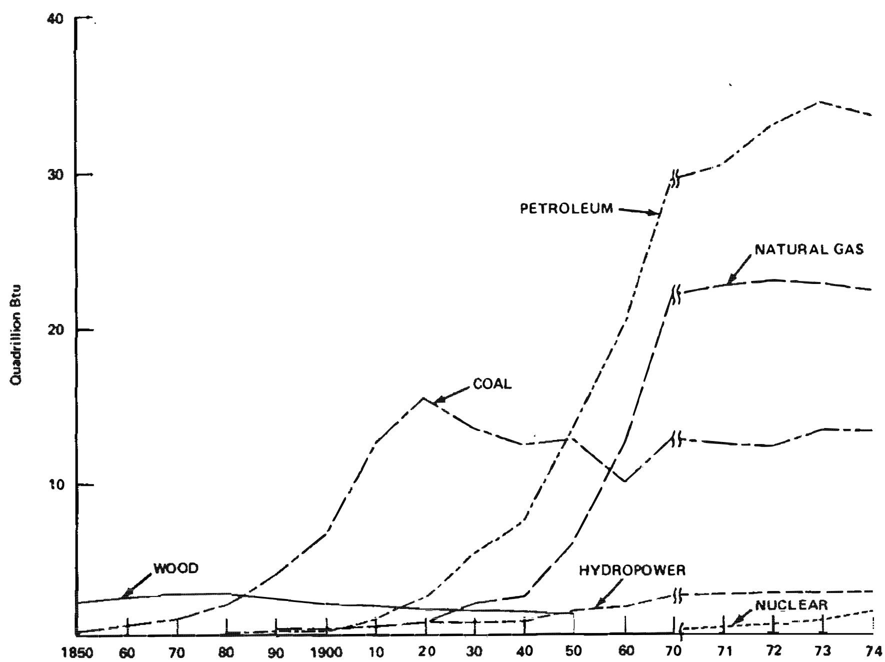
4-12 / U.S. ENERGY CONSUMPTION 1850-1975

U.S. Energy Consumption Trends, 1850-1974
(Quadrillion Btu)[1]

YEAR	COAL	PETROLEUM	NATURAL GAS	HYDROPOWER	NUCLEAR	FUEL WOOD	TOTAL
1850	.2	–	–	–	–	2.1	2.3
1860	.5	–	–	–	–	2.6	3.1
1870	1.0	–	–	–	–	2.9	4.0
1880	2.0	.1	–	–	–	2.9	5.0
1890	4.1	.2	.3	–	–	2.5	7.1
1900	6.8	.2	.3	.3	–	2.0	9.6
1910	12.7	1.0	.5	.5	–	1.9	16.6
1920	15.6	2.6	.8	.8	–	1.6	21.3
1930	13.6	5.4	2.0	.8	–	1.5	23.3
1940	12.5	7.6	2.7	.9	–	1.4	25.0
1950	12.9	13.5	6.2	1.4	–	1.2	35.2
1960	10.1	20.1	12.7	1.7	–	–	44.6
1970	12.7	29.5	22.0	2.7	.2	–	67.1
1971	12.0	30.6	22.8	2.9	.4	–	68.7
1972	12.4	33.0	23.0	2.9	.6	–	71.9
1973	13.4	34.7	22.8	2.9	.9	–	74.7
1974	13.0	33.8	22.3	2.9	1.2	–	73.2

[1] 1 Quadrillion Btu = 500,000 barrels petroleum per day for a year
= 40 million tons of bituminous coal
= 1 trillion cubic feet of natural gas
= 100 billion kWh (based on a 10,000-Btu/kWh heat rate)

Source: Energy Perspectives, U.S. Department of the Interior, February 1975.



Source: Historical Statistics of the United States, Bureau of the Census; U.S. Bureau of Mines.

U.S. energy consumption trends, 1850–1974.

Figure 9-4. U.S. Energy Consumption Trends, 1850-1974. (Source: Energy Handbook, Van Nostrand Reinhold, New York, 1978.)

Table 9-1. Energy Intensiveness of Typical Building Materials.

Material	Btus/Pound	Btus/Unit
Aluminum	41,000	
Ceiling Materials	1,500	
Concrete	413	
Concrete Blocks (8 X 8 X 16 inches)		15,200 per block
Copper	40,000	
Dry Wall	2,160	
Glass	12,000	
Insulation		
• Duct (1-inch/3-pound density)		51,400 per square foot
• Pipe (2-inch)		7,700 per square foot
• Building Board		2,040 per square foot
Paint	4,134	
Roofing		6,949 per square foot
Steel	13,800	
Vinyl Tile	8,000	

Roose, Robert W., *Handbook of Energy Conservation for Mechanical Systems in Buildings*, New York: Van Nostrand Reinhold Company, 1978, p. 35.

TRANSPORTATION SYSTEMS

Transportation systems represent approximately 25 percent of the total energy consumption of the United States. In their infant stages, industry and commercial establishments were located near navigational rivers and seaports so that their goods and services could be shipped to other regions and so that raw materials might be imported. Railroads, trucking and water-borne transportation have advanced the ability to ship large quantities almost anywhere. Air cargo has become a source of transportation for rapid service across long distances. American economy moves on the wheels, wings and ships of its transportation systems. At the same time, its cost in terms of energy consumption is high.

Transportation systems also serve the commuting public, whether it be for work, leisure, education or our daily living routine. Automobiles have fulfilled our primary needs for transportation, especially when petroleum products were low cost.

The United States has traditionally been dependent on petroleum-oriented transportation systems. Higher costs of petroleum and lower speed have decreased the use of automobiles and have forced us to focus more on mass transportation alternatives.*

The energy picture in transportation is complex because of the types of materials that must be moved, the schedules available, individual comforts, cost and the unpredictable energy source to power transportation systems. Let's look at the energy cost of moving people, i.e., the amount of energy required on the average to move from one location to another. A comparison

*Smith, Craig B., *Efficient Electricity Use—A Practical Handbook for the Energy Strained World*, New York: Pergamon Press, Inc., 1976, p. 303.

Table 9-3. Energy Consumption in a Water or Wastewater Treatment Plant.

1. *Pumping Costs.* Electric costs of conveying sewage, sludges, plant water, potable water, chemical slurries, dry chemicals and other liquid or semiliquid materials.
2. *Hydraulic Head.* Headloss due to hydraulic design must be evaluated. The model differentiates between hydraulic head and pumping head to draw specific attention to the cost of hydraulic losses.
3. *Equipment Power.* Energy requirements of unit process systems are evaluated by consideration of electrical power, steam, fuel and other energy uses. Consideration of energy required to exhaust or cool equipment areas because of excess equipment heat must be considered.
4. *Waste Energy Utilization.* Waste products are also a source of energy. Heat values of sewage sludge gases converted for use in space heating or as electrical energy must be included in an energy balance.
5. *Transportation.* Energy utilized in the transportation of sludges, chemicals and other materials contribute to a plant's energy consumption. Alternative transportation systems, haul volumes, distances and cost of disposal sites influence energy use as well as life-cycle costs.
6. *Lighting.* As in buildings, the type of fixture, controls and operating voltage influence power and energy use.
7. *Space Heating.* Comfort control in the form of heating, ventilating and air conditioning are often areas of wasted energy in a plant facility. In plant designs, major emphasis is placed on the system operation at the expense of support systems. Plant designs are also complicated by the heat generated by unit processes and equipment. Much of this energy can be converted to a useful source of heat. System design and control of mechanical HVAC systems are recognized in this section of the energy model.

   It should be noted that the building envelope and environmental systems should be evaluated as a part of an energy model for a water or wastewater plant.
8. *Chemicals.* Water and wastewater treatment processes offer many alternative solutions to treatment. Chemicals applied to the treatment process represent major costs of operation. These costs continue for the operating life of the facility. Chemical dosage rates are based on characteristics of the water or wastewater, flow rate, temperature, mixing energy required to get the chemicals into solution, pH, and the allowable detention time. Millions of dollars each year are wasted because of poor management of chemicals. We pause here to study the effects of chemical usages and the conditions under which they are used.
9. *Staffing Costs.* Cost of personnel for operation and maintenance of a facility are also part of the resources involved in a project. Costs vary with the wage scale, quality of workmanship, productivity, process requirements and working conditions.

BUILDING AND ENERGY DESIGN

Energy consumption for constructing and operating buildings represents approximately 30 to 40 percent of our total national energy usage. This is the equivalent of 70 quadrillion Btu of energy use.* It is estimated that approximately 30 percent of the total energy consumption in buildings could be eliminated through the use of energy conservation and the redesign of existing buildings and structures. New buildings are being designed with more emphasis on the efficient use of energy. Figure 9-10 is an illustration of the projected energy reduction that can be obtained from building design. Of this amount, it is estimated that approximately 39 percent of that energy use is directly related to building energy requirement. It is further estimated that approximately 13.6 percent of that amount could be saved through conservation, solar heating and other design modifications. This is certainly a sizable amount of our overall energy needs. It would also help to decrease our reliance on nonrenewable energy sources. To express this in terms of

*Watson, p. 50.

we know how to conserve energy. ASHRAE regulations now provide minimum standards in which to design building and occupied spaces. These determine the minimum U coefficient of transmission to ensure a minimum building standard for building insulation. Added insulation will save energy. In addition, the design criteria used to determine the number of air changes, and comfort levels used to design buildings greatly influence energy use. Building orientation, described later in this chapter, also impacts energy use.

ENERGY MODELS

A means of accounting for the energy uses for the construction and operation of buildings and plant facilities is needed. More specifically, it is necessary to know the areas within a building which are energy consumers and to learn how much energy a building uses as a comparison to the amount of energy that a building should use. The categories in a building that utilize or consume energy are the heating systems, cooling systems, ventilation, water heating requirements and lighting requirements. Other energy consumers include miscellaneous equipment which is specifically related to the function of the building. Cooking equipment, computer equipment and other machinery used within a building are a part of the power consumption and ultimate energy use within that structure. In addition to the areas contributing to energy consumption in a building, it is also important to be able to recognize the time span into which energy consumption occurs. Energy consumption is tailored to the months or seasons of the year to account for the changing weather conditions and the building systems that service the structure. Figure 9-12 is an energy model for a typical building design. Energy consumption in Btus is plotted along the ordinate, and the time frames in months of the year are plotted along the abscissa. Consumption rate in Btu square feet is also shown. Each of the energy-consuming sources in the building are plotted, and a total annual energy picture is projected.

Another example of an energy model for a building can be seen in Figure 9-13. This energy model also depicts the energy requirements of the shopping center. It also depicts the categories of heat-consuming processes. This model is used to account for the energy consumption used in a building. The purpose is to give the designer a sensitivity as to where energy is being consumed, the time of the year it is being consumed, and the impact of the change in operating hours and weather conditions that will alter energy consumption rates.

ANALYZING BUILDING ENERGY USE

Having discussed the energy model and its use, now let's look into the methods used to analyze energy consumption in a building. In his article "Energy Management for Commercial Buildings: A Primer,"* Fred Dubin outlines seven key steps in analyzing consumption in existing commercial buildings. These seven steps are as follows:

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*Dubin, Fred & Long, Chalmers, G., *Energy Conservation Standards for Building Design, Construction and Operation*, p. 207.