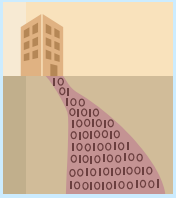


On-Line Fast Track for Energy Managers

Energy Codes and Standards Including
Indoor Air Quality IAQ

Energy Policy Act 1992

- **States must establish more stringent building energy codes**
- **Established minimum efficiency standards for commercial size HVAC equipment, electric motors and lamps**
- **Requested private sector to establish standards for windows, office equipment, and luminaires (if not, DOE would do it)**

EPACT 92 Cont'd

- **Allowed federal agencies to sign long-term performance contracts—up to 25 years long**
- **Required federal facilities to install by January 1, 2005 all energy and water conservation measures with payback periods less than 10 years**

EPACT 2005
Energy Policy Act of 2005

- First major piece of national energy legislation since EPACT 1992. Signed August 8, 2005 by the President, and effective January 1, 2006
- Major thrust of EPACT 05 is energy production
- However, there are many important sections of EPACT 05 that do help promote energy efficiency and energy conservation
- EPACT 2005 has some significant impacts on Federal Energy Management

Why is Federal Energy Management so Important?

- Single largest energy user in US
  - 1.6% of US energy use
  - About $10 billion energy budget
    44% for buildings and facilities (non mobile)
- Single largest product purchaser
  - $6 billion for energy using products, vehicles and equipment
- Federal sector leads by example
- Source for data on this slide - Alliance to Save Energy – Joe Loper 11/05

Summary of Major Energy Bill Provisions Affecting Federal Energy Managers

- 102. Energy management goals
  - Annual energy reduction goal of 2% from FY 2006 - FY 2015
  - Reporting baseline changed from 1985 to 2003
  - Retention of energy and water savings by agencies
  - DOE recommends new requirements for FY 2016-25 by 2014
- 103. Energy use measurement and accounting
  - Electric metering required in federal buildings by 2012

- 104. Procurement of Energy Efficient Products
  - Energy Star and FEMP-recommended products procurement requirement
  - Exception when not cost-effective or meets agency functional requirements
  - Energy efficient specs required in procurement bids and evaluations
  - Requires premium efficient products: electric motors, air conditioning, and refrigeration equipment procurements
- 104 (c) Energy efficient products in Federal catalogs
  - Requires listing of Energy Star and FEMP-recommended products by GSA and Defense Logistics Agency

- 105. ESPCs
  - Reauthorizes ESPCs through September 30, 2016
- 109. Federal Building Performance Standards
  - Buildings to be designed to 30% below ASHRAE standard or International Energy Code if life-cycle cost-effective
  - Application of sustainable design principles
  - Agencies must identify new buildings in their budget request and identify those that meet or exceed the standard
  - DOE must determine cost-effectiveness of subsequent standard revisions within one year

- 111. Enhancing efficiency in managing Federal lands
  - Energy efficiency technologies in public and administrative buildings to the extent practical
- 203. Federal purchase requirement (renewables)
  - Renewable electricity consumption by the Federal government can not be less than:
    - 3 percent in FY 2007-FY 2009
    - 5 percent in FY 2010-FY 2012
    - 7.5 percent in 2013 and thereafter
  - Defines several types of renewables
  - Double credit for renewables
    (1) produced on the site or on Federal lands and used at a Federal facility or
    (2) produced on Native American lands

- 204. Use of photovoltaic energy in public buildings
  - Establishes a photovoltaic energy commercialization program in Federal buildings
  - Issue rules, develop strategies and reports annually to Congress
  - Install 20,000 solar energy systems in Federal buildings by 2010
  - Authorizes funds for the program (not the same as an appropriation)
- 206. Installation of a photoelectric system
  - Authorized funds for a solar wall at DOE's Forrestal Building (not the same as an appropriation)

Tax Provisions for Conservation and Energy Efficiency

- Tax credits for residential solar photovoltaic and hot water heating systems
- Tax deductions for highly efficient commercial buildings
- Tax credits for highly-efficient new homes
- Tax credits for improvements to existing homes including high-efficiency air conditioners and equipment
- Tax credits for residential fuel cell systems
- Tax credits for fuel cell and microturbines used in a business.

An Important Distinction

There is an important difference between a tax deduction and a tax credit. A **tax deduction** is subtracted from income before total tax liability is computed.

On the other hand, a **tax credit** is subtracted directly from the total tax liability. This means that a deduction and a credit have very different values, with a credit being 3 or more times more advantageous to the taxpayer than a deduction.

For example, a tax credit of $1,000 for someone in the 28% tax bracket is equivalent to a tax deduction of $3,571.

Commercial Buildings

- This provision offers business taxpayers a deduction of $1.80 per square foot for commercial buildings that achieve a 50% reduction in annual energy cost to the user, compared to a base building defined by the industry standard ASHRAE/IESNA 90.1-2001.
- Energy costs refer only to heating, cooling, lighting and water heating, since only these uses are within the scope of the ASHRAE standard and within the control of the building designer.
- Each of the three energy-using systems of the building is eligible for one third of the incentive if it meets its share of the whole-building savings goal.

Executive Order 13423

- *Strengthening Federal Environmental, Energy and Transportation Management*
  - Signed January 24, 2007; supercedes earlier related EOs
  - Set more challenging goals than EPAct 2005
- Requires Federal agencies to reduce energy intensity by 3% each year, leading to 30% by the end of FY 2015 compared to an FY 2003 baseline (this goal was given the weight of law when ratified by EISA 2007)
- Requires Federal agencies to reduce water use intensity (gallons per square foot) by 2% each year through FY 2015 (for a total of 16%) based on a water consumption baseline in FY 2007

Energy Independence & Security Act of 2007 (EISA 2007)

(PL 110-140)

- "To move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government, and for other purposes."

EISA 2007 (continued)

- Increased Corporate Average Fuel Economy (CAFE) Standards for passenger vehicles and light trucks
- Targets improved energy security through increased production of biofuels
- Increased energy savings through improved standards for some categories of appliances and lighting products
- Accelerated research on renewable energy and carbon capture and sequestration

EISA 2007 (continued)

- Amended NECPA, requiring Federal energy savings of 3% per year FY2006-2015 relative to a 2003 baseline (ratifying EO 13423)
- Requires comprehensive energy and water evaluations of covered Federal facilities at rate of 25% per year so that evaluations are conducted at least once every four years
- Directs General Services Administration (GSA) to establish a Federal High-Performance Green Building Office
- Extended life cycle cost analysis period for Federal facilities from 25 to 40 years
- Requires metering of natural gas and steam by October 1, 2016
- Permanently authorizes ESPCs in Federal facilities and restricts agencies from limiting duration of ESPCs to less than 25 years

Energy Improvement and Extension Act of 2008

(PL 110-343, Division B)

- Part of the Emergency Economic Stabilization Act of 2008 (commonly referred to in the media as the "Bailout Bill")
- Extends and/or modifies some existing tax credits and deductions
- Establishes electricity as a clean-burning fuel for tax purposes
- Contains new tax credit for plug-in hybrid electric vehicles for less than a year after the first 250,000 are sold

American Recovery and Reinvestment Act of 2009

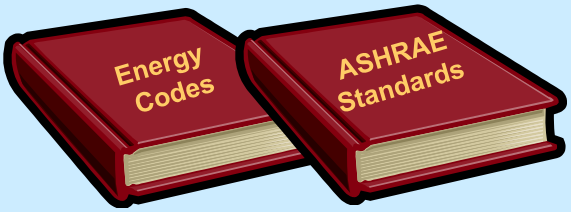
(PL 111-5)

- "Making supplemental appropriations for job preservation and creation, infrastructure investment, energy efficiency and science, assistance to the unemployed, and State and local fiscal stabilization, for the fiscal year ending September 30, 2009, and for other purposes."
- Commonly referred to in the media as the "Stimulus Bill"
- For details and progress, see www.recovery.gov

Tax Provisions as of 2009 for Conservation and Energy Efficiency

- Federal tax credits for energy efficiency include: (see www.energystar.gov for details)
  - Tax Credits for Consumers
  - Tax Credits for Efficient Cars
  - Tax Credits for Home Builders
  - Tax Deductions for Commercial Buildings

Energy Codes and Standards



Energy Codes and Standards

- **Energy codes –** specify how buildings *must* be constructed or perform, and are written in mandatory, enforceable language.
- States or local governments adopt and enforce energy codes for their jurisdictions.
- **Energy standards –** describe how buildings *should* be constructed to save energy cost-effectively. They are published by national organizations such as the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).
- They are not mandatory, but serve as national recommendations, with some variation for regional climate.

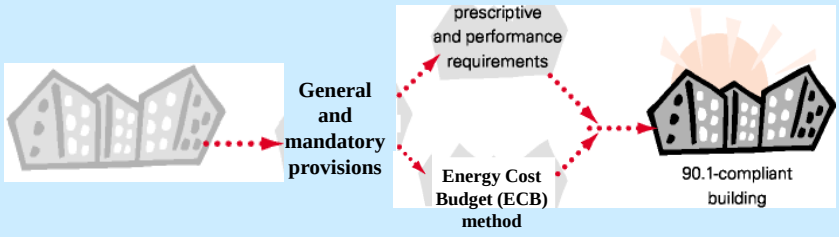
State Building Codes
-Energy Component -

- **Most states use the ASHRAE 90 standard as the basis for the energy component of their building codes.**
  - **ASHRAE = American Society of Heating, Refrigerating, and Air Conditioning Engineers**
  - **ASHRAE 90.1 for commercial buildings**
  - **ASHRAE 90.2 for residential buildings**
  - **Some states had quite comprehensive building codes (e.g. California Title 24)**

- **The requirement for the Federal sector to use ASHRAE 90.1 and 90.2 as mandatory standards for all new Federal buildings is specified in the Code of Federal Regulations - 10 CFR 435.**

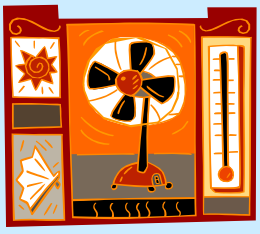
ASHRAE 90.1 Compliance

Courtesy Trane Engineers Newsletter



Significant Parts of ASHRAE 62 - 2007

- Ventilation standard – much more later
- Example for offices in a commercial office building (VRP)
  - Prescriptive -- 17 CFM outside air per person
  - Performance -- Measure CO2 in return ducts of zone and keep CO2 less than 1000 PPM. This is also called Demand Control Ventilation, or DCV.
    - Requires sensors, control system, and active damper.
    - Actually 700 ppm above ambient (300 – 350 ppm)



- States and local governments frequently use *energy standards* as the technical basis for developing their energy codes.
- Some *energy standards* are written in mandatory, enforceable language, making it easy for jurisdictions to incorporate the provisions of the energy standards directly into their laws or regulations.
- The requirement for the Federal sector to use ASHRAE 90.1 and 90.2 as mandatory standards for all new Federal buildings is specified in the Code of Federal Regulations - 10 CFR 435.

The International Energy Conservation Code

- The International Code Council (ICC) publishes and maintains the International Energy Conservation Code (IECC), which is a ***model energy code*** that makes allowances for different climate zones.
- Because it is written in mandatory, enforceable language, state and local jurisdictions can easily adopt the model as their energy code.
- Before adopting the IECC, state and local governments often make changes to reflect regional building practices.

Indoor Air Quality, IAQ
Why Manage it?

ASHRAE 62 - 2001

Indoor Air Quality, IAQ
Why Manage it?

- Occupant Health, Comfort and Productivity
- Corporate Liability & Risk Management
- Compliance with Codes
- Impacts on Energy Consumption & Operating Costs
- Property & Asset Value Management
- Be Able to Deal with Occupant Complaints & Concerns

IEQ in LEED

- Note: Be alert to the LEED Green Buildings' term, Indoor Environmental Quality, IEQ. Although IAQ is a fundamental part of IEQ, it includes other factors such as lighting levels, noise, and controllability of systems. IEQ is much broader in scope than IAQ.

ANSI / ASHRAE Standards Related to IAQ

These describe the basic "Standard of Care" required in buildings.

- ***Standard 62-2007 Ventilation for Acceptable Air Quality***

  Two Alternative Procedures are described:

  Ventilation Rate Procedure

  Air Quality Procedure

Standard 55-2004 Thermal Environmental Conditions for Human Occupancy

ASHRAE Standard 62

Purpose

To specify minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to minimize the potential for health effects.

Definition of Acceptable Indoor Air Quality

Acceptable Indoor Air Quality: air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority, 80% or more, of those exposed do not express dissatisfaction.

Scope of ASHRAE 62 - 2007

- Applies to all indoor or enclosed spaces that people may occupy, except where other applicable standards and requirements dictate larger amounts of ventilation than this standard.
- Considers chemical, physical, and biological contaminants that can affect air quality. Thermal comfort requirements are covered in ASHRAE Standard 55

Method 1: Ventilation Rate Procedure

- **Breathing Zone Rates**

  Prescriptive procedure in which outdoor air intake rates are determined based on space type/application, occupancy, and floor area (see Table 6.1)

  $V_{bz} = R_p \times P_z + R_a \times A_z$

  where V_{bz} = *breathing zone outdoor airflow* (cfm)
  R_p = *people outdoor air rate* (cfm/person)
  P_z = *zone population* (persons)
  R_a = *area outdoor air rate* (cfm/ft^2)
  A_z = *zone floor area* (ft^2)

Example "Minimum Ventilation Rates in Breathing Zone"
Source: ASHRAE 62.1-2007, Table 6.1

(See Standard for complete details and necessary supporting notes for application)

Occupancy Category	People Outdoor Air Rate R_p (cfm/person)	Area Outdoor Air Rate R_a (cfm/ft^2)	Default Occupant Density (#/1000 ft^2)	Default Combined Outdoor Air Rate (cfm/person)
Educational Facilities				
Classrooms (age 5-8)	10	0.12	25	15
Classrooms (age 9 plus)	10	0.12	35	13
Science laboratories	10	0.18	25	17
Lecture classroom	7.5	0.06	65	8
Computer lab	10	0.12	25	15
Hotels, Motels, Resorts, Dormitories				
Bedrooms, living room	5	0.06	10	11
Lobbies/prefunction	7.5	0.06	30	10
Multipurpose assembly	5	0.06	120	6
Office Buildings				
Office space	5	0.06	5	17
Reception areas	5	0.06	30	7
Telephone/data entry	5	0.06	60	6
Main entrance lobbies	5	0.06	10	11

M2: Indoor Air Quality (IAQ) Procedure

- This provides an alternative to the Ventilation Rate Procedure for achieving acceptable air quality while minimizing energy costs.
- The IAQ Procedure provides a direct solution by restricting the concentration of all known contaminants of concern to some specified acceptable levels.
- However, in a sense, the IAQ Procedure puts a "burden of proof" requirement onto the design team that many are reluctant to accept.

ASHRAE Standard 55-2004 Thermal Environmental Conditions for Human Occupancy

This covers several environmental parameters including: temperature, radiation, humidity, and air movement. The Standard specifies conditions in which 80% of the occupants will find the environment thermally acceptable. This applies to healthy people in normal indoor environments for winter and summer conditions. Adjustment factors are described for various activity levels and clothing levels.

ASHRAE 55 – 2004 Cont'd

Important features include:

- A definition of acceptable thermal comfort
- A discussion of the additional environmental parameters that must be considered.
- Recommendations for summer and winter comfort zones for temperature and humidity
- A guideline for making adjustments for activity levels
- Guidelines for making measurements

Certified Indoor Air Quality Professional

The AEE has developed a Certification for a CIAQ Professional. The program objectives are to:

- Raise professional standards of those engaged in IAQ
- To improve the practice of IAQ by encouraging individuals in a continuing program of professional development.
- To identify persons with acceptable knowledge of the principles and practices of IAQ, related disciplines and laws affecting IAQ. This through completing an exam and fulfilling prescribed standards of performance and conduct.
- To recognize IAQ professionals who have demonstrated a high level of competence and ethical fitness for IAQ.

Sample CEM Test Questions

1. The ASHRAE Energy Standard for commercial buildings is:

   A. 55 B. 62.1 C. 90.1 D. 90.2

2. New Federal commercial buildings designed today must meet the requirements of:

   A. 10 CFR 433 B. 10 CFR 434 C. 10 CFR 435

3. What is the default prescriptive combined outdoor air ventilation rate per person in office space in an office building according to ASHRAE 62.1-2007?

   A. 15 cfm B. 17 cfm C. 20 cfm D. varies

4. The ASHRAE Ventilation Code is Standard:

   A. 55 B. 62 C. 90.2 D. 135

5. ASHRAE 62 requires a detailed pollutant study for all commercial buildings for compliance.

   A. True B. False

Conducting an Energy Audit

Initiating An Energy Management Program

Designate an energy manager/energy management team.

Energy managers must have support from top management to get cooperation from the maintenance and operating personnel.

Management must provide support for:

1. **Funding to implement the most cost-effective improvement**
2. **Collecting energy use and cost data**

Dealing With Energy Costs in Overhead

A difficult problem for an energy manager:

Trying to reduce energy costs for a facility when these costs are accounted for as part of general overhead.

Best solution to this problem:

Top management should allocate energy costs down to "cost centers“ in the company or the facility.

Managers then have a direct incentive to control energy costs to improve the overall cost-effectiveness of the production center.

Allocation of Energy Costs for Multi-Tenant Buildings

- **Large buildings are often "master metered" to reduce utility fixed charges and reduce rates.**
- **Each tenant should receive a bill and pay for its own energy consumption.**
- **"Master metering" plus submetering can be an attractive approach.**
- **Utility grade submeters are readily available and cost effective.**

Starting an Energy Management Program

1. **Put administrative and management structure in place.**
2. **Conduct an energy audit.**

   An energy audit (or energy survey) is a study of how energy is used in a facility and an analysis of what alternatives could be used to reduce energy costs.

   - **Use your facility people, utility services, or consultant or ESCO services.**

Goals of the Energy Audit

- **Clearly identify types and costs of energy use**
- **Understand how energy is being used--and possibly wasted**
- **Identify and analyze more cost-effective ways of using energy**
  - **improved operational techniques**
  - **new equipment, new processes or new technology**
- **Perform an economic analysis on those alternatives and determine which are cost-effective for your business or industry.**

Analysis of Bills

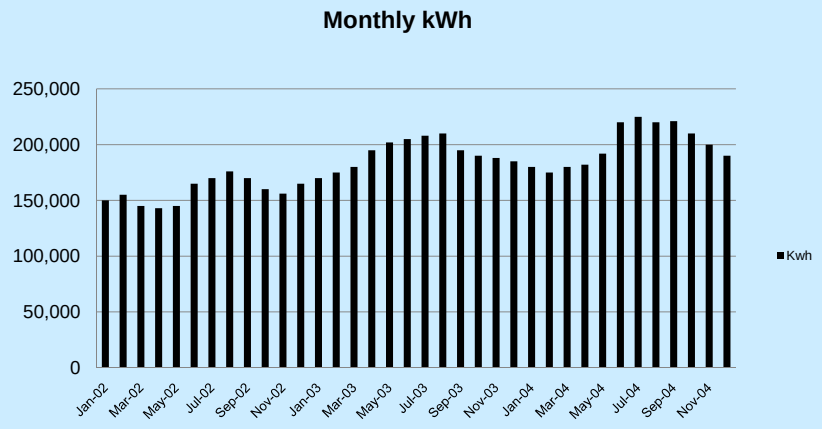
The audit must begin with a detailed analysis of the energy bills for the previous twelve months. This is important because:

- **The bills show the proportionate use of each different energy source when compared to the total energy bill.**

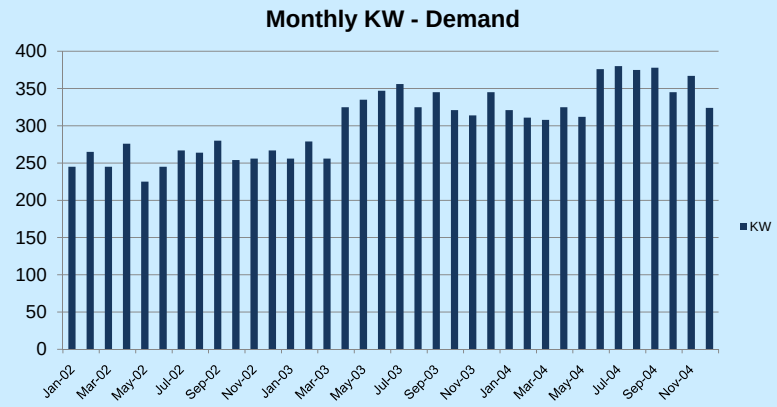
An examination of where energy is used can point out previously unknown energy wastes.

The total amount spent on energy puts an upper limit on the amount of money that can be saved.

Example of Monthly Electric Consumption - kWh



Monthly Electric Peak Demand - kW



Energy Bill Analysis

A complete analysis of a facility's energy bills requires a detailed knowledge of the rate structures in effect for the facility.

To determine accurate costs of operating individual pieces of equipment, separate energy bills into their components.

E.g. demand charge and energy charges for the electric bill.

This breakdown also allows more accurate savings calculations for Energy Management Opportunities (EMOs) such as high-efficiency equipment, rescheduling of some on-peak electrical uses, etc.

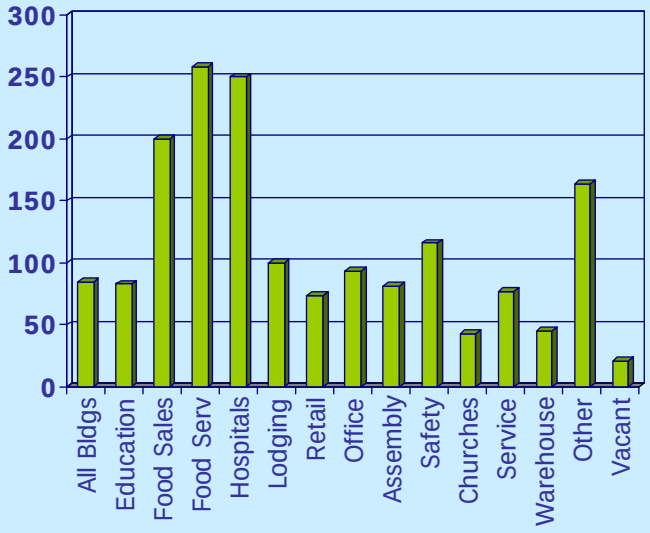
Energy Use Index (EUI)

- Basic measure of a facility's energy performance
- A statement of the number of Btu of energy used annually per square foot of conditioned space
- To compute the EUI
  - Identify all the forms of energy used in the facility
  - Tabulate the total energy in Btu used in the facility
  - Determine the total number of square feet of conditioned space

- The Energy Use Index is the ratio of the total Btu used per year to the total number of square feet of conditioned space.
- A typical office building in the US has an EUI of about 92,900 Btu/square foot/year.
- Food service facilities in the US have the highest average EUI's of over 258,000 Btu/square foot/year.
- Inpatient health care facilities are just under 250,000 Btu/square foot/year.

Energy Use Index for Commercial Buildings

1000 Btu/sq ft/yr (2003 CBECS data)



EUI Computation Example

- An office building has 100,000 square feet of conditioned floor space and uses 1.76 million kWh and 6,500,000 cubic feet of natural gas in one year.
- Convert the electric and gas use into Btu by finding the appropriate conversion factor in the table on pages F-3 and F-4.

- One kWh electric energy is equal to Btu.
- Thus, 1.76 million kWh is equal to

- One CF of natural gas is 1000 Btu, so 6,500,000 CF of gas is equal to

- The EUI is then Btu divided by square feet, and is equal to Btu/square foot/year.

- This value of Btu/square foot/year is larger than the EUI for an average building of 91,000 Btu/square foot/year, and also larger than the average EUI for an office building of 92,900 Btu/square foot/year.

  The EUI has some fairly obvious limitations.

  Problem with mix of fuel and electricity

  Looks only at site energy - not source

  National average information on the Energy Use Index for different types of commercial buildings is shown on the next slide.

2003 CBECS EUI Data
1000 Btu/Square foot/yr

All Bldgs	91.0		
Education	83.1	Vacant	20.9
Food Sales	199.7	Food Service	241.2
Health Care	187.7		
Inpatient	249.2		
Outpatient	94.6		
Lodging	100.0		
Retail Non mall	73.9	Retail – mall	102.2
Office	92.9		
Public Assembly	93.9	Safety	115.8
Churches	43.5	Service	77.0
Warehouse	45.2	Other	164.4

Energy Cost Index

The Energy Cost Index is sometimes used as a simpler and more meaningful measure of energy efficiency.

- The Energy Use Index is somewhat misleading since all Btu are not really equal.
- Electric energy is much higher quality energy than oil or gas, and it costs about three times as much per end use Btu.
- The Energy Cost Index adds up all costs of energy and divides result by total square feet of conditioned space.

Benchmarking Audit

- This audit includes performing a detailed preliminary analysis of energy use and accounting.
- Very cost effective when dealing with many facilities (i.e. – where are the major opportunities for savings, depending on EUI or ECI as compared to other facilities)

Type I – Energy Audit

- This audit includes performing a walk-thru inspection of the facility to identify maintenance, operational, or deficient equipment issues and to also identify areas which need further evaluation.

Type II – Energy Audit

- This audit includes performing economic calculations and may include performing monitoring/metering/testing to identify actual energy consumption and losses.
- ASHRAE level II – energy survey and analysis

Type III – Energy Audit

- This audit includes the performance of computer modeling to determine the actual year round energy consumption.
- ASHRAE level III – detailed analysis of Capital Intensive Modifications

Investment Grade Audit

- This audit includes weighing risk into the economic calculations of a type II or III energy audit. This audit can be utilized to obtain funding for the projects identified.

Benchmarking Audit

- **Benchmarking Audits** are associated with the idea that after the energy bill data is collected and processed, some facility information will be collected on a walk-through, and the data will be run through some benchmark to determine if there is a potential for significant improvement in energy efficiency and reduction in energy operating cost.
- Examples of existing benchmarking programs are EPA's Portfolio Manager, LEED-EB, California Energy Benchmarking, Chevron BM, ARCH, etc.

Benchmarking Criteria

- Energy Cost Index - $/sqft/year
  - Total, Electric, Gas, Oil
- Productivity Index
  - Btu/lb, Btu/person, Btu/student, Btu/ton, Btu/item
  - kWh/lb, kWh/person/ kWh/ton, kWh/item
  - Gal H2O/lb, or /student, or /item (also sewer)
- System performances
  - kW/ton cooling, CFM/HP air, kWh/gal pumping
- Energy Use Index - Btu/sqft/year
  - Total, Electric, Gas, Oil

Example Using Degree Days

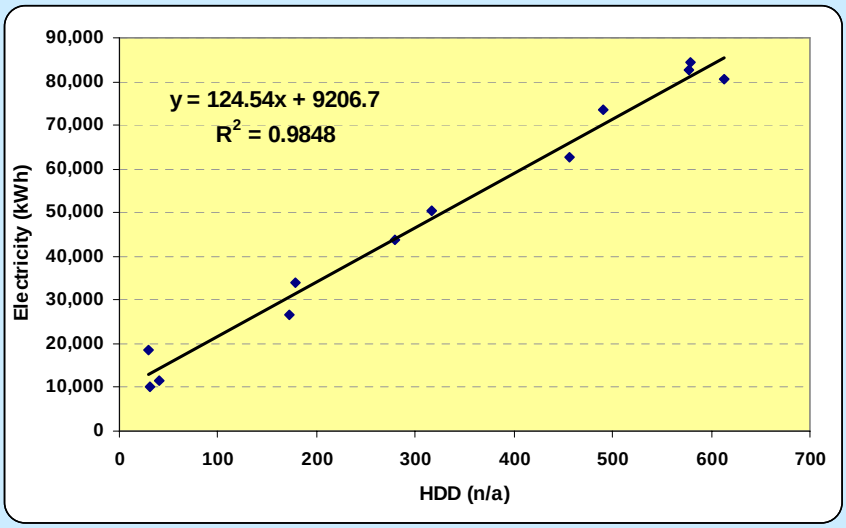
Table 1: Sample Energy Data for a School

Month	Heating Degree Days	Total Electricity kWh
Feb 01	577	82,800
Mar 01	613	80,640
Apr 01	490	73,440
May 01	279	43,920
Jun 01	179	33,840
Jul 01	29	18,720
Aug 01	31	10,080
Sep 01	40	11,520
Oct 01	172	26,640
Nov 01	316	50,400
Dec 01	456	62,640
Jan 02	579	84,240

Use Straight Line Linear Regression

- Y = mX + b
  - Y = kWh of electric use per month
  - X = number of degree days per month
  - m, b are slope and intercept from analysis
- How do you do this?
  - Many calculators can do this
  - Spreadsheet programs like Excel, Lotus,
  - Statistical packages for PCs

School Building



Geographic Location/Degree Days/Weather Data

- Geographic location of facility and weather data for that location are important.
- Obtain average degree days for heating and cooling for that location for the past twelve months from:
  - local weather station,
  - local utility, or
  - state energy office
- Degree-day data is very useful in analyzing energy needed to heat or cool facility.

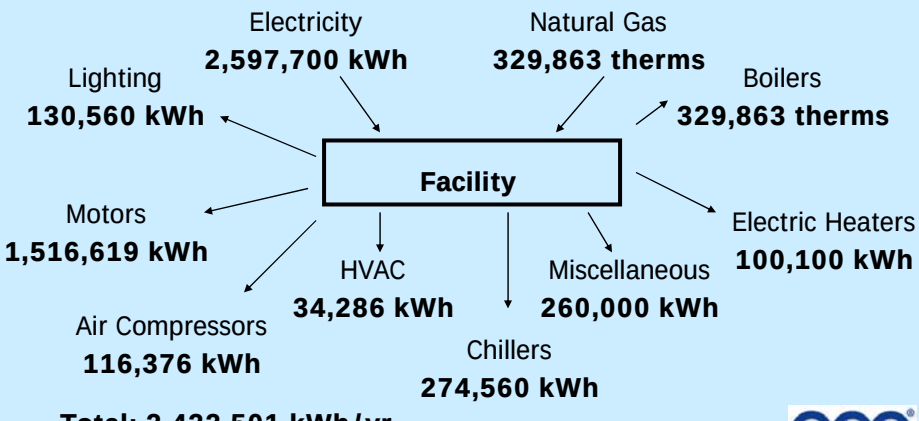
Equipment List

- Get equipment list for facility and review it before conducting audit.
- Identify all large pieces of energy-consuming equipment such as: heaters, A/C units, water heaters, and specific process-related equipment.
- List all major energy consuming equipment, with annual hours of use and energy ratings or efficiencies.
- The equipment list and data on operational uses of equipment provide an understanding of major energy-consuming tasks or equipment at facility.

Nine Major Systems To Consider

1. **Building Envelope**
2. **HVAC System – people comfort**
3. **Electrical Supply System**
4. **Lighting**
5. **Boiler and Steam System**
6. **Hot Water System - domestic**
7. **Compressed Air System**
8. **Motors – that I can see**
9. **Special Purpose Process Equipment**

Energy Balance for a Facility



Tools for the Audit

- **To obtain the best information for a successful energy cost control program, the auditor must make some measurements during the type of energy-consuming equipment audit visit.**
- **The equipment needed depends upon the type of energy-consuming equipment used at the facility, and on the potential EMOs.**
- **For example, for a waste heat recovery EMO, the auditor must take substantial temperature measurement data from potential heat sources.**

Safety Considerations

- **Safety-a critical part of any energy audit**
- **All auditors should have a basic knowledge of safety equipment and procedures**

Preliminary Identification of Energy Management Opportunities

Identifying EMOs requires a good knowledge of energy efficiency technologies available to do the same job with less energy and cost.

During the on-site audit, take notes on potential EMOs that are evident.

General rule: Devote the greatest effort to analyzing and implementing the EMOs that show the greatest savings, and the least effort to those with the smallest savings potential.

The Energy Audit Report

The energy audit report details the final results of the energy analyses and provides energy cost saving recommendations.

The length and detail of this report will vary depending on the type of facility audited.

A residential audit may result in a computer printout from the utility.

An industrial audit should have a detailed explanation of the EMOs and benefit-cost analyses.

Emission Reductions from Energy Savings Data from FEMP BLCC Program

	Electricity lb/KWh	Light Oil lb/gal	Natural Gas lb/therm
CO_2	1.2806	22.3887	11.6426
SO_x	0.0108	0.0309	0.0001
NO_x	0.0055	0.0185	0.0088

Appendix for Conducting an Energy Audit

Degree-days

Heating degree-days (HDD) and cooling degree-days (CDD) are separate values and are specific to a particular geographic location.

The degree-day concept assumes:

1. **The average building has a desired indoor temperature of 70° F.**
2. **5° F of this is supplied by internal heat sources such as lights, appliances, equipment, and people.**
3. **The base for computing degree-days is 65° F.**

Example

Assume a period of three days when the outside temperature averaged 50° F each day.

The number of HDD for this three-day period would be:

HDD = (65-50) x 3 days
= 45 degree-days.

The units of DD are °F days/yr.

Energy Audit Instrumentation

1. Electrical System Performance

Multimeter-Voltage, Amperage

Insulated Gloves

Power Meter – Watts, Vars, VA, PF

Light meter- light levels

Energy Audit Instrumentation (cont.)

2. Temperature Measurements

Thermometer

Surface Pyrometer

Portable Electronic Thermometer

Thermocouple Probe

Energy Audit Instrumentation (cont.)

3. Combustion Measurements

Handheld, microcomputer Combustion Analyzers

to measure

0_2, CO, CO_2, temperature

- **Sometimes SOx and NO_x**
- **No particulates**

Energy Audit Instrumentation (cont.)

4. Air Velocity

Anemometer - Deflecting Vane

Anemometer – Rotating Vane

Pitot Tube

Heated Thermocouple

Hot Wire Anemometer

Energy Audit Instrumentation (cont.)

5. Pressure Measurement

Manometer

Draft Gauge

Bourdon Gauge

Energy Audit Instrumentation (cont.)

6. Humidity Measurement

Psychrometer
Electrical Conductivity
Hand-held units
Hair Hygrometer

Energy Audit Instrumentation (cont.)

7. Infrared Measuring Equipment
The real temperature of an object can be found by measuring its emitted radiation.

Infrared Camera System

Hand-held temperature guns

Energy Audit Instrumentation (cont.)

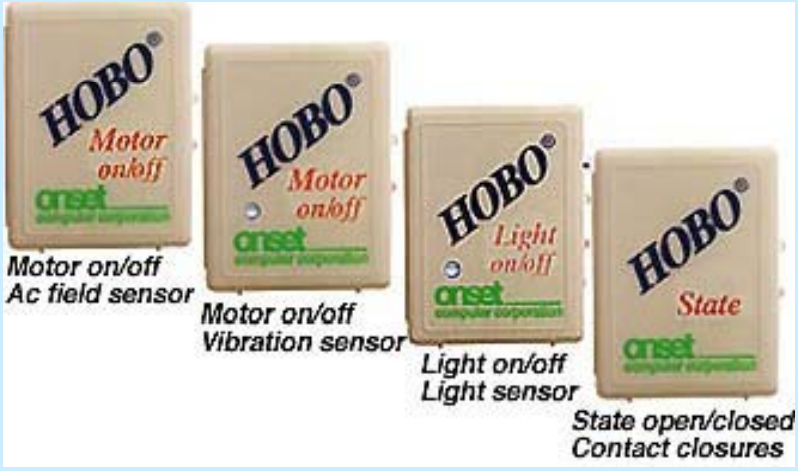
8. Compressed Air Leaks
Ultrasonic Leak Detectors
- **Tunable ultrasonic receivers**

9. Steam Leak Detectors
Ultrasonic leak detectors
- **Use for steam-traps**

Energy Audit Instrumentation (cont.)

- **Mini Data Loggers**
  - **Light on-off**
  - **Motor on-off**
  - **Temperature**
  - **Relative Humidity**
  - **General channel**
    - **Any 0 to 2.5 volt input**

Mini Data Loggers



Energy Audit Report Format

1. **Executive Summary**
   Provides a brief summary of recommendations and cost savings.

2. **Table of Contents**

3. **Introduction**
   Describes the purpose of an energy audit.
   Emphasizes the need for a continuing energy cost control program.

Report Format (cont.)

4. **Facility Description**

   Product or service, and materials flow.
   Size, construction facility layout, and hours of operation.
   Equipment list, with specifications.

5. **Energy bill analysis**

   Utility rate structures.
   Tables/graphs of energy consumptions.
   Discussion of energy costs and energy bills.

Report Format (cont.)

6. Energy Management Opportunities

- **Listing of potential EMOs**
- **Cost and savings analysis**

7. Energy Action Plan

- **Recommended EMOs and an implementation schedule**
- **Designation of an energy monitor and ongoing program**

8. Conclusion

- **Additional comments not otherwise and determine which are cost-effective for your business or industry.**

Sample CEM Test Questions

1. Either a Bourdon gauge or a Pitot Tube can be used to measure air velocity.

   A. True B. False

2. The position of a thermocouple probe makes a big difference in the temperature readings that can be obtained.

   A. True B. False

3. A very good estimate of the real temperature of an object can be found from its emitted radiation.

   A. True B. False

4. Which instrument is used to measure relative humidity?

A. Psychrometer
B. Pyrometer
C. Thermometer
D. Anemometer

5. What instrument would you commonly use to measure the current in an AC circuit?

A. Ohmmeter
B. Ampmeter or ammeter
C. Wattmeter
D. None of the above

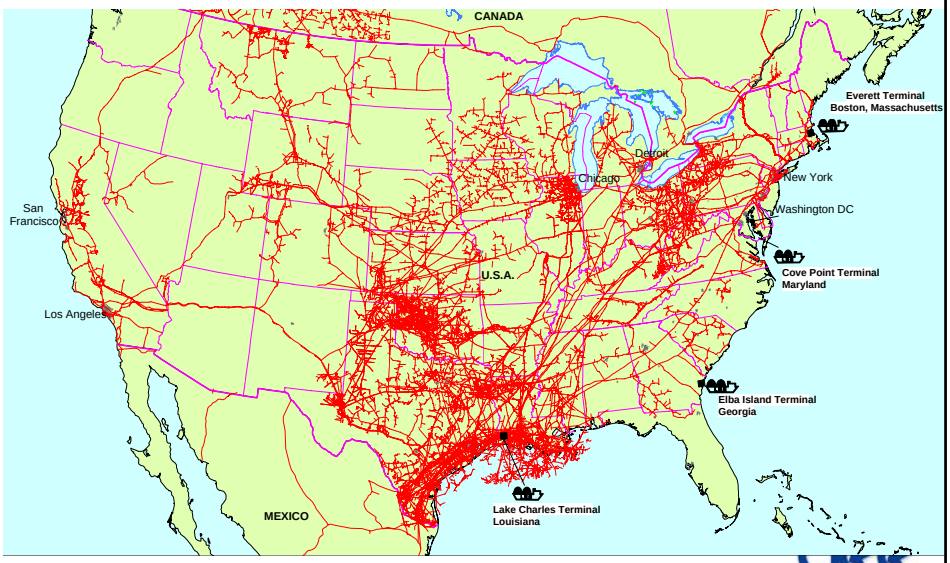
Energy Purchasing

Energy Procurement
-Introduction-

- Procurement of energy (electricity, natural gas, fuel oil, coal, etc.) is becoming a major part of the energy manager's job
- Cost effective energy procurement requires understanding of the market, regulatory limitations and opportunities, and contingency planning
- Optimal energy choice involves many issues including purchase price, contract terms and conditions, availability, environmental impacts, and above all, knowing the level of risk within your organization

Natural Gas

Basic Natural Gas System US

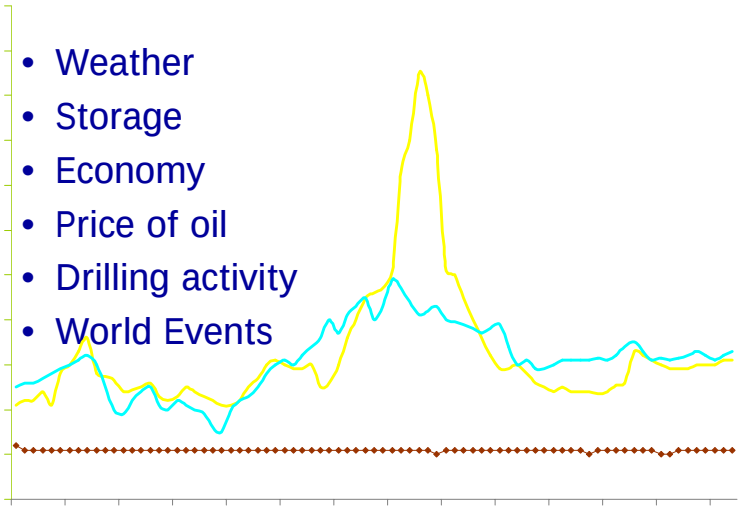


Purchase Opportunities

- Buy from:
  - your LDC at Firm Rate
  - your LDC at Interruptible Rate
  - your LDC Gas Marketing Department
  - Interstate pipeline company
  - non-LDC Gas Marketer
  - Gas Broker
- Must pay any transportation charges
- State regulations may control or prevent some of these choices

Factors Affecting Gas Prices

- Weather
- Storage
- Economy
- Price of oil
- Drilling activity
- World Events



PRICE DISCOVERY OF NATURAL GAS - THE COMMODITY

Today, Futures and Option Contracts are traded on the NYMEX Division of the New York Mercantile Exchange to assist in limiting price risks, as well as providing for price discovery

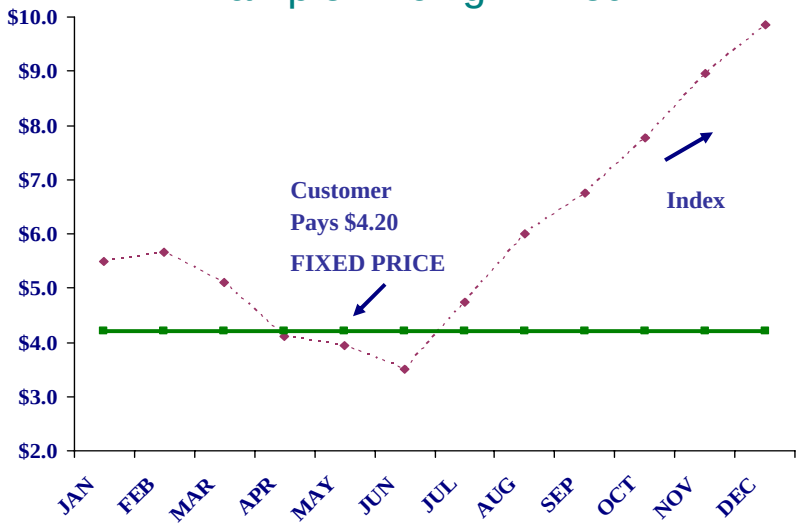
New York Mercantile Exchange - NYMEX

INDEX PRICING METHODOLOGIES

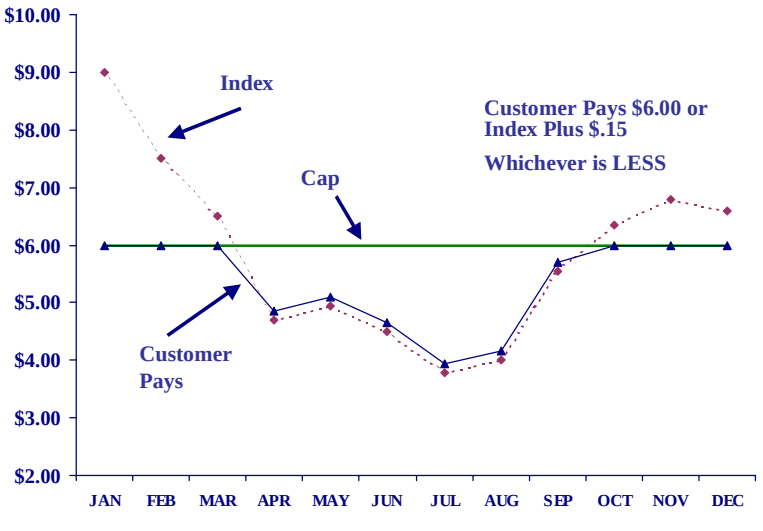
Fixed Index
Index with Floor
Index with a Cap
Index with a Collar

Example Pricing - Index

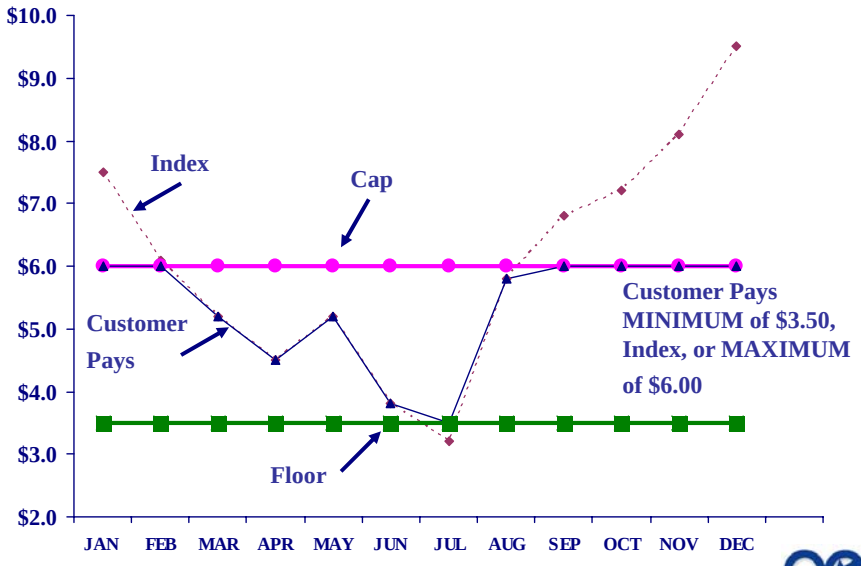
Example Pricing - Fixed



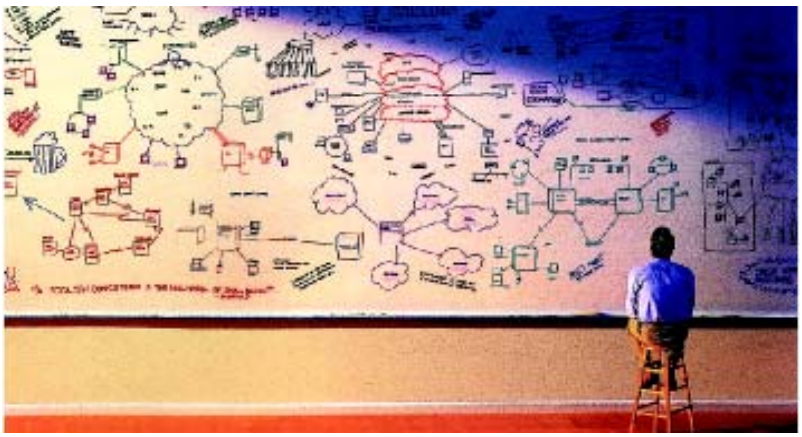
Example Pricing - Index with a cap



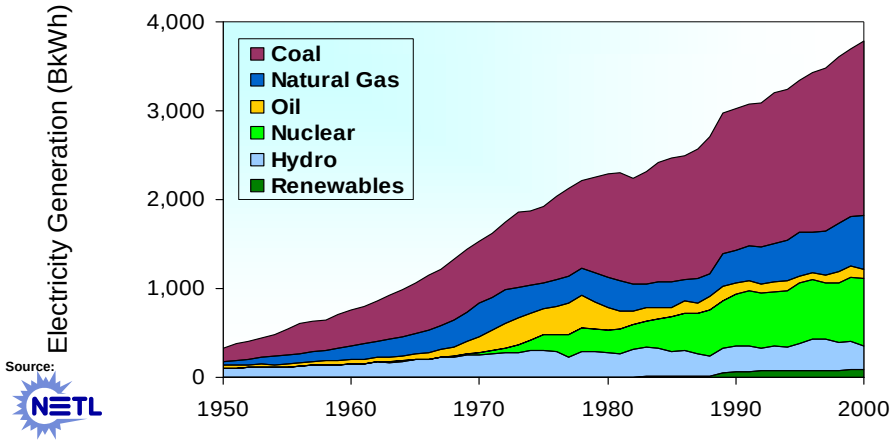
Example Pricing - Index with a collar



Electrical Energy Purchasing



Fuels Used to Produce Electricity

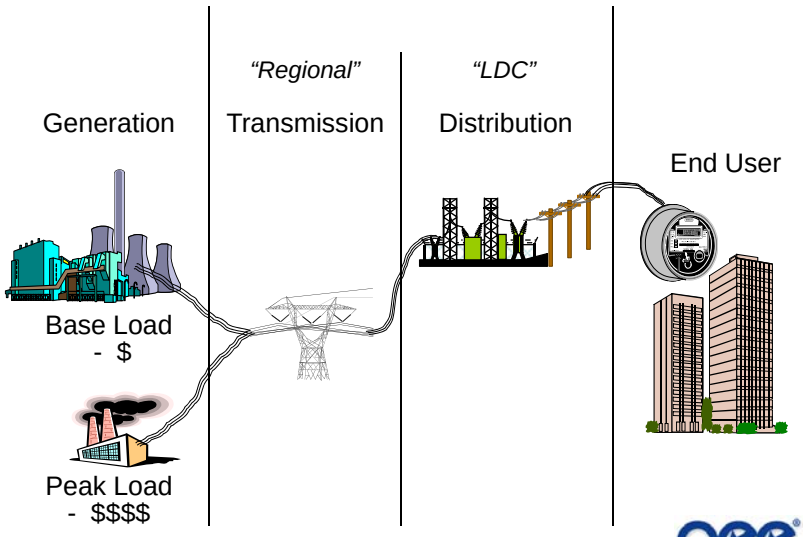


Source: NETL

Public Utility Regulatory Policies Act (1978)

- Defines qualifying facilities (QF's)
- Defines small power producers (SPP's)
- Utilities must buy excess power
- Utilities must provide backup power
- QF's and SPP's are not regulated as utilities
- All rates just and reasonable (avoided cost)
- See Section Q for requirements for QF's and SPP's

Re-regulated Environment



Electric Deregulation

- **Wholesale deregulation**
  - **PURPA (1978) QF's and SPP's**
  - **EPACT(1992) EWG's**
  - **FERC orders 888 and 889**
- **Retail deregulation**
  - **EPACT (1992) - removed the federal prohibition against retail deregulation.**
  - **EPACT (1992) - did not require states to deregulate retail sales; it only allowed states to do it if they wanted to.**

Electric Deregulation Cont'd

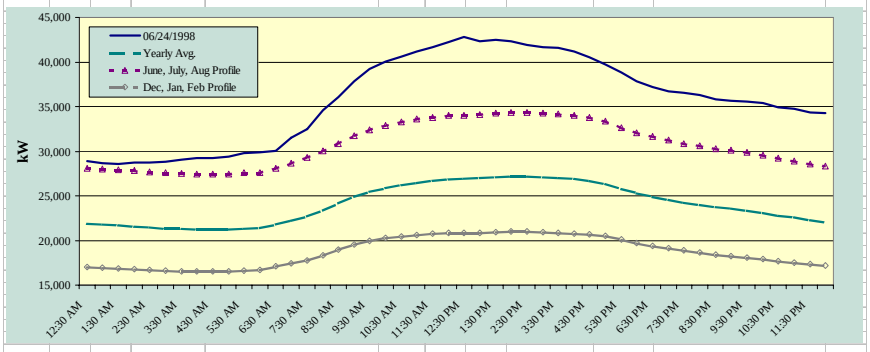
- Thus, retail deregulation is proceeding on a state-by-state basis.
- Some states allow customers to choose their electric power supplier. This is called retail deregulation.

Purchase Opportunities

- Everyone
  - Buy firm power from your LDC
  - Buy interruptible power from your LDC
- Some
  - Buy from Power Marketer (has Title to energy
  - Buy from Power Broker (Does not have Title to gas or Power)
  - Must pay all transmission charges
  - State regulations give other specific charges

Example - Daily Electrical Consumption

06/24/1998 **Wednesday June 24, 1998**



June 24, 1998			June, July, Aug Profile		
Daily Average	35,774	kW	Season Average	30,738	kW
Daily Max	42,764	kW	Average Max	34,699	kW
Daily Load Factor	83.7%	of Daily Maximum Load	Seasonal Load Factor	88.6%	of Daily Maximum Load

April 1998 - March 1999			Dec, Jan, Feb Profile		
Yearly Average	24,116	kW	Season Average	18,737	kW
Yearly Max	42,764	kW (on 6/24/98 at 12:30 pm)	Average Max	21,163	KW
Yearly Load factor	56.4%	of Yearly Maximum Load	Seasonal Load Factor	88.5%	of Daily Maximum Load

What is Demand Response?

Customers reducing their electricity consumption in response to either price or system reliability events,

Customers being paid for performance based on wholesale market prices.

Customers can also, in some case, be paid by their power marketer

Demand  **Supply**

Why Do We Need Demand Response?

Reliability Benefits

- Demand Response is a resource to solve short-run planning and reliability problems.
- 1 MW of Demand Response = 1 MW of Generation

Regional Economic Benefits

- Short-Term: Reduces spot market price spikes
- Long-Term: Reduces price volatility, risk and lowers prices
- Limits Supplier Market Power
- **Gives Customers Control**

Environmental Benefits

Strategic Energy Commodity Purchasing Plan

- Assess Risks
- Determine Risk Tolerances
- Delineate Program Objectives
- Create Budget Setting Methodology
- Establish Procedures
- Design Internal Controls
- Determine Quantifiable Hedge Strategy
- Draft Policy & Procedure Document
- Present Program Senior Management Approval

Point of Use Costs

Higher and Lower Heating Values

- Combustion of hydrogen develops water vapor which raises dew point of stack gas.
- Thus, stack temperature in normal combustion must be kept above dew point.
- Dew point for natural gas is around 175 (250^0F).
- Higher heating value (HHV) counts all the heat – about 1000 Btu/cubic foot for natural gas.
- Lower heating value (LHV) ignores the heat in the water vapor and thus is a lower number – about 900 Btu/cubic foot for natural gas.
- USA uses HHV most of the time (we will use mostly HHV in this class, but LHV is required for calculations to meet QF conditions).

Table E-1: Energy Conversion Units

1 kWh ..... 3412 Btu
1 ft^3 natural gas..... 1000 Btu
1 Ccf natural gas .... 100 ft^3 natural gas
1 Mcf natural gas.. 1000 ft^3 natural gas
1 therm natural gas ..... 100,000 Btu
1 barrel crude oil .....5,100,000 Btu
1 ton coal.....25,000,000 Btu
1 gallon gasoline..... 125,000 Btu
1 gallon #2 fuel oil..... 140,000 Btu
1 gallon LP gas ..... 95,000 Btu

Table E-1: Energy Conversion Units (cont.)

1 HP.....746 watts
1 cord of wood .....30,000,000 Btu
1 MBtu* ..... 1000 Btu
1 MMBtu*.....10^6 Btu
1 therm .....10^5 Btu
1 Quad..... 10^{15} Btu
1 MW** ..... 10^6 Watts

1 Boiler HP .....33,475 Btu/hr

Note:
* In English units, M = 1,000
** In SI units, M = 1,000,000

Point of Use Cost

- True cost or “point of use” (POU) cost depends on purchase price and efficiency of use
- All energy sources can be compared with POU for each converted to some base measure (therm, million Btu, kWH, etc.). We will use million Btu as the common unit to start with.
- POU = (purchase price per common unit)/efficiency of use

Point of Use Cost Example

The steam boiler for a facility can operate on natural gas or oil. Using natural gas at $0.95 per therm, the boiler is 75% efficient. Using oil at $2.50 per gallon and 140,000 Btu per gallon, the boiler is 78% efficient.

Which fuel source provides the lowest operating cost?

Solution:

Select 1 MMBtu as the common unit of steam output.

$$POU_{gas}\ \frac{\$}{MMBtu} = \frac{\$0.95}{therm}\left|\frac{1\ therm}{100{,}000\ Btu}\right|\frac{1{,}000{,}000\ Btu}{MMBtu}\left|\frac{1}{0.75}\right.$$

$$= \$12.67/MMBtu$$

$$POU_{oil}\ \frac{\$}{MMBtu} = \frac{\$2.50}{gal}\left|\frac{1\ gal}{140{,}000\ Btu}\right|\frac{1{,}000{,}000\ Btu}{MMBtu}\left|\frac{1}{0.78}\right.$$

$$= \$22.90/MMBtu$$

Use gas if possible

Sample CEM POU Examples to work for practice

- For a large boiler, you have the choice of the following energy sources. Calculate the POU cost per million Btu for each.
  - Natural gas at $6.00 per MCF, Eff = 80%
  - #2 Fuel oil at $1.50/gallon, Eff = 78%
  - Electricity at $.075/kWh, Eff = 99%

Point of Use Costs
-Answers-

- Gas
  - $7.50/MMBtu

  - Oil
  - $13.74/MMBtu

  - Electricity
  - $22.20/MMBtu