High School

Energy Audit

Energy Audit Workbook and Training Manual

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CHAPTER I. ENERGY AUDIT OVERVIEW

Welcome to a new way of learning science. In this course you will be asked to work as a member of a student team conducting an energy audit of your high school. You will take scientific measurements, question school staff, and obtain various kinds of information related to how your school uses energy. As you finish each investigation, you will write a scientific report with graphs and recommendations and present it to school officials. Your team's recommendations will cost the school little or no money and, if acted upon, will likely save at least 10 percent of last year's energy bill. These savings can continue this year and in the years to come. Is this a lot of money? In this study you will find out. Dollars saved may be available for such things as computers, athletic events, school dances, or for other school needs. As important, energy savings help the earth by reducing resource use and environmental pollution.

You will find that your school uses lots of energy, and that energy costs both money and the environment! Dollars are leaking out of your school every day, and it is up to you to find out the location and size of the leaks. In this workbook you are asked to find information. So, who has this information or where can you find it? It is up to you to find the right people and get the information you need; much like detectives investigating a crime scene. As in any investigation, you will collect a lot of information, develop a list of suspects, organize your information, and present your findings along with recommendations. Let's look at an example of school energy use. At Roosevelt High School in Portland Oregon, the electricity, fuel oil, and natural gas bills for the 1993 school year came to $109,943. Of that, $73,199 was for electricity; $23,177 for #5 fuel oil; and $13,567 for natural gas. The electricity bill for November of 1992, just one month, was $6,544. What was the electricity used for? You probably will think of lights. But, what other parts of your school use electricity? Where are other energy forms used in your school? Often about 10% of the energy cost of your high school can easily be saved. Can you or your team meet or beat this goal?

A crime investigation is usually initiated with the discovery of a loss or injury. But how do you know that an "energy crime" has been committed and energy is being wasted. One tool is energy accounting. This is tracking your energy bills

Tracking expenditures helps prioritize where you should look first for savings, it enables you to measure whether steps you implement make a difference, and it permits you to spot unexpected anomalies that can lead to significant savings. In this workbook our focus will be expanded to include some other services such as water and garbage. Savings are often available by reducing water use and solid waste generated by your school.

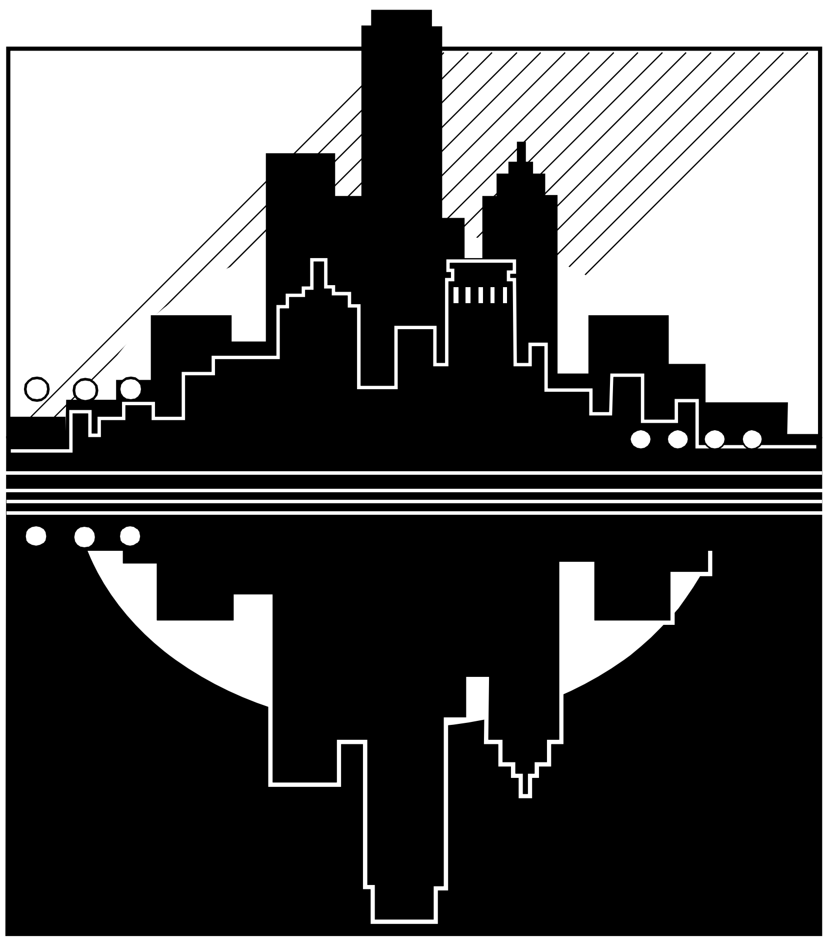
The problem of identifying and capturing energy savings is very real. Tools you will use to answer these questions touch on many occupations. The energy manager is interested in tracking energy use in buildings, understanding opportunities for saving energy, and implementing those that are cost effective. The building operator increasingly needs to know how to maintain equipment, help occupants adopt energy saving strategies, and be able to suggest ways to save. Consultants, designers, and engineers need to be able to identify, analyze, and recommend energy saving strategies.

The second major tool you will use is the audit. This involves going through your building to identify what is present. Where is energy being used, what type of energy, and how much is being used? How much solid waste is being collected from your school? Where is it generated and what are its characteristics? You then compare what you have with the cost and savings possible with other options to recommend specific actions.

In this project you will need to:

(1) collect data through both accounting and an audit of your school,
(2) analyze the data from the audit and tracking of existing usage (this will include graphing, correcting for climate and building usage, and calculating the economic cost-benefit of different alternatives),
(3) make recommendations based on your findings,
(4) write a report of your findings,
(5) present your findings to school officials and, lastly,
(6) evaluate what recommendations are adopted and how much energy and money is saved.

In addition to saving money, reductions in energy use has significant benefits for the environment. Energy use is damaging our environment. What can we do? Surprisingly, some of the solutions are quite simple. We can improve efficiency to get the same benefit while using less energy. For example, worldwide sales of compact fluorescent lights increased 23 percent last year to 134 million bulbs. Substituting these bulbs for standard, incandescent lights will save up to 6,000 average megawatts of electricity each year (mega means million so megawatts means million watts). That is a savings equivalent to the annual energy output of ten large coal-fired power plants or about seven average nuclear plants. That's good news for the environment but also good news for consumers. A compact fluorescent used three hours daily will eventually save $35 even after taking into account the interest that could be earned by putting the additional money used to purchase the compact fluorescent light into a savings account.



Energy Basics

Efficiency: Laws of thermodynamics apply to both living (for example, you and me) and non-living (for example, your car or refrigerator) energy consumers. The concept of *efficiency refers to the percentage of energy that can be transferred from one step to the next. The Second Law of Thermodynamics guarantees that you will lose in a transfer; but you can choose the transfer that is the most "efficient", the one that lets you use more of your energy.*

Only 16% of all commercially produced energy flowing through the US economy performs useful work. This means that 84% of all commercial energy used in the United States is wasted. About 41% of this energy is wasted automatically because of the Second Law of Thermodynamics. <u>That leaves 43% of the commercial energy used in the United States that is unnecessarily wasted</u>. An important point here is that efficiencies vary. A car that gets 40 miles per gallon of gas is more efficient than a car that gets 20 miles per gallon of gas. To go a given distance in the less efficient car you will burn twice as much gas as in a car that is twice as efficient. Since gasoline (energy) costs money, you will also spend twice as much money.

Energy Conversion Efficiency

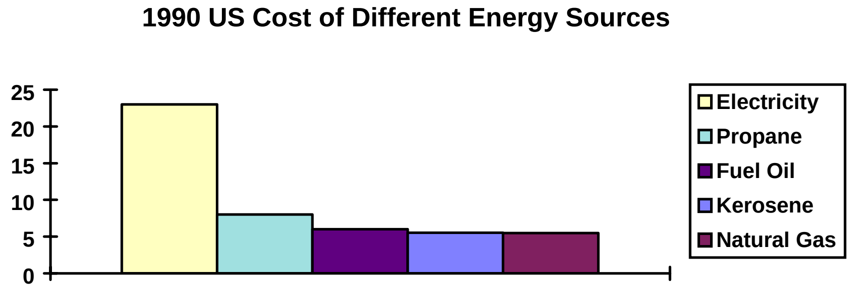
Energy Conversion Device	Efficiency (% energy transferred)
Incandescent light bulb	**5%**
Internal combustion engine (gasoline)	**10%**
Human body	**20-25%**
Fluorescent light	**45%**
Fuel cell	**60%**

FUEL COST: In addition to efficiency, often there are different types of fuels that can be used for the same task. For example, you could heat your house by burning $1 bills, $10 bills, or $100 bills in a woodstove. All would provide the same amount of heat, but use of $100 bills would cost 100 times the cost of using $1 bills. Using US paper currency, what would be the most cost efficient fuel to use?

_____ $ 1 bills
_____ $ 10 bills
_____ $100 bills

1990 US COST ($) OF 250,000 KILOCALORIES FOR HEATING SPACE OR WATER

Energy Source	1990 US Cost (Dollars/250,000 kilocalories
Electricity	**23.00**
Propane	**8.00**
Fuel Oil	**6.00**
Kerosene	**5.55**
Natural Gas	**5.50**



In 1990, the average price of obtaining 250,000 kilocalories for space or water heating in the United States was $5.50 using natural gas, $5.55 using kerosene, $6 using fuel oil, $8 using propane, and $23 using electricity. Whether one fuel costs less than another in a specific application will depend both on how much the energy costs and on the efficiency of the conversion process that is used to convert the energy to the desired end product, in this case heat.

Some schools have saved money by using equipment that could use either oil or natural gas and using that fuel that was least expensive at a given time. Energy cost however is only one of the factors that must be considered in considering which is best in a specific application. Other factors include the cost of the necessary equipment, convenience, safety, environmental impacts and other factors

Energy Units: Developing a common basis for comparison. You probably have already encountered many of the ways energy is measured. The concepts of calorie, Calorie (Kilocalorie), British Thermal Unit (BTU), Therm and Kilowatt Hour all have to do with measuring amounts of energy. Many different units can be encountered when measuring energy use in a school. As an example, Roosevelt High School during January, 1993, made the following energy purchases:

Energy Source	**Amount**	**Cost**
Natural Gas	4,135.6 Therms	$2,144.31
Electricity	116,399.8 kWH	$6,563.40
#5 Fuel Oil	16,233 Gallons	$7,308.02
Total Energy Cost January 1993		**$16,015.73**

Make a prediction: From this one month's data (1/12) of a year, what do you think was the total cost of energy at Roosevelt High School?

Why would the month of January not be a good representative month?

To compare the use of different energy sources it is important to know the definitions of the different energy units and how to convert from one to another.

Definitions: (Note: See Table D-1 Auditor Workbook Level I JRB Associates)

Unit	Energy needed to Raise	
Kilocalorie (C)	**1000 gm water**	**1**° Centigrade (C)
calorie (c)	**1 gram water**	**1**° Centigrade (c)
British Thermal Unit (BTU)	**l pound water**	**1**° Fahrenheit (F)

(about the heat of one lighted wooden match)

Therm: A unit of gas containing **100,000 BTUs**

Watt-Hr: The energy in 1 ampere flowing under a voltage of one volt for one hour (3600 joules)

Food Energy:

Carbohydrate 1 gm =	4 Cal (1.01 BTU)
Protein 1 gm =	4 Cal (1.01 BTU)
Fat 1 gm =	9 Cal (2.27 BTU)

Conversion Factors: The following factors enable you to convert between different energy units.

BTU =	252.5 c or 0.252 C
Kilowatt Hour (KWH) =	3413 BTU
Horsepower-hours =	1.341 KWH
Propane, gallon =	92,500 BTU*
Gasoline, gallon =	125,000 BTU*
Kerosene, gallon =	135,000 BTU*
Diesel oil, gallon =	138,700 BTU*
Fuel Oil, gallon No. 5 =	148, 000 BTU*

*This is an approximate value typically used for this conversion. Because these are average values, the exact BTU content varies with type and source, it is important to contact the supplier when accuracy is important.

How do you compare Therms with Barrels with Kilowatt hours to do a specific task?

Energy Conversion Chart

Cubic Feet Natural Gas(CF)	Barrels Oil (bbl)	Short Tons Bituminous Coal (T)	British Thermal Units (Btu)	Kilowatt Hours Electricity (KWH)	Bone Dry Douglas Fir Bark & Wood (T)
1000 (1 MCF)	0.18	0.04	1 Million	293	0.56
3,413	0.61	0.14	3.41 Million	1000 (1 MWH)	0.19
1 Million (1 MMCF)	180	40	1 Billion	293,000	56

Exercise: Convert the Following Energy Units

Calculations:

How many calories (c) in a KWH ? ________________
How many kilocalories(C) in a KWH? ________________
How many calories in a Therm ? ________________
How many kilocalories in a Therm? ________________
How many KWH in a Therm ? ________________

Question: A 200 Watt computer represents how much "horsepower"? ________*HP*

Consultant Question: I just bought a 550 Gallon Hot Tub that I will heat with electricity. I will change my water every three months.

How many Calories (Kilocalories) will it take to heat the water ______? How many BTUs ______? How much electricity (KWH) will it take ______? How much will it cost me $$ to heat it ______?

Hint: you need the temperature difference of tap water to (40^{o} C).

It takes 1C to heat 1000 grams of water 1^{o} so....how many grams and how many degrees?

Working with conversions helps you understand how to convert from one unit to another. Understanding the price of the units is also important. Converting units may seem hard to do but you already know how to convert dollars into quarters, dimes, nickels and pennies. Energy conversions are similar, except that it is like changing dollars of foreign currency such as pesos (Mexico) or yen (Japan) into American dollars. Similarly, British Thermal Units can be converted into Calories or calories; Kilowatt hours can be converted to BTUs and so forth. For a given time and supplier (price), all of these units can also be converted into dollars ($$).

Investigative Questions:

How much does a KWH cost? _______________(Call your Electric Co.)
How much does a Therm cost? _______________ (Call your Gas company)
How much does a gallon of #5 fuel oil cost? ________________ (Call a local Fuel Co.)

Group Discussion:

Get together with your team and come up with a list of the factors that you think are important in determining how much energy is needed to run a large building such as your school. In considering factors, think about things that are related to energy use such as outside temperature, locating of the building, what the building is made of, and other features that determine how much electricity, natural gas, and fuel oil it takes to operate your school.

Factors that Influence the Amount of Energy your School Uses

____

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____

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As pointed out, in this course you will learn in the context of a real world problem To succeed, you will need to work as a group and have the support of others. Your teacher will be your team coach and assist you in collecting data. However, it is up to you and your team to get the needed information, analyze it, and present your findings. In this process you will need the support of you school's facility managers, teachers, office personnel, fellow students, and equipment and fuel suppliers. Our expectation is that similar teams will be working in other schools throughout Oregon. By communicating with these other efforts, you can compare results and share ideas. Just like a soccer, baseball or football team depends on each player to be good, it is up to you to be a member of the highest scoring energy team.

Let's get started!

CHAPTER II - Resource Accounting

(Where the Rubber Meets the Road)

All successful energy management programs have certain steps in common; a system for tracking energy use in the building, knowledge of the features in the building that use energy, and a management strategy for reviewing and improving building performance. These three steps must be undertaken, but there is no prescription for which must be implemented first, or specifically how they must be carried out.

Tracking of energy use is a good place to start. The goal is to provide energy data in an organized and usable form so that sound business decisions may be made. By looking at past performance you can establish a baseline against which to measure your impact. You can identify areas of existing high energy use and use that information to prioritize where to focus your next efforts. Sometimes, by reviewing billing patterns you are able to identify problems that can immediately save the school money.

By comparing energy consumption with the average for similar buildings or for the same building over a period of time, it is often possible to identify when equipment begins to malfunction.

A good example was one school's water bills. As their records were entered into a tracking program they noticed that summer usage did not significantly decrease even though the school was not being used! Investigating, they determined that a lot of the water "use" resulted from a water leak. Since sewage bills are based on the water bill, the school had been charged for sewage fees for water that was leaking into the ground and not going to the sewage treatment facility. Clearly the leak needed to be located and fixed, but the school was also received a refund of the money it paid for sewage treatment that it never used.

In this chapter you will design or chose a system for tracking energy use in your school. You will research and report on how your school is charged for water, energy, and removal of solid waste. You will implement a system for tracking energy and water consumption including recording your school's use records for the past year and implementing a system to capture and record these records over the course of your project.

To be successful you will need the support of office personnel in you school or district who have access to the utility records of your school.   With their support and help from the utility service providers you should be able to understand how you are charged; something you need to know if you are to identify and prioritize different savings opportunities.

Use your team. Take advantage of members with computer strengths to research and implement the tools you use to record the energy use data. Take advantage of members with strong people skills to work with the office personnel to obtain the school's billing history. Divide up the work so while one individual or group is researching how the school is charged for electricity, another is researching natural gas, a third is looking into solid waste, and a forth is looking at water and sewage. Then report back to the full group and write it up so your work can benefit others who follow and so you complete that portion of your final report while it is fresh.

Resource Accounting Options

Energy accounting is something that every energy manager needs to do. As a consequence, there are a number of programs readily available to help organize the data. Some like ENACT, developed by the Washington State Energy Office, are very elaborate. They can track multiple buildings and follow different energy forms and water usage. It corrects for weather variations and produces a number of reports and graphs enabling you to easily compare data from different time periods. Along with the higher degree of sophistication, ENACT requires a significant amount of time and resources to input data. If you are only following one or two buildings one typically does not need such a sophisticated program and can use a spreadsheet. Again some pre-made ones are available or you can make your own to fit your specific situation. The table appearing later in this chapter can easily be converted to a spreadsheet to capture both energy and water use and cost. Such a table enables comparisons between different time periods. As presented however, the table does not include information that would permit corrections for variations in weather or changes in how the buildings are used.

Potential resources for locating available tracking software include your state energy office, the facility managers responsible for you school or your district, or your local utility. If your school or district has a Resource Conservation Manager (RCM), see them. They are probably already tracking energy use at your school.

Understanding Your Bills

Spend time understanding how your school is billed for utilities. Then test your understanding by reconstructing a few of the bills to be sure you calculate the same value as reflected in the billing. For example a typical bill for electrical service to a residence includes a fixed charge associated with the utility having to maintain and read a meter and hook-up at your home. The rest of the charge is associated with how much electricity in kilowatt hours (KWH) you used during the year. Electricity charges can vary based on usage depending on how the rates are structured. For example sometimes one rate may apply for the first 300 kWH and a different rate for additional consumption. Electricity rates for schools and other commercial buildings typically have the same elements as the residential rates plus a "capacity demand charge". This charge is based on the highest "demand" or largest number of kilowatts required by the school over a 15 or 30 minute period during the billing period. “Demand” is often a control issue. For example if all the lights, electric ceramic kilns and ovens, air handling motors, and electric water and portable space heaters turn on at the same time, the demand charge will be very high. But if you can fire the ceramics at night when other equipment is not being used, the school can save money by lowering demand even though they are using the same amount of energy. In many locations, electricity rates for commercial buildings will vary based on the time of day when electricity is used.

Graphs and Reports

Once energy data has been collected and organized, it must be made comprehensible to those who will use it or to those who you will present it to. It is important to identify the audience that will be using the energy data to make decisions. In addition to transmitting data, reports may be used to generate awareness, motivate and reward, or serve as a public relations tool.

To best convey information it is necessary to get the readers attention. Colorful graphs, tables, and pie charts provide essential information, but in a more visually appealing form than text. Many graphics programs are now available in schools such as Harvard Graphics and Freelance that allow graphs on color transparencies or slide film. Graphs include the following:

Natural Gas and Electricity by month (MMBTU)
Costs by fuel type per month
Natural Gas by month (CCF or THERM)
Electricity Consumption by month (kWh)
Electric Demand by month (kW)
Degree Days by month

Other Graphs:

Avoided Costs
Annual Savings
12 Month Rolling Summary (MMBTU, kWh, therm, $)
Btu/Sq.Ft./Degree-Day
Utility Costs/Unit ($/therm, cents/kWH, $/kW)
Building Comparisons (Total Energy, by month)

These graphs generally require additional computations, but can be well worth the effort to emphasize a particular point or better understand a consumption trend.

An increase in annual electricity, natural gas, or fuel oil consumption can be the result of several factors.

Greater number of degree-days (colder weather)
Added equipment or floor space (kitchen equipment, computers, space heaters, swimming pool)
Problem in operation of heating system (dirty air filters, time clock malfunction, steam trap maintenance needed.
Further analysis can determine which of these factors is most likely the cause of increased consumption.

Analysis (Natural Gas Example)

A. Determine the THERM/Degree-Day consumed for the previous year.

B. Multiply by number of degree-days for current year to obtain estimated natural gas consumption

C. If actual consumption is equal to or less than estimated consumption, the increase is due to weather conditions.

D. If actual consumption is significantly greater than estimated consumption, factors other than weather are the cause of this increase.

E. Determine if new gas-consuming equipment has been installed or if floor space has been added.

F. If no new equipment or floor space was added, the increase in consumption is most likely the result of a problem in the heating system. Provide corrective maintenance and continue to monitor monthly consumption.

Seasonal Loads vs. Base Loads

In the workbook you looked at "outliers" as a way of identifying problem areas. Seasonal loads, such as heating or air conditioning, are identified as the portion of consumption or cost located above the line used to establish base loads on the graph (usually the annual average which is equal to Total Annual Energy Cost / 12 = Monthly Average Cost) or for a school, the baseload may be a month when the school operates, but when heating or cooling is not needed.

High seasonal loads may reveal an opportunity to reduce consumption by making improvements to the heating and air conditioning equipment, temperature controls, the building envelope, or to other systems affected by seasonal operation.

Establish a Baseline Year

In order for energy consumption data to have a meaning, a baseline year is needed as a standard for comparison. This is important to see how you are doing over time. Are energy costs going up? By how much? Typically, the year previous to initiating an Energy Management Program is used in order to show how much progress has been made since that year. If complete records are not available for that year, use a more recent year or an average of several previous years to obtain typical values.

Project and Exercises

A. *Obtain data on the cost and use of energy, water, and garbage services at your school.*

What you will calculate and or record:

Electricity KWH and $ per month; total for the year
Natural gas Therms and $ per month; total for the year
Fuel oil Gallons and $ per month; total for the year
Water Use Gallons and $ per month; total for the year
Waste Hauling Charges $ per month; total for the year

Equipment and Information needed:

1. A method or form for recording energy use; complete either the table below, a computerized spreadsheet, or accounting software that will record and print similar information. Accurate data is critical

2. Utility bills (most recent year) showing usage and cost

3. Information to understand how the bill is determined; how usage is converted to cost

B. *Convert each energy type to BTUs*

Total amount of electricity used ____________ KWH X 3413 = __________________BTU

Total amount of natural gas used ____________Therms X 100,000 = ______________ BTU

Total amount of fuel oil used ___________ Gallons X 148,000 = ______________ BTU

Total BTUs used for the year = ______________________ BTU

C. *Report your findings to your full group. Emphasize any anomalies or areas that you feel warrant further investigation.*

School Resource Use

Month	Electricity KWH	Cost $	Natural Gas Therms	Cost $	Fuel Oil Gallons	Cost $	Water Use Gal	Water Cost $
JAN								
FEB.								
MAR								
APR								
MAY								
JUNE								
JULY								
AUG.								
SEPT.								
OCT.								
NOV.								
DEC								
Total								
Total Cost								

Chapter III: Building Inventory

In the previous chapter you started to develop a method for tracking energy use. In this and the following chapter you will begin to develop a precise listing of energy using features in your buildings and your options for saving energy.

There are three fundamental systems associated with understanding energy use in buildings: (1) energized systems, (2) non-energized systems and (3) human systems.

Energized systems are those which consume energy directly and include heating, ventilation, cooling, humidification, dehumidification, lighting, water heating, waste handling, cooking, and equipment such as kilns, shop equipment, televisions, and computers.

Non-energized Systems do not consume energy directly but affect the amount of energy which an energized system must expend to get its job done. Typical non-energized systems include walls, windows, floors, roof, ceiling, and doors. Other factors influencing energy use are landscaping and siting.

> An example of these can be made with a car. If you are cold you can start the engine and either run the heater or roll up the windows. Can you identify the energized and non-energized components?
>
> *Start the engine and run the heater (circle one) E NE*
> *Roll up the windows (circle one) E NE*

Human systems are persons who affect when and in what quantity energy is consumed. These persons include students like yourself, teachers, staff and visitors. When your mother yelled at you, "Close the door, we can't heat up the whole outdoors" she was trying to influence a component of the human system (YOU) in her energy use environment. Your mother realized that an open door wastes energy, and she knew the energy has a cost, because she paid the heating bill.

You can see that energy use depends on the equipment you are using, it's efficiency and reliability, and on behavior. Whether we use energy wisely or wastefully depends on the choices we make. For example, it does not make much sense to change to higher efficiency lighting and then leave the lights on all the time. The savings are canceled by an increase in usage.   Buildings don't use energy, people do.

Project and Exercises

A.   *Measure and record the characteristics and equipment in your school that account for its energy use.*

Tools
1. Blueprint of your school
2. Ruler, tape measure, clip board and pad

Steps

1. Confirm the blueprints - At a time that is not disruptive to classes, confirm that the blueprints accurately reflect the current school facilities. Note any changes that have taken place. Have walls been moved? Are the rooms still used for the original purpose or is a classroom now a weightroom or a lounge a classroom? Note any changes and unusual energy using equipment such as a kiln. At this stage a lot of detail is not needed. Major energy using equipment such as lighting and the kitchen will be looked at in greater detail later. If you do not have blueprints, now is a good time to create a floor plan of the school that you can use as a reference for your energy management program. Note different heating/cooling zones and where the controls are located.

2. From the floor plan determine the heated square footage of the school. This can be done by referring to the dimensions of the blueprints or by measuring the outside dimensions of the building (length x width), and multiplying this area by the number of floors (height). Generally basement areas and mechanical areas are not included as heated areas unless heating units are installed and operating.

B. *Use your results above with the energy use information you determined in chapter II to determine the BTUs and dollars per square foot/year.*

Calculate BTU per Square Foot

(1) Total # BTU used for the year: ____________ BTU
(2) Total square feet of heated space in your school: _________________ ft^2
(3) Divide (1)/(2) to get BTU/square foot _________________________ BTU/FT^2
(4) Divide #3 by 1000 to get kBTU/square foot/year ________________

Calculate $ per Square Foot

(1) Total Energy $ spent for the year __________________ $
(2) Total square feet of conditioned space in your school ______________________ ft^2
(3) Divide (1)/(2) to get Dollars $/square foot __________________________ $Dollar/ft^2$

Energy Utilization Index (EUI)

Energy auditors use a measure called Energy Utilization Index or Energy Use Index, "EUI" to enable comparisons between different buildings and energy types. EUI is calculated by converting all energy used in a building to a common unit, BTUs, and then dividing it by the square footage of the heated/cooled space in the building. The Energy Use Index (EUI) is the most common means of expressing the total energy consumption for each building . The EUI is usually expressed in BTUs/Square Foot-Year and can be used to compare energy consumption relative to similar building types or to track consumption from year to year in the same building. Sometimes EUI is given as thousands of BTU/square foot-year. This alternate definition will be used in the following example from the Portland Schools. The average for Portland Public Schools is 70 (seventy thousand Btu per square foot of conditioned space per year) with a low of 35 and a high of 120. Place your school on the scale below: How did your school do? (See item B.4 at the bottom of the previous page)

EUI for Three Portland Public Schools

L__________________________________X__________________________________H
35 70 120
x x x
Lincoln (52.17) Roosevelt (70.23) Grant (78.96)

The Energy Utilization Index (EUI) provides information similar to "average gas mileage" of your car. Cars with a low average gas mileage burn a lot of gas per mile;

those with a high average gas mileage burn less gas per mile. These data allow energy managers to construct a *base year*. Normally the base year is the observed EUI before an energy program is started. Alternatively, the base year can be the average energy use per square foot of the last three years. Changes in energy use can then be seen over time. Obtaining accurate values for the data used in your audit such as square feet of conditioned space and careful selection of the base year is critical. Other factors such as climate and size of the student population may be of importance.

EUI and Base Years

What do energy statistics look like? How do the numbers help us to make decisions? The table below shows monthly energy use EUI statistics for March, 1993 for the Portland Public School District. The base year used for the District is June 1989 to May 1990 or energy use that was prior to a retrofit. Depending on your school district, these data may or may not be available. However, with monthly energy bills you can establish your own base year and create a table similar to this one.

Do a field investigation: Science investigators often identify "outliers" or standouts in their research. In a toxicology study, close observation of the mice who survived a sublethal dose is looking at standouts. Why did these mice live while the others died? Or looking at why some people get cancer when exposed to carcinogens and others do not. You can look at energy outliers too. In Portland, for example, Franklin High School had the highest energy use index (EUI) and Jefferson High School had the lowest (EUI). WHY? Consider taking a field trip to schools in your district that have very high or low EUIs to see if you can identify what the differences are in terms of location, construction, and operation. You should be able to get energy use data from the Energy Coordinator in your school district. Find out who this person is and think about doing some interviews. How about people who should know why there are differences. School custodians? Administrators? Keep record of your notes.

Example: Monthly Energy Use Statistics - March, 1993

Portland Public Schools

Facility	Monthly Consumption(mmBtu)	Monthly Cost	EUI Type	EUI	EPI

Franklin	1,975	$10,969	1	85.76	102.87
Wilson	2,724	$14, 545	1	84.01	90.01
Grant	2,456	$12,824	1	78.96	95.23
Voc. Vill.	553	$3,144	1	78.85	113.39
Roosevelt	2,235	$12,267	1	70.65	103.87
Benson	3,349	$19,117	1	70.23	78.36
Marshall	1,814	$12,215	1	69.28	127.28
Madison	2,488	$12,334	1	67.03	146.88
Cleveland	1,850	$12,041	1	65.69	90.71
Jefferson	2,446	$13,958	1	65.22	117.95
Lincoln	1,333	$8,553	1	52.17	91.98

EUI types:

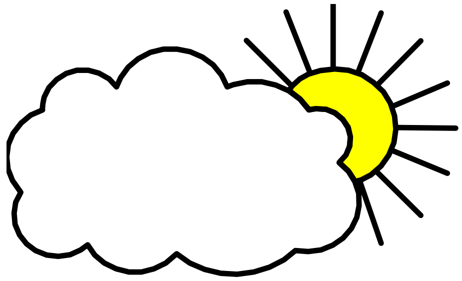
1 - kBtu/sq ft/yr
2 - kBtu/ million gallon/yr
3- kBtu/user-defined unit/yr
4 - kBtu/yr

EUI-Energy utilization Index

EPI - Energy Performance Index. Comparison to last year energy use =100. Wilson is using about 10% less energy than last year; Madison about 47% more.

Does it make most sense to compare buildings based on energy used per square foot? Would energy used per student, or energy used per square foot -hour of operation be better measures on which to base comparisons? What do you think?

CHAPTER IV. SCHOOL LIGHTING AUDIT



There is significant potential for lighting system changes and dollar savings in most schools. These changes can save energy (and associated costs) and still provide occupants with the quality and quantity of light that is needed to perform their various tasks. A key finding in a study: *Energy Efficiency Guidelines for Oregon Schools (1993)* is that the first investments should be made in the lighting system and ventilation system controls of schools. If you want to look for ways to save energy in buildings look long and hard at LIGHTS.

A lighting system is just that -- a system. It is important to consider the impact of the different elements on the whole. Its many elements are interrelated just as the lighting system itself is interrelated with other systems in the building. While energy can be conserved by properly removing lamps (light bulbs) and light fixtures, such action should be taken only after the impacts on the complete system have been considered to be sure the changes will not cause a problem. While conservation of energy is important it must be achieved without the loss of safety, productivity, visual comfort, aesthetics and compliance with federal, state, and local laws and ordinances.

"You know, I don't think 10 lumens is gonna cut it"

An excellent initial step to save money through more efficient lighting is to reduce lighting levels consistent with the current use of the different spaces as identified during the building audit. In other words, how is the area being used and how much light is needed in the space for that use?

Controls: Turn off lights when not needed

Plan a program to turn lights on only when and where they are needed. The major advantages of such programs are that they can be tailored to the characteristics of the space, adjusted to the needs of its occupants, and implemented relatively inexpensively and quickly. The key element of a lighting use program is a lighting schedule related to occupant usage patterns. Personnel should be assigned, trained and made responsible for the efficient use of lighting according to the needs in the area. A light that is turned on is like a meter running in a taxi-cab.

"You mean I'm gonna have to pay the energy bills around here?"

Appropriate Lighting Levels:

Areas can have too little light and they can have too much light. In the latter case, they are "overlamped". Below are recommended Federal Energy Administration maximum lighting level standards. With a light meter, it is relatively easy to determine, the lighting level by area.

Task or Area	Foot-candle Levels	How Measured
Hallways or corridors	10	Measured average
Work and circulation areas	30	Measured average
Normal office work	50 (40-60)	Measured at work station
Prolonged office work	75 (55-90)	Measured at work station
Office work visually difficult	100 (80-210)	Measured at work station

A second source for recommended lighting levels is the Handbook of the Illumination Engineering Society. The following table presents specific values pertaining to schools from the IES Lighting Handbook.

Special Areas: Schools

ENVIRONMENT WHERE TASK IS DONE	TASK DONE	Foot-candles Recommended
ANY SPACE WHERE:	Reading printed material	30
	Reading pencil writing	70
	Drafting, benchwork	100
	Lip reading, chalkboards, sewing	150
CLASSROOMS		
	Art rooms	70
	Drafting rooms	100
	Sewing room	150
	Cooking room	50
	Note-taking	70
LABORATORIES	Dissection, experiments, etc.	100
LECTURE ROOMS		
	Audience area	70
	Demonstration area	150
MUSIC ROOMS		
	Simple scores	30
	Advanced scores	70
SHOPS	Operate machinery	100
STUDY HALLS/LIBRARY	Study/typing	70

Source: Illumination Engineering Society, IES Lighting Handbook.

Comparing different types of Light Sources: You already know that the type of light source makes an enormous difference in energy usage. Recall that incandescent light bulbs have an efficiency of 5% as compared to fluorescent lights with an efficiency of 45%. Clearly you will save money every time you replace an incandescent lamp with a fluorescent lamp. However, all lights of the same type are not the same in terms of efficiency. With fluorescent lights, the type of ballast (provides the correct current and voltage to run the lamp) and design of the fixture is very important. For example, fluorescent lamps show considerable variation in terms of how many lumens of light they produce for one watt of electricity. The newer electronic ballasts significantly outperform the older magnetic ballasts.

Lamp-Ballast System Comparison: Two-Lamp Open Air Systems

Ballast Type	Lumens Produced per Watt Efficacy
Magnetic (Standard)	61
Magnetic (Energy Efficient)	68
Electronic	85
Electronic IS	92

Source: Advanced Lighting Guidelines: 1993 (Revision 1) Electric Power Research Institute.

These are selected values, however, notice that the best electronic ballast fluorescent lamp (92 lumens/watt) is about 51% more efficient than the worst magnetic ballast fluorescent lamp (61 lumens/watt).

In choosing the most cost desirable option there are other factors to consider besides energy needed to run the lamp. How much do the lamps cost? How long will they last?

Performance Characteristics of Various Light Sources

Lamp Type	Efficacy (Lumens/Watt)	Average Life (Hours)
Standard Incandescent	5-20	750-1000
Tungsten-Halogen	15-25	2000-4000
Compact Fluorescent (5-26 watts)	20-55	10,000
Compact Fluorescent (27-40 watts)	50-80	15,000-20,000

Source: Lighting Fundamentals Handbook Lighting Fundamentals and Principles for Utility Personnel. Electric Power Research Institute Publication.

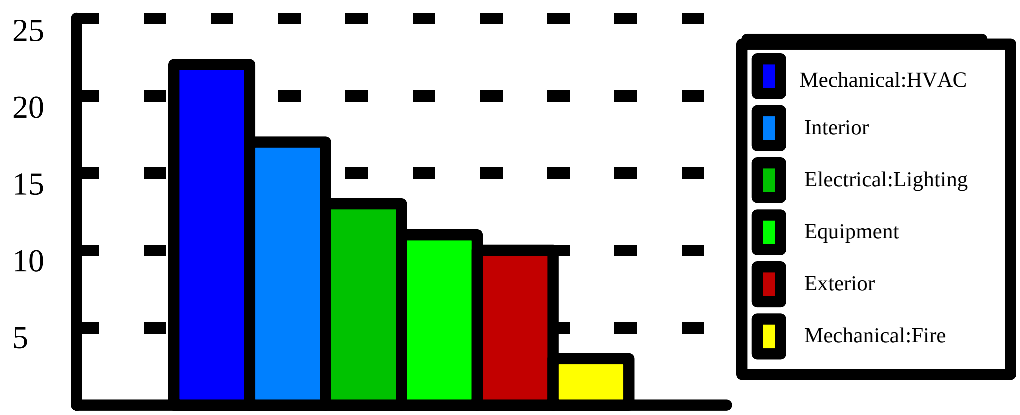
Beyond the energy costs associated with selection of equipment, there are also maintenance costs. If you use incandescent lamps in your home with an average of 1,000 hours you will replace ten bulbs for every fluorescent lamp. If the change takes as little as six minutes you will have invested an hour of labor in "bulb changing". This idea also applies to building equipment. The maintenance costs for various building activities are listed below. Although your team will be concerned primarily with the energy costs associated with your school you may want to consider the labor hours that are saved by recommending equipment, especially lighting, that has longer lifespans and therefore do not need to be changed out as often. For buildings like your school the table below shows the relative maintenance costs of facility maintenance.

Problem: You are about to buy a light bulb for $5.50 that has a rated life of 850 hours. You then notice that you can buy a bulb that produces the same light for 18,000 hours but costs $62.00. Energy use is the same for each bulb. Which bulb is the better bargain?

_____ The $5.50 bulb_____ The $62.00 bulb

Hint: you will have to buy about 21 bulbs that live 850 hours to get 18,000 hours of service (21 X 850 = 17,850 hours). Those 21 bulbs will cost you $115.50!

Relative Facility Maintenance Costs



Source: Washington State Energy Office. 1991 Facility Management.

In a recent presentation at a PGE Conference Center, a Resource Conservation Manager from the Eugene School District pointed out that the main reason why custodians liked switching to an energy saving exit light was that they had extremely long life spans. Even more important to them than energy conservation was that they did not have to change them as often. The law requires exit lights to be visible all of the time. The task of keeping on top of those that burn out and replacing them can be a rather time consuming and burdensome chore.

Lighting Surveys: You will notice that the amount of energy used to produce lighting depends on: 1) the *type of device used to produce the light (incandescent vs. fluorescent), (2) the amount of light produced, (3) conditions in the space such as the color of walls, if any, and, (4) the amount of time that lights are on. The lighting survey is intended to provide information on these variables. Switching to a more efficient lamping system does not make much sense if the lights are then left on all the time, nor can it be economically justified if the lights are never used. In your lighting recommendations, consider whether it is more economical to switch to more efficient lights; add controls that switch lights off when not needed; or delamping areas where lighting is excessive.*

Common lighting recommendations of building energy auditors include the following:

Utilize fluorescent energy saver tubes and/or ballasts when replacement becomes necessary.

Convert interior incandescent fixtures to energy efficient fluorescent lighting.

Convert exterior incandescent fixtures to higher efficiency lower wattage lighting sources, such as metal halide, or high or low pressure sodium. Consult a lighting specialist.

Lighting may or may not provide for additional security after hours. People don't "hang out" in dark unlit places. Consider delamping and evaluating the change.

Maintenance costs of electrical (lighting) ranks under HVAC, plumbing, and interior construction. Accordingly life span of the bulb is directly related to relative maintenance cost of a facility.

Source: Washington State Energy Office, 1991. "Facility Management".

Project and Exercises

A. Do a Lighting Inventory

Take a lighting inventory for your school and complete the Room Lighting Checklist that follows. Your team will need a floorplan of the school, a light meter that measures footcandles of illumination, and a plan of attack. Lighting surveys can be completed in a couple of hours and at various times of the day when the school is in operation. It is important to find all of the lights (and ballasts if applicable and possible), both inside and outside as well as determining the type of controls that are used to turn them on and off. Most of the room lights are operated by a wall switch; some of the outside lights may be on timers or photocells.

Equipment needed:

1. Tape Measure
2. Light meter (measure foot candles)
3. School Room Locator
4. Lighting Survey Form (data collection)

Procedures: Inside Lights

Determine lamp type used to light the room space
Highlight areas with incandescent lights on the school floor plan
Take Light Level Readings (Foot-candles)
Note how many lights and their wattage
Note how lights are controlled
Note how many tubes per fixture (Luminare)
Where possible identify the type and make of the ballast

Outside Lights

Walk around the perimeter of the building noting outside lights on the floor plan
Note how lights are controlled
Locate the timeclock and read the on and off times
Note height of fixtures or mounting.

Room Lighting Checklist

Room Number	Room Use[1]	Incandescent Bulbs #Watts2	Fluorescent Lamps # Watts[2] including Ballasts	High Intensity Discharge #[2] and Wattage	Foot Candles3	Comments:4 (windows,skylights, reflector condition)

1. Room use: List primary activity such as Biology, office, art, music, conference, and home economics.
2. Bulb Count/ Watts: Identify the type and number of bulbs and wattage of each bulb. As appropriate, include ballast type and its wattage.
3. Foot Candles: The reading obtained from the light meter at representative work locations.
4. Comments: Does the room have windows, skylights? Are the reflectors dirty? Ceiling reflective?

B. Write a report analyzing how well your school performs relative to existing lighting standards.

Most lighting standards can be grouped into one of two categories:

1. The amount of electrical energy used, which includes such measurements as watts per square foot .

2. The measurement of light output, commonly the measurement of foot-candles or
equivalent sphere illumination.

Understanding Watts/Square Foot

One common approach for developing a standard for lighting efficiency is watts per square foot or W/f^{t^2}.

The technique uses a watts per square foot standard to establish a power limit for buildings. The assumption is that the reduction in allowable total wattage will require energy efficient lighting systems that produce adequate lighting. Watts per square foot is easily computed. If used as a single value for all areas of a building, one has only to total up the connected load of all lighting system components and then divide by total square footage in the building.

Is your school energy-conserving simply because it complies with codes? Not necessarily. The hours of operation of a lighting system have a great deal to do with the total energy consumed. For example:

> Consider a 10,000 square-foot space lighted by a system rated at 20,000 watts or (20 KW). Its W/ft^2 rating is two (2). If the lights are used for 2,000 hours per year, total energy consumption is 40,000 KWH (kilowatt-hours). Now, consider the same space with a 10,000 W lighting system rated at one W/ft^2 used 5,000 hours per year. Total energy consumption is 50,000 KWH (10 KW X 5,000 hours).

Note that even though the lights are using less electricity, total consumption increased because the number of hours increased. In other words, the system with a one W/ft^2 rating, which is only half that of the other, consumes 25 percent more energy because it is on longer. The above example points out that this method cannot indicate energy consumption or energy waste, only the relative energy requirement. Watts per square foot has been used extensively in establishing lighting budgets for buildings. Generally speaking, a "light budget" of two watts per square foot is acceptable.

The second type of standard deals with whether the light is sufficient for the type of task to be performed. Tables in this chapter contain recommended lighting levels from the

Federal Energy Administration and the Illumination Engineering Society. How do the levels you measure for your school compare with these standards?

The light meter you will be using in this exercise measures light in foot-candles. Be careful where you take your measurements, the recommendations are based on light levels on task, as opposed to overall or general ambient light levels in the room.

1 Foot-candle = 1 Lumen/Sq. Foot

C. Based on your lighting inventory and analysis, recommend actions your school should take to improve lighting quality and efficiency.

CHAPTER V. WATER RELATED SAVINGS

Savings are possible by reducing water use. If you have not already conducted the analysis suggested in Chapter II, review the water bills for your school. Check for evidence of leaks and billing errors. Review how water is being used to identify any opportunities for savings. Further energy savings are possible by reducing hot water use and improving the efficiency of its delivery.

Measuring Flowrates

A one gallon container can be used in showers (gym) to determine the flow rate in gallons per minute. This is important because it takes energy to heat water and energy costs money. To measure the flow rate, turn on both the hot and cold water and adjust the temperature of the water and the flow to the point where you would normally shower. Note the time on your watch (with a second hand) and fill up the one gallon bucket, noting how much time it takes to fill in seconds.

1 gallon shower water = _____________ seconds. Divide “1” (calculate the reciprocal) by this number and multiply the result by 60 to get gallons per minute = ________________GPM.

Now turn off the cold water and find out how long it takes to fill the one gallon container with hot water.

1 gallon hot water = ________________ seconds. Again calculate the reciprocal and multiply the result by 60 to get gallons hot water per minute = _________________GPM.

Showerheads are available that provide “satisfying” showers and use only 2.5 GPM or less. Not all showerheads however are created equal. When flow rates in excess of 2.5 GPM are found, energy can be saved by changing the shower heads. Care must be taken however to be careful to use types that perform acceptably. If not satisfied, users tend to damage or remove the showerheads resulting in more energy and water use.

System Efficiency

At some schools during warm weather, a boiler is operated simply to supply hot water. Sometimes savings can be obtained by installing a smaller, hot-water heater for use when space heating is not required. In some schools, the hot water heater is distant from the point of use. In these situations it may be possible to save by installing a second water heater close to the point of use. Heating needs can be reduced by insulating hot water pipes where they are accessible.

Fuel Source

Consider the cost of different forms of energy at your school. Sometimes significant savings can be generated by switching to a less expensive fuel. For some application it may be possible to use the sun or take advantage of heat being exhausted from the buildings or kitchen to heat or pre-heat the water.

Project and Exercises

In 1994, a common method for generating new sources of electricity is through the use of a gas fired combustion turbine. If using gas to produce electricity is it better for the environment to us a gas fired water heater or an electric water heater? Explain your reasoning.

A. Find the following information:

Amount of hot water (gallons) used per month
Amount of electricity (KWH) or natural gas (Therms) used per month to heat water.
GPM (flow rate of school showers in gallons per minute*)*
Volume of water used in cubic feet per minute
Energy cost per cubic foot; per gallon
Number of calories of energy needed to heat school water per gallon and per liter (Note: 2.78 Liters = 1 gallon)
.

Equipment needed:

1. Thermometer
2. One gallon container
3. One liter flask

Information you will need:

Total amount of hot water used per month (cubic feet)
Type of energy used to heat water
___ Boiler (Fuel Oil) Energy units in gallons
___ Natural Gas Energy units in Therms
___ Electric Energy units in KWH

One cubic foot equals 7.69 gal
One calorie equals the amount of energy necessary to heat 1 gram of water 1 degree Centigrade.

B. Calculate the amount of energy used to heat water at your school.

1. Measure the temperature of unheated tap water (Cold) and the temperature of hot water using a thermometer that measures in degrees Centigrade.

Temperature of cold water ______C
Temperature of hot water ______C
Difference cold vs. hot ______C

2. How many calories does it take to heat each liter of water at your school ___________?

3. How many calories does it take to heat each gallon of water ___________? (There are 2.78 liters per gallon)

4. How many calories does it take to heat each cubic foot of water________?(There are 7.69 gallons per cubic foot)

5. How many calories does it take to heat the water your school uses each month? ____________________? (About one third of the total water used is heated).

Convert Total Calories (#4) to:

6. BTUs _________________

7. Therms ________________

8. Kilowatt Hours __________

9. Calculate the cost of meeting the hot water needs at your school using a gas hot water heater and an electric water heater. State your assumptions regarding water heater efficiency, system efficiency, and rates.

A calorie (c) is defined as the amount of energy it takes to heat one gram (gm) of water one degree Centigrade. A gram of water is equal to a cubic centimeter (cc) and milliliter (ml) in the metric system. A gram is a unit of mass; cubic centimeter and milliliter units of volume. A kilocalorie (C) is the amount of energy needed to heat 1 liter (1000 milliliters or 1000 cubic centimeters) of water one degree centigrade. So how many calories (C) does it take to heat one liter of the water that your school uses? Remember that tap water temperatures vary; the colder the incoming water, the more energy it will take to heat up to a certain point.

C. True or False

If incoming water is preheated by having it run through solar panels, it will take less energy to heat the water and will save money. ___T ___F

D. Write a report presenting your findings relating to water use in the school. Can your school save by fixing leaks, reducing water or hot water use, converting to a different source of energy for water heating, or installing a more efficient heating system?

E. (Optional Research Question)

Although not common in the Northwest, in some areas the price of electricity goes up or down according to time of day. Rates are higher during "peak demand" times and lower during "low demand" times, usually at night. I own an electrically heated hot tub that heats water anytime the water temperature drops below a certain level, regardless of time of day. Would it make sense to put a timer on my tub so that it could draw electricity to heat water only during times when electricity rates are low? You might think about what you would do if gasoline prices for your car were $1.50/gal between 8 a.m. and 6 p.m. and $1.10/gal between 6 p.m. and 8 a.m. When would you buy gas? Although "time of day" rates are not common, demand charges are. Given the demand charges it may make sense to track and shift electricity usage to periods when other energy demands in your facility are less.

1. Does your utility have a variable rate structure? ___yes ___no

2. If no, find out where there is one (there are many in northeast United States) that does and consider the price differences in electrical use.

3. How much would a timer cost? ________________ How long would it take the electricity saved to pay for the timer? ________________yrs.

4. Compare the cost of an alternative fuel; gas if water is currently heated by electricity and electricity if it is currently heated by gas or oil.

What is your recommendation?____________do it ___________don't do it. Are there other options? Switch to a different fuel? Lower temperature? Does it cost more during winter months than summer months? How much more? How quickly does water "cool off" if being heated intermittently (look up the definitions of specific heat and capacity).

School Hot Water Use

Month	Cubic Feet (CF)	Gallons (Gal)	Liters (L)	Energy Dollars ($)
JAN				
FEB				
MAR				
APR				
MAY				
JUNE				
JULY				
AUGUST				
SEPTEMBER				
OCTOBER				
NOVEMBER				
DECEMBER				
Totals				

*Note: About 1/3 total water usage is heated water.

Chapter VI: The School Boiler

Many schools have a boiler to provide space and water heating. Given the greater sophistication and safety concerns regarding these systems, what you can do will be limited and you will need help. Take advantage of your school's boiler operator to learn about the system and keep an eye open for recommendations you can suggest that may save. In order to determine the efficiency and operation of the school boiler several measures must be taken which include an evaluation of the burn efficiency and smokestack temperature readings. In this part of the energy audit your team is going to need the services of a consultant.

Field Trip to the School's Boiler Room: Contact your faculty coach to arrange for a guided tour of the boiler room by custodial staff. In the tour find out who is responsible for maintaining the boiler, what type fuel it uses, and when it was last inspected. Review the energy data that you collected in chapters II and III in terms of how much and when fuel is being used. Are there any surprises?

Professional Boiler Inspection: Contact your school and district resources and entities like Northwest Natural Gas Company to see if it is possible to schedule a boiler inspection and report to your energy team. Information from this inspection will be used in your final report and recommendations.

Scheduling: Review the time periods when the school's boiler is operated. Are there periods such as winter, spring, and summer breaks when it could be completely turned off. Is it? A quick check of schools in the Portland area over one recent Christmas break found many school buildings operating on the same schedule as if they were being used! Significant savings were possible simply by turning off heating, lighting and other energy using systems which are not needed at that time.

Boiler Room Checklist

The following items should be covered by the boiler inspector. You may want to review why these are important after the inspection has been completed.

Daily Requirements:

- ☐ Check temperature of exhaust gasses
- ☐ Check the steam pressure
- ☐ Check for unstable water level
- ☐ Check the burner
- ☐ Check motors and auxiliary equipment
- ☐ Check blowdown
- ☐ Keep a daily log, pressure, temperature of room, stack, water

Weekly Requirements:

- ☐ Check exhaust gas composition and temperature
- ☐ Check relief valve
- ☐ Check water level control
- ☐ Check pilot and burner assemblies
- ☐ Check boiler operating characteristics

Monthly Requirements:

- ☐ Check blowdown and water treatment procedures
- ☐ Exhaust gases
- ☐ Combustion air supply - keep air supply openings free of obstructions
- ☐ Check fuel system
- ☐ Check belts and packing glands
- ☐ Check for air leaks
- ☐ Inspect boiler room for cleanliness
- ☐ Inspect linkages for tightness
- ☐ Observe the fire when unit shuts down
- ☐ Inspect all boiler insulation, refractory, brickwork, and boiler casing for hot spots and air leaks.

Source: Northwest Natural Gas Company Commercial Conservation Checklist.

Chapter VII Food Services
Laundries and Recycling

To complete this section, the Energy Audit Team needs to inspect the food service area of the school and evaluate a number of conditions.

Equipment Needed: Thermometer to measure water temperatures.

Task: Complete the following cooking and water heating checklists. To collect data you may have to interview some food services staff and do an on site inspection.

Cooking

Yes	No	Commercial Food Service Energy Conservation Checklist
		Second fry unit, broiler, overn, etc. used only for peak business hours.
		Oven preheats at desired temperature; not at a higher temperature.
		Smaller energy efficient ovens used whenever possible.
		Ovens loads and unloaded quickly to avoid unnecessary heat loss. Every second an oven is open it loses about one percent of its heat.
		Cooking and heating units not used are turned off.
		Meat cooked slowly at low temperatures. Cooking on roast for five hours at 250^{o} Fsaves 25-50 percent of the energy used in cooking for three hours at 350o F.
		Baking and roasting scheduled so that oven capacity can be fully utilized.
		Ovens are not opend during operation.
		Food cooked on small part of grill heating only portion being cooked on.
		Place weight on bacon and sausage to quicken their cooking time.
		Frozen foods thawed in refrigeratior helping to reduce power demand for refrigerator.
		Thaw all foods before cooking unless product characteristics prohibit.
		Foods are prepared in containers with lids on them.
		Fryers cleaned and oil filtered at least once a day.
		Food warmers and hot plates turned on only as needed.

Dishwasher - Water Heating

Yes	No	Dishwasher and Water Heating
		Turn water down to 75o F on closing, turn to 140o F two hours before opening.
		Drain water heater every six months.
		Use hot water only when necessary.
		Dishwasher run only when there is a full load.
		Hot water heater coils free from lime accumulations.
		Leaking faucets? Dripping water faucets are costly in water and energy use.
		Water pressure regulators on hot water lines to reduce wasted hot water.
		Hot water lines insulated?
		General-use hot water temperature 140o F. Taps at 110o F.
		Cleaning done during daylight hours?
		Mop from bucket to conserve hot water?

Source: Northwest Natural Gas Company Commercial Food Service Energy Conservation Checklist,

In the Kitchen

In some areas you will pay more for the electricity used by some refrigerator models during their lifetimes than you paid for the refrigerator. You can work with vendors to find the availability and cost of alternative models. Would it be cost effective for the school to replace its existing equipment? Are there other options such as cooking in a central facility and transporting the food to the school?

Pilot lights use as much as 30% of all the gas a range uses.

In an experiment, cooking the same recipes in the same kitchen with the same utensils, some cooks used twice as much energy as others. How?

a. Using pots about the same diameter as the burner.
b. Using lids on their pots
c. Using a pressure cooker instead of a regular pot
d. Turning off the burner off a few minutes before the dish is done.
e. Deciding what you want before opening the refrigerator door.
f. Taking from the refrigerator everything you need for a meal all at once and quickly.
g. Running only full loads in the dishwasher.

In the Laundry

Some schools have a laundry. If so, this can present opportunities for savings. Opportunities can include;

> Doing only full loads. This saves hot water and electricity. Many items can be washed in cool water and almost everything can be rinsed in cold water.
>
> Warming up a clothes dryer takes energy. Save energy by drying loads one right after another without letting the dryer cool off.
>
> Keep the lint filter of the dryer clean. A clogged filter keeps air from circulating and that means the dryer has to run longer to dry a load.

Recycling Materials
Schools in Eugene were able to save by recycling paper milk cartons from the lunch room. A special station was developed to enable students to crush the cartons before leaving them in specially marked containers. By recycling paper, milk cartons and other materials, the schools are able to reduce the amount of waste picked up by the garbage hauler. This can be a significant savings as well as being benefitial to the environment. Become familiar with your school's solid waste contract and resources in your community relating to solid waste. In many communities there are individuals and organizations who will help you set up a program that is appropriate for your school and geographic area.

Using materials over again can save energy. For example, it takes about 20 times more energy to get aluminum from ore (bauxite) than from used cans.

Buying items and selecting options that will last a long time, can be repaired if they break, are made from recycled materials, can be recycled, and have a minimum of packaging is an excellent way of saving energy.

Recycling programs emphasize the three R's.

REDUCE
REUSE
RECYCLE

Chapter VIII: The Project Report

The Project Report

Once you have completed the work in this book you are ready to assemble your data, create the necessary graphs and overheads and make formal energy recommendations. Your job is to make an appointment with the decision maker responsible for operation and maintenance of the building to present the energy audit findings of your team.

As a group, take the information you have collected and make a set of formal recommendations on how to save energy at your school. There is no magic number so you may have more, or less recommendations than in this table. However, you should try to identify the major sources of energy use and evaluate how much it will cost to implement the recommendation. Further, estimate payback by comparing the cost of your recommendation divided by the energy saved each year. For example, if it costs $18,000 to do a lighting retrofit that saves $6,000/year the payback is $18,000/$6000yr = 3 yr. Use this information to help prioritize your recommendations. Emphasize those that you feel should be done first. Reasons for a particular priority can be economic but it can also be for other reasons, to improve the safety, quality, or comfort in a particular space, to take advantage of planned maintenance or to the need to replace a particular piece of equipment, or to capitalize on the interests of particular teachers, students, or maintenance personnel.

Energy Savings Recommendation	Cost of recommendation	Projected energy savings/yr	Payback(years)

Preparing for the Presentation

1. Prepare graphs, charts, and tables. Decide how you want your audience to encounter the material. Choose the clearest way possible to get your point across. Remember that you now know a lot more about your school’s energy use than the people in your audience.

a. overheads
b. handouts
c. demonstrations

2. Contact your school principle to determine which audience should hear your material and make an appointment to be placed on the agenda.

3. Invite guest speakers (energy auditors from local utility company) that will support your data and make sure that your parents are allowed to see your team's presentation.

SUPPLEMENTAL MATERIALS

ENERGY AND THE ENVIRONMENT

Environmental Costs of Energy (Externalities)

Economists call a cost that is not reflected in the purchase price of the product or service an externality. For example, people who buy gasoline for their cars do not pay for many of the costs associated with the production of cars or fuel. The Environmental Protection Agency (EPA) estimates[1] that (on a national average) for every kilowatt-hour of electricity produced; 1.5 pounds of carbon dioxide (CO_2), 5.8 grams of sulfur dioxide (SO_2), and 2.5 grams of nitrogen oxides (NO_2 and NO_3) are produced. This may not seem like a lot but when we look at these values with respect to national energy production the amounts are enormous. If energy-efficient lighting were used everywhere it was profitable, the nation's demand for electricity could be cut by more than 10 percent. This would result in the following reductions:

- 202,000,000 metric tons of the greenhouse gas carbon dioxide (4 percent of the national total or the equivalent of the exhaust emitted from 44 million cars).
- 1,300,000 metric tons of sulfur dioxide (7 percent of the national total).
- 600,000 metric tons (4 percent of the national total).

1. The EPA estimates reflects the mix of sources used to produce electricity nationally. Regionally, there will be differences based on the specific mix of resources used to produce electricity. For example in the Pacific Northwest, a significant percent of electricity is produced from hydroelectric resources. Electricity use in that region will have more impacts on fish and other river related impacts than in other regions.

Exercise: Evaluate the Externalities of Incandescent vs. Fluorescent Lamps

Recently I went to a store and purchased a standard 60 Watt incandescent bulb for $0.43 and a 9 Watt compact fluorescent bulb with adapter for $9.95. Both produce the same amount of light. Which bulb was cheaper? In terms of the price of the product the incandescent bulb was about twenty times more expensive. Complete the table that follows using these values:

	Incandescent bulb	Fluorescent bulb
Price	\$0.43	\$9.95
Lifespan (hrs)	1000	10,000
Energy used per hour (W)	60	9

Externalities per kilowatt-hour:

Carbon dioxide CO_2 .... l.5 lbs
Sulfur dioxide SO_2....... 5.8 grams
Nitrogen oxides NO_x .. 2.5 grams

When you buy a light bulb you are really buying both the light and the energy necessary to operate that light. Complete the table and answer the questions that follow. To make calculations simple, lets evaluate the cost of 10,000 hours of light using the incandescent and compact fluorescent bulb given in the above example.

Bulb type	Cost[1]	Cost 10,000 hr	Watts	KW	Energy cost ($.06/KW)	CO_2 Grams	SO2 Grams	NOX Grams
Incand.	$0.43							
Comp. Fluor..	$9.95							

1. Incandescent bulb lasts 1,000 hours; Compact Fluorescent bulb lasts10,000 hours.

Financial costs:

1. What is the cost of 10,000 hours of light using incandescent?

____

Hint: ($4.30 bulbs + $36.00 energy)

2. What is the cost of 10,000 hours of light using compact fluorescents?

____

3. The Incandescent bulb uses_____% more electrical energy than the compact fluorescent bulb.

Environmental Costs

4. The Incandescent light produces _____% more carbon dioxide than the compact fluorescent lamp.

5. The Incandescent light produces_____% more nitrogen oxides than compact than the fluorescent lamp.

6. List a problem associated with increasing amounts of carbon dioxide CO_2 in the environment:

____

7. List three problems associated with increasing amounts of *sulfur dioxide* SO_2 and *nitrogen oxides* NO_x in the environment:

1.____

2.____

3.____

By now you already know a lot more about energy than most people. In terms of energy, many of us think about energy the same we do as with death and taxes, as unavoidable fixed costs of living. Energy costs are neither unavoidable nor are they fixed. You already know that to buy light there is the cost of the light bulb and the cost of the energy it takes to run the light. According to the EPA, fluorescent lamps, even though they are very efficient when compared to incandescent lamps have large energy costs. In fact, 90% of the cost of fluorescent light is energy, 6% of the cost is in the materials of the lamp, 3% in the labor to produce the lamp, and 1% in recycling costs. Fortunately, new technology has dramatically improved the efficiency of fluorescent lights from about 45% to over 90% in some cases.

Energy Costs in the Future

Question:

Based on what you have read, seen on television, or have heard from others what do you think energy prices, in dollars $$, are likely to do in the future?

_____ stay the same
_____ go up
_____ go down

Team Exercise

Identify the reasons why energy costs may go up such as adding the cost of externalities (pollution clean up, de-acidification of lakes, etc) to the rate people pay; increased demands; increased costs of production and why energy costs may go down such as advances in technology, changes in consumer behavior, etc.

	Reasons for Energy Costs Increasing	Reasons for Energy Costs Decreasing
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

THE “PHYSICS” OF ENERGY USE

Non-energized Systems

The Building Envelope

Buildings are like "leaky boats" in that the air you have heated or cooled tends to leak to the outside environment whenever there is a temperature difference. The temperature difference however is why you heated or cooled the air in the first place! The factors which influence heat loss and heat gain from a building include how it is oriented to the sun, its surroundings and design features such as size and placement of windows, the materials insulating the walls and ceilings, the infiltration (how much air leaks into and out of the building), and energy using equipment in the building such as lights, computers, fans, space and water heaters etc..

Heat Loss. Heat travels through three mechanisms; conduction, convection, and radiation.

Convection: Heat transfer through convection occurs when the hot or cool air moves from one space into another. As air leaks into a building, infiltration, or out of a building, exfiltration, it takes with it whatever energy it contains. Infiltration refers to the passage of outside air into a building through cracks around windows and door jambs, doors and windows left open or broken, and outside air dampers that do not close tight. Being in a building is like being in a leaking boat. You have to bail water as fast as the water enters or you sink. The bigger the hole, the faster you must bail, and bailing is work! In buildings, during winter months, the cool outside air entering the building must be heated. During summer, warm outside air entering the building may be cooled; many schools which in the past haven’t operated in the summer generally were not air conditioned. In buildings that are occupied throughout the year, infiltration causes heat gain in the summer and heat loss in the winter. In many cases additional energy must be used to humidify (add water vapor), dehumidify (remove water vapor) or filter the outside air. When warm air enters an air conditioned space money is leaking out; when cold air enters a heated space, money is leaking out. It takes energy ($) to both heat and cool indoor spaces.

Ventilation: Ventilation is the function of the mechanical ventilation system that draws in fresh outside air. Ventilation impacts the heating and cooling system the same way that infiltration does but in much greater quantities. The rate of ventilation is referred to in terms of cubic feet (of air) per minute, or CFM. The greater the CFM, the more heating or cooling is required to offset the heat loss or heat gain caused by the unconditioned air that is brought into the building. When it can be done while maintaining safe indoor air quality, a way to achieve quick energy savings with virtually no expense -- involves reducing the ventilation rate.

Energized, non-energized, and human systems all affect infiltration. If a building's air handling system maintains a positive or negative air pressure in the building (interior air pressure differs from exterior pressure); then the mechanical air handling system is itself creating forces that bring outside air into the building. In home with ducted furnace systems, researchers have recently found that leaks in the ducts increase home heating requirements by about 25% on an average. Non-energized systems are involved because the condition of the building's exterior envelope, doors, windows, etc. determines the number, size and location of infiltration points. Human systems are involved because people are responsible for leaving windows and doors open, as well as for observing, reporting and correcting cracks or broken windows.

Conduction is how heat is transferred through a solid. Physically, it can be thought of as the motion of one molecule being transferred to an adjoining molecule. Thermal barriers are used to slow this transfer down and are defined as materials that slow heat flow such as a strip of non-conducting material (i.e. wood, vinyl, or foam rubber) that separates inside and outside surfaces and slows conduction of heat to the outside. The conductance of any material is measured by R and U Values. An R-Value is the resistance of an object to heat flow, the higher the value the more resistance to heat flow. A U Value is a coefficient expressing the thermal conductance of an object or a composite structure (i.e. wall or window) in BTUs per square foot per hour per degree F temperature difference. In buildings you want to have large R-Values and low 'U' Values to reduce heat flow.

Have you ever touched single pane glass in the winter on a cold day? Did you notice that the glass felt cold? If you touched the wall you noticed it was not as cold as the glass. Which had greater thermal conductivity?

_____ the wall_____ the glass

The rate of heat conduction depends on the composition of the various materials used in construction of the building envelope. This rate can be affected by, among other things, additional insulation or storm windows, especially on those portions of the buildings where most of the energy is being lost. This reduces thermal conductivity, in other words, it makes it harder for heat to move either in or out.

Why does metal at 0^o C feel colder than wood at 0o C?

Substances that have a high coefficient of conductivity are said to be good conductors of heat; heat flows through them rapidly. The best conductor of heat is copper whereas gasses are generally very poor conductors (good insulators). Wood is also a poor conductor because it contains lots of air bubbles. It is for this reason that cold metal feels so much colder than cold wood. The metal and wood may be at equal temperatures, but heat leaves the hand much more quickly when it is in contact with the metal than with the wood. The temperature of the portion of the hand making contact with the substance drops much more rapidly in the first case. It is safe to lift a kettle of boiling water by its wooden or plastic hand-grip, because the heat from the metal (which it is wise not to touch) enters the wood or plastic slowly enough for heat loss from the handle to keep pace.

Radiation is the transfer of energy through electro-magnetic radiation; a good example is the transfer of heat from the sun to earth. The amount of heat loss or gain occurring through conduction and radiation depends on a number of factors including the temperature difference between two objects or inside and outside. Heat is always transmitted from an area of higher temperature to an area of lower temperature. Unless “pumped” uphill through the application of work (like in a heat pump and refrigerator), heat always flows "downhill", from higher to lower temperature. Accordingly, during winter, heat flows from the inside to the outside. During summer the process reverses. Heat flow is similar to diffusion. Particles of matter (atoms or molecules) will diffuse from an area of high concentration to an area of low concentration. Water molecules (H_20) will diffuse (move from high concentration to low concentration) through a semi-permeable membrane, a process called osmosis. For example, you can smell perfume in a room because once it is released (an area of high concentration) it diffuses to the areas of low concentration (where you are standing).

Question

John and Karen were off the Oregon coast in a small boat fishing.
The boat capsized. It looks like it may take several hours before they are spotted.
If they had wet suits available should they put them on?

___ Yes, they must reduce heat flow from their bodies to retard hypothermia.
___ No, it will take more energy to put them on than they will save.

Equipment: Nearly all energized devices including lights refrigerators, radios, video machines, computers, business machines, coffee makers, and television sets contribute to heat gain. In some cases this heat, or some of it, can be recovered from one part of a building where it is not needed and ducted to another part of a building which requires heat. Internal heat gain is generally beneficial in winter because it provides heat which otherwise would have to be provided by mechanical systems. In summer months, of course, the mechanical cooling system must compensate for the heat gain from light sources and other energized devices such as computers, monitors, copy machines, and FAX machines.

Efficiency

Efficiency is defined as the proportion of usable energy that remains after each step of a transfer process. If each part of a system worked as efficiently as possible, the least amount of energy required to get the job done would be used. Although it is seldom achieved, this ideal is the ultimate goal of any energy management program and of this school project. There three methods of reducing energy use: (1) reduce the use of the system, (2) use the system more wisely, and (3) make the system more efficient.

Here is another example using cars: three methods can be used to reduce the energy consumption of a typical automobile. The first method is to drive the car less. It is a good approach if the car is used more than it is needed. Simply put, it suggests that cars don't use gasoline if you don't drive them. The second method considers driving habits such as driving the car at 50 MPH (the most efficient speed), avoiding panic stops and accelerating carefully. These behaviors relate to human habits and are similar to turning off unnecessary lights and closing exterior doors and windows when the heat or air conditioning is on. The third method ensures that all systems in the car that affect energy consumption are operating as efficiently as possible. Radial tires generally give better gas mileage than non-radials because of reduced rolling resistance. An engine with a plugged fuel injector or misfiring spark plug will use considerably more gasoline than one that is operating properly. Tires inflated to the correct pressure give better gas mileage than under-inflated ones. The exterior finish of the car, when waxed and smooth, has less wind resistance than one which is comparatively rough, and less wind resistance means the engine works less and more efficiently.

The function of an energy audit is to expose all the different ways in which energy consumption is affected and to create numerous options (choices) -- some more effective than others -- that can be implemented to reduce energy consumption. This means identifying numerous potential energy savings options then picking and choosing among those options to reduce consumption in a manner that is most compatible with the time, people, and budget available. Identifying sources of energy loss, then choosing alternatives to save energy is the goal of an energy audit.

Exercise

Question: Amy owns a 1981 Toyota Corolla and wants to get better gas mileage. She drives to and from school but not long distances. Should she: (Check one below)

_____ *Spend $29.95 for a wax job or*
_____ *Inflate her tires to the recommended level ?*

*Note: both of the above will increase efficiency but sometimes increases are large and sometimes they are small. Some are expensive and some are less expensive.

The example above is used to make an important point. Namely, that some energy saving options make sense and others do not. Systems analysts use the concept sub-optimization to describe improving a part of a system that has little effect on the overall performance of the system. For example, putting jeweled wheel bearings on a wheel barrow will not improve the overall performance of the wheel barrow. The energy saved by the slight reduction in wind resistance from the wax job would be hard to even measure whereas driving around town on under-inflated tires will cause substantial reductions in efficiency. Also notice that inflating the tires to the proper pressure cost noting. Later in this workbook you will be asked to think about options in terms of a cost/benefit ratio; simple payback; and the present and future value of money. These are methods to answer the question "is it worth it?"

Although a building is obviously different than a car, the basic principles remain the same. Maximum energy savings can be achieved by considering all of the options and the way these different options impact each other, the potential benefit versus the cost, and numerous other factors. It should be stressed, however, that maximum energy savings come from maximum efficiency. Using an untuned car less does not make it more efficient. However, if the car is driven less and driven well, and kept in tune, the least amount of energy ($$) is consumed each time the car is used.

ENERGY PERSPECTIVES

Energy; A historical, world perspective

Fossil evidence suggests that the most recent form of our species, Homo-Sapiens Sapiens, has lived on Earth for only about 40,000 years, a brief instant in the planet's estimated 4.6 billion year existence. During most of this time, we survived as nomadic hunter gatherers. More recently, the Agricultural Revolution (10,000 to 12,000 years ago) and the Industrial Revolution (155 years ago) radically changed our relationship with the planet's resources. Both of these revolutions increased the amount of energy available to man. The Agricultural Revolution freed man from relentlessly roving to search for food (energy) and allowed communities and civilizations to form. The Industrial Revolution began in England with the development of the steam engine in the 1840s. It enabled the use of energy from fossil fuels (coal) to power new technologies applied to food production and manufacturing. Since the Industrial Revolution, there has been an enormous increase in the average direct and indirect energy use per person in all developed countries.

Energy Used Per Person at Various Stages of Human Culture Development

Cultural Development	Kilocalories per Person/Day
Primitive	2,000
Hunter Gatherer	5,000
Early Agricultural	12,000
Advanced Agricultural	20,000
Early Industrial	60,000
Modern Industrial (other developed nations)	125,000
Modern Industrial (United States)	230,000

Notice in the table above that the average energy consumption of each of us in the United States is 230,000 Kilocalories per day while the rest of the developed world uses only 125,000 Kilocalories per day. In other words, we are using almost twice as much energy per person than people who live in countries like Germany and England. So what? We are finding that not only does energy cost money (we have always known that), but that many of the byproducts of energy production are destroying the environment and damaging our health.

The United States is the world's largest user of energy, with only 4.7% of the world's population, we use 25% of the world's commercial energy. It is breathtaking to consider that you, me and the other Americans use 230,000 Kilocalories per person per day. Since the average person eats about 2,500 to 3,000 Kilocalories per day this amount of energy represents what it takes to sustain about *ninety two people!*

A Biological Perspective

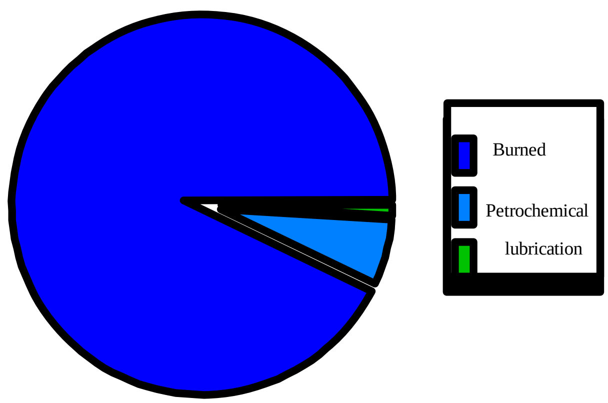
You are using and giving off energy every minute of the day. For example, your body continuously gives off heat equal to that of a 100-watt light bulb or, a hectowatt. The energy that you use to power your body (proteins, fats, carbohydrates) comes from the sun. Green plants can transform energy from sunlight to chemical energy through a process called photosynthesis. In brief, photosynthesis is called an endergonic reaction, it takes energy. Plants can combine carbon dioxide (an atmospheric gas) with water using energy from the sun to produce glucose. Plants can take glucose and make virtually everything they need including proteins, starches, fats, and waxes.

Products of Photosynthesis ($6CO_2 + 6H_2O$ --------> $C6H_{12}O_6 + 6O_2$)

The energy that you use to power your car (gasoline) or home (natural gas & electricity) also came from plants that converted the sun's energy to chemical energy. This energy, however is chemical energy that is millions of years old. Let's take a closer look at this type of energy and how it is used.

Energy Sources

How Fossil Fuel is Currently Used



Most of the energy we use exists in the form of *chemical energy (fossil fuels)* that was stored millions of years ago. Because it takes so long to naturally convert plant material to these resources it is referred to as nonrenewable. The main forms of fossil fuel that power industrial nations consist of *oil, coal, and natural gas.* Other forms of energy, such as the energy in the food you eat, comes from ongoing or recent conversion of sunlight to chemical energy through photosynthesis. Since these processes occur over a relatively short time period they are considered renewable.

Hydroelectricity is a form of solar energy that is converted to electricity by taking advantage of the water cycle. As water evaporates from the ocean and moves over land, it recondenses in the form or rain or snow. This water can be collected behind a hydroelectric dam where the stored water represents **potential energy** that can be converted to **kinetic energy** by spinning turbines to generate electricity. In the northwest, dams have already been built at about half of the locations where hydropower generation is possible. But, most if not all of the remaining locations are not likely to be developed because of concern about the environment .

Energy can also be obtained from nuclear fission reactions. Again because of concern for the environment people are increasingly looking to other alternatives for future energy resources. This includes wind (a solar resource), geothermal (using some of the heat from inside the earth), biomass (the use of plants), tidal energy, direct conversion of sunlight to heat or electricity, or instead of producing more we can learn how to use the energy we produce more efficiently; doing more with less.

A common misconception is that energy can be made or created. However, the First law of thermodynamics (energy) states that in any physical or chemical change, no energy is created or destroyed, but in these processes energy can be changed from one form to another. However, you can't get more energy out of something than you put in; in terms of energy quantity, **you can't get something for nothing.** The Second Law of Thermodynamics holds that in any conversion of heat energy to useful work, some of the initial energy input is always degraded to a lower-quality, more dispersed, less-useful energy, usually low-temperature heat that flows into the environment; you can't break even.

A simple way to visualize the First and Second law of thermodynamics is to see yourself as a farmer on a ten-acre plot. You and your partner have two children. Assume that you can grow enough corn to produce the 10,000 Calories per day your family will need. That's about 2500 Calories per person so no one in the family is getting fat. What if you develop a taste for fried chicken? Because a loss of energy occurs with each energy transfer, you will have a problem.

Average Energy Transfer in Food Chain

Food source	Kilocalories
Corn	**10,000**
Fed to Chickens	**1,000**
Chickens fed to Hogs	**100**

Question:

How many "fish" Calories would you end up with if the hogs were fed to fish in a commercial operation? ________ Cal..

Notice that only about 10% of the energy in the corn ended up in chickens and only 10% of the energy in chickens ended up in hogs. If you answered the question above, you noticed that feeding the hogs to fish in a pond made matters even worse in terms of energy. Where did the rest of the energy go? Because of the Second Law of

Thermodynamics, approximately 90% of the energy in a food chain is lost with each transfer, primarily in the form of heat. This type of transfer is like a thousand dollar bill that goes to $100 to $10 to $1 to $.10 (dime) to $.01 (penny).

It is because of the Second Law of Thermodynamics that many of the people in poorer countries are forced to eat low on the food chain where rice, corn, and wheat and other plant products are the primary food staples of the culture. Because it takes sixteen pounds of grain to produce one pound of meat, eating low on the food chain is a matter of survival rather than preference.

Although the Second Law of Thermodynamics mandates that you will always lose in a transfer process; there are some processes that result is less loss than others. Systems of energy transfer where loss is minimized are said to be efficient. Efficiency is simply finding ways to do more with less.

THE ENERGY IN FOOD

> Did you know? **?**
>
> The energy to raise food (a form of stored energy) is not just sunlight. On the modern farm it takes 3 gallons of petroleum to raise a hog and 30 gallons to raise an acre of peanuts.
>
> Most of the coal mined in the United States is burned to generate electricity -- Coal fired power plants are the largest source of electricity in the United States.
>
> If all the electricity used in a typical United States home for a year was provided by coal fired generation, it would use about <u>twenty tons of coal.</u>

Energy is necessary for the work performed by your body. The food you eat is organic, which refers to a molecule that contains the element, carbon. The food that we eat is used for both energy and building blocks for our body. Molecules in food that we use and have nutritive value are grouped into carbohydrates (contain carbon, hydrogen, oxygen), fats (contain carbon, hydrogen, oxygen) and proteins (contain carbon, hydrogen, oxygen, and nitrogen). These organic compounds have different amounts of energy. Proteins and carbohydrates contain about 4 Calories per gram; fats contain about 9 Calories per gram. Recently, the Gallup Poll conducted a study that involved a random survey of 1,004 Americans to find out if they knew how to figure how much fat they were eating. They found that only seven out of one hundred people (7%) could figure how much fat they were eating or how to convert fat grams into fat calories. You can now be in the top 90% of all Americans. On the back of a box of Original Wheat thins there is this information:

Serving size (1/2 oz 8 crackers)
Calories 70
Protein 1 gram = _____ Calories
Carbohydrate 9 grams = ______Calories
fat 3 grams = _______Calories

Question:

What percent of the calories (70) come from fat? ________
Hint: 1 gram of fat=9 calories; 3 grams of fat = 27 calories and 27 is 38.57% of the total.

It probably comes as no surprise that some foods have more energy in them than others. If you were asked to choose between a carrot and a candy bar to select the one that had the most energy, you would probably pick the candy bar, and you would be right. This also holds true for fuel types. For example, if you were heating your home with a woodstove, the type of wood used would make a big difference in heating. You can see that using black locust would provide about twice as much heat as an equivalent volume of basswood.

Fuel Values of Popular Firewood

Wood Type (air dried)	Heat value per cord of wood in millions of BTU's
Black Locust	26.5
Birch	24.7
Red Maple	19.1
Pine (Tamarack)	19.1
Pitch Pine	18.5
White Birch	18.2
Hemlock	15
Red Spruce	15
Balsam Fir	13.5
Basswood	12.6

*From: Residential Energy Auditor Training Manual, 1988. AHP Systems Inc.

There are two types of work performed by your body that use the energy we get from the food we eat: involuntary and voluntary work.

1. Involuntary work (basal Metabolism Rate/BMR)

This is the work done by the body in a fasting state (no food) and at rest. Energy is needed for vital life processes, e.g., breathing, heartbeat and circulation of blood, kidney function and all of the chemical reactions which are constantly taking place in the body. You are spending this energy when you are at complete rest, "doing nothing". All living organisms require energy. In fact, part of the definition of "life" is the ability to metabolize - to convert foods to release the energy necessary for the chemical processes of life.

General factors affecting basal metabolic rate/BMR:

Sex: Males have a higher BMR than females.
Age: BMR is highest during the first year of life and declines with age.
Surface area: The large the surface area to volume, the higher the BMR.
Diet: High protein diets increase BMR
Fever: The rate of energy burned rises 7% with each degree of rise in temperature.

As a general rule if your are a male you require 10.8 Calories (C=kilocalories) per pound of body weight every 24 hours. If you are a female you require approximately 10.5 Calories per pound of body weight every 24 hours.

Exercise: Calculate your Basal Metabolic Rate in Calories.

Male ______________________ X 10.8 = _________________*Cal. = BMR*
Your weight (lbs)
Female ____________________ X 10.5 = _________________ Cal = BMR

2. Voluntary Work.

All of the energy you need above the resting level is called "voluntary work". You did "voluntary work" when you got up this morning and came to school. You spend energy to contract your muscles to do any activity such as walking or running. The greater your activity level, the more calories you burn.

Your energy requirements depend on your type of activity. The higher the activity level the more calories you burn. This is similar to driving your car -- the faster you drive, the more gas you burn. For example, you burn 30% more gas at 65 miles per hour than at 55 miles per hour. You also burn more gas if you are towing a heavy trailer, driving uphill, or driving against the wind.

Type of Activity: Calories burned per pound of body weight per hour

Running 4.5 C	Bicycling 1.7 C.
Swimming 4.0 C.	Typing 1.0 C.
Dancing 2.4 C.	Eating a meal 0.7 C.
Walking Rapidly 2.2 C.	

A female requires only 86% of the amount of energy required of males. Activities such as those in the table above are how many extra calories you must consume to engage in them without losing weight.

As pointed out, the normal daily energy requirements depend on age, sex, weight, and activity level. The following figures represent the approximate number of calories necessary per day to maintain present weight in a moderately active 25 year-old male and female.

Female: Weight, 128 pounds - 2100 C. (16.4 Cal/lb.)
Male: Weight, 154 pounds - 2900 C. (19 .0 Cal./lb.)

John and Karen like their current weight and do not wish to gain weight (eat more calories than they burn) or lose weight (burn more calories than they eat). How many calories can both eat each day to maintain normal weight? Also figure this out for a male and female at your weight.

John (190 LB)____________Calories; Karen (120 LB)___________Calories.
You (male) ______________Calories (female) ________________Calories.
See what the difference would be if you were a different gender. Why do you think that, pound for pound, females use less energy than males?

SAMPLE RECOMMENDATIONS FOR CONSIDERATION

The Building Envelope and Interior

Most winter heat loss is through the roof, most summer heat gain is through the walls. Almost all buildings let air leak in (infiltration) (or out exfiltration). This is the first thing that many people fix.

Caulking: Cracks where neither side is supposed to move are sealed with a material called caulking. Most caulking comes in cartridges. The cartridges fit in an inexpensive "gun" that squeezes the caulking out of a nozzle like toothpaste from a tube. Caulking doesn't last forever. Some last only one or two years, some last more than ten years.

Indoor pollution: As people become more energy conscious and reduce infiltration (ventilation) in a building it becomes more important to be conscious of what is going on inside the building. In every house and building people do things to pollute the air. They smoke tobacco, fry food and glue things together. They use cleaners and polishes that evaporate, and hair sprays and paint. Often they store those items inside the house where they slowly leak their contents into the building. Plastics, particle board and even soil and stone may give off harmful gasses. Is air pollution created inside your school? (art room, shops, laboratories?)

______ yes ____ No

Conservation Recommendations: Commercial Buildings
Northwest Natural Gas Company

Envelope and General Building:

Caulk window and door frames to seal infiltration leaks.
Weather-strip all doors that go from heated to unheated areas.
Install ceiling insulation to current code.
Install floor insulation to current code.

Lighting:

Utilize fluorescent energy saver tubes and/or ballasts when replacement becomes necessary
Convert interior incandescent fixtures to energy efficient fluorescent lighting.
Convert exterior incandescent fixtures to higher efficiency lower wattage lighting sources, such as metal halide, or high or low pressure sodium lamps. Consult a lighting specialist.

Controls:

Adjust thermostat setting to 68o F in the heating season (winter) and 78^{o} F in cooling season (summer).

Locking covers should be installed on all thermostats.
Timed setback thermostats should be installed to insure proper control of your heating/cooling system.
One person should be given the responsibility for operation and control of the heating/cooling system.
have thermostats and other systems controls *inspected and calibrated to ensure proper operation.*

H.V.A.C. (Heating, Ventilation, and Air Conditioning) Maintenance:

Clean or replace the filters on all heating/cooling equipment on a monthly basis.
Inspect heat exchanging devices such as radiators, fin tubes and baseboards on an annual basis.
Repair all leaks in boiler and water lines to reduce heat loss and the need for additional water in the system.
Repair duct system leaks to reduce heat loss and provide a more even distribution of heat.
Outside air should be increased to provide your gas or oil fired heating system with sufficient combustion air.
Insulate warm and cold air ducts in unheated areas.
Clean fan blade cups to ensure that a proper amount of air is being distributed through your system.
Inspect belts for slippage and wear/or proper alignment on a yearly basis.

Water Heating:

Reduce water heater thermostat setting to 120^{o} F except where a higher temperature is specifically required.
Insulate hot water pipes in all unheated areas.
Install water flow restrictors on all shower outlets.
Lubricate circulating pumps on a quarterly basis.

Contact Energy Consultant for Additional Information:

Northwest Natural Gas Co.
220 NW 2nd Avenue
Portland, OR 97209.
(503) 226-4211

Metric Nomenclature

Because you will encounter a number of terms that assume knowledge of metrics, in fact you have already encountered the idea of megawatts, please review the table that follows for the metric meaning of "how much" we are talking about. If you were offered the following choices which would you take?

_______megadollar or _______kilodollar?
_______hectodollar or _______centidollar?
_______dekadollar or _______decidollar?

Check the table that follows to see how you did.

Multiples and Submultiples of Metric Units

Prefix	Meaning of Unit	Numerical Expression	Scientific
Giga	Billion	1,000,000,000	$1 X 10^{9}$
Mega	Million	1,000,000	$1 X 10^{6}$
Kilo	Thousand	1,000	$1 X 10^{3}$
Hecto	Hundred	100	$1 X 10^{2}$
deka	Ten	10	$1 X 10^{1}$
deci	Tenth	1/10	$1 X 10^{-1}$
Centi	Hundredth	1/100	$1 X 10^{-2}$
Milli	Thousandths	1/1000	$1 X 10^{-3}$
Micro	Millionth	1/1,000,000	$1 X 10^{-6}$
Nano	Billionth	1/1,000,000,000	$1 X 10^{-9}$
Pico	Trillionth	1/1,000,000,000,000	$1 X 10^{-12}$

So, would you like a megadollar _____ or a picodollar ______?

CHAPTER I SELF TEST

1. How many calories are derived from:

1 gm of protein __________ Cal.
1 gm of carbohydrates __________Cal.
1 gm of fat __________ Cal.

2. Matching:

___ Second Law of Thermodynamics
___ First Law of Thermodynamics
___ The amount of energy needed to "stay alive"
___ Kilocalorie
___ Therm
___ Kilowatt Hour
___ British Thermal Unit
___ *calorie*

a. The amount of energy required to heat 1 gram of water 1^{o} Centigrade
b. Basal Metabolic Rate (BMR)
c. An energy unit equal to the amount of heat required to raise one pound (LB) of water one degree Fahrenheit (59-60 ^{o})
d. Energy cannot be created or destroyed
e. Transfer of energy always results in a loss (heat)
f. The amount of energy required to heat 1000 grams of water 1^{o} C.
g. A unit of gas containing 100,000 BTUs
h. An electrical energy unit equal to 3413 BTUs

True/False:

1. ___ Sixteen pounds of grain fed to cattle will result in sixteen pounds of "beef".

2. ___ The human body is more efficient than a steam turbine or fuel cell.

Arrange from lowest to highest energy: (4=highest, 1=lowest)

____ BTU
____ Calorie (kilocalorie)
____ calorie
____ Therm