/tip_sheets_pumps.html
- DOE and Hydraulic Institute: Improving Fan System Performance: A Sourcebook for Industry
- Contact Cecile Gordon at 617-626-1092 or cecile.gordon@state.ma.us

To Install or Not to Install: Why Businesses Choose On-Site Renewable Energy

Michelle Miilu
MA Office of Technical Assistance

Energy Efficiency Techniques & Technologies for Environmental Assistance Providers webinar

June 3, 2008

Background

- Renewable energy lead for office
- Concern about low % of manufacturers applying for state grants
- Driving forces and common ground
- Tool to identify good candidates

Information Sources

- Industry organizations
- State funding organizations
- Businesses with on-site renewables
- Industry currently in the installation process

Types of Businesses

- Food processors
- Plastics
- Pharmaceuticals
- Aluminum extrusion
- Semiconductors
- Inverter manufacturer
- Beauty salon

Main Concerns for Those That Install

COST/BENEFIT

ENVIRONMENTAL

Cost/Benefit

- Paybacks typically 5-10 years
- Certainty about future energy prices
- Large energy users minimize or cut costs while growing business
- Stay competitive

Environmental

- Reliance on fossil fuels
- GHG emissions
- Concern for employees
- Positive affect on regional air quality

Technology-Specific Concerns

- Availability of resource
- Structural/roof issues
- Efficiency of technology

On-site Renewable Energy is Not for Everyone

- Struggling businesses
- Low energy prices
- No energy efficiency effort

Upper-level commitment is important

How to Choose the Right Renewable

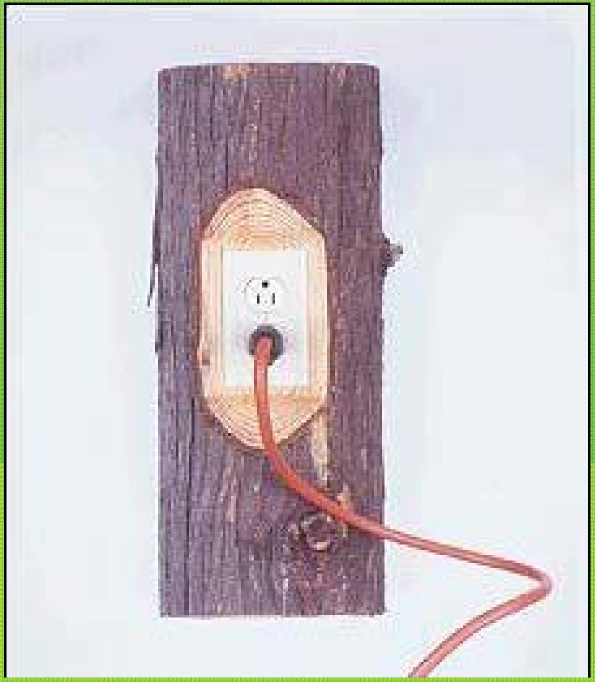
- Availability of resource
- Energy demand of business
- Community acceptance

Good Solar Hot Water Candidates

- Have a relatively large demand for hot water
  - Beauty salons
  - Laundries
  - Food processing
  - Plating
  - Textiles
  - Pulp & paper
- Year around direct sun from 9am-4pm
- Space for installation
- Structurally sound location

Good Biomass Candidates

- Proximity to resource
- Demand for heat
- Sufficient space



Good PV Candidates

- Preferred installation area: flat or SW-SE facing, **structurally sound**, low-cost, minimal obstructions or shading
- If roof PV, where roof will not require replacement soon
- Where surcharges for peak electricity exist

Good Wind Candidates

- 24/7 operations
- >1000ft from nearest residence
- Class 3 or better wind (6.5m/s at hub height)
- On hill tops
- Away from trees, airports, and sandy soil

Fresh Hair - Solar Thermal

- Full service beauty salon
- Considered PV, but too expensive
- Projected 8yr payback
- $9,400 50-60MBtu/yr project, ~3/4 of need
- Tax incentives pay 40%, no grant money
- Pro: Investment in company and environment
- Con: Water out for 1-2 days during installation and a couple hours during annual maintenance

Harbec Plastics - Wind

- Injection molder
- Considered solar, but better wind resource
- Projected 8-9yr payback
- $375K 250kW project, no grants or tax benefits
- Pro: Everyone knows Harbec is environmentally responsible even if they don't know what Harbec does
- Con: Took 13 months to get planning board approval

Bixby - PV

bixby international corporation

- Plastic sheet extruder
- Considered wind, but initial investment too high
- Projected 6-7yr payback
- $345K 51kW project, $257K in tax incentives and state grants
- Pro: A lot of publicity
- Con: Cloudier winter than expected

Things That Renewables Owners Would Change

- Location
- Equipment
  - Type
  - Efficiency
  - Manufacturer
- Sooner!

Other Items That May Concern You

- #1 complaint was that the process took longer than expected
- Except for Fresh Hair, renewables have been completely transparent to production operations
- Everyone said they'd do it again if they had it to do over

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Note to Assistance Providers…

- Many companies pursued on-site renewables as a result of direct outreach!
  - Fresh Hair
  - Bixby
  - Cordis
  - Varian Semiconductor

Questions??

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