ENERGY, CULTURE AND STANDARD OF LIFE

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Contents

Summary

Energy, culture and standard of life are linked in complex ways that are often difficult to discern. These relations are examined in this chapter. In the first part, culture and standard of life are described. Then, the main energy forms and sources are discussed, including fossil fuels, non-fossil resources, renewable energy and electricity. Energy use is described, and its relation to population and urbanization for different countries is examined. The environmental impact of energy use is described, and such environmental concerns as global climate change, stratospheric ozone depletion and acid precipitation are discussed. Then, the impact of energy use on society, culture, standard of life and sustainability is discussed, and the task of achieving sustainable development described. Finally, possible energy-use modifications to improve standard of life and culture are addressed, including increased efficiency, fuel and energy-resource substitution, strategic planning, and the use of exergy analysis and other second-law analysis techniques. The differences between developing and developed countries are addressed throughout the chapter.

1. Introduction

In early civilizations, people relied extensively on fire. They burned wood to obtain sufficiently high temperatures for cooking and heating, as well as for melting metals, extracting chemicals and converting heat to work. During combustion, the carbon and hydrogen in wood combine with oxygen (O2) to form carbon dioxide (CO2) and water (H2O), respectively. The CO2 is then absorbed by plants and converted back to carbon, thereby becoming available for use as a fuel again. Since wood proved inadequate to meet all fuel demands and had other limitations, the use of fossil fuels (e.g., oil, coal and gas) began, at the time of the Industrial Revolution. These energy choices have had a strong influence on cultural and economic development and the standard of life achieved (including the state of the environment). For example, using fossil fuels has increased the CO2 concentration in air (see Table 1). Despite past warnings about the risks associated with emissions of greenhouse gases such as CO2, significant actions to reduce environmental pollution have not been taken and many researchers now believe that global warming is occurring.

This historical discussion demonstrates that energy, culture and standard of life are linked. The relations between these areas are often complex and sometimes difficult to discern, for both developing and developed countries. Historical data on global energy-resource use and related environmental emissions and impacts, from 1860 to the present, are given in Table 1.

	Year							
	1860	1880	1900	1920	1940	1960	1980	2000
Energy-resource use								
Global primary energy supply (millions of barrels of oil equivalent per day)	0.3	3	13	18	20	42	110	170
Global fossil fuel use (millions of tons of oil equivalent per day)								
All fossil fuels						2400	6000	8000
Oil						800	2800	3400
Coal						1500	1800	2500
Energy-related emissions								
Carbon emissions from burning fossil fuels (million tons)								
World						2400	5000	6600
Industrial countries						1500	2600	3000
Developing countries						470	1100	2800
Former East Bloc countries						500	1200	700
Energy-related environmental impacts								
Atmospheric CO_2 concentration (parts per million)	283	290	292	298	308	311	330	370
Average temperature at earth's surface (°C)	14.5	14.6	14.8	14.7	15.0	15.0	15.1	15.3

[a] Data are only available in source for last half century for items missing earlier data. Data for the year 2000 is based on extrapolations of data for the 1990s.

Sources: Barbour, I. (2000). Energy. *Technology and Society: A Bridge to the 21st Century* (ed. L.S. Hjorth, B.A. Eichler, A.S. Khan and J.A. Morello). Upper Saddle River, New Jersey: Prentice Hall; and Colonbo, U. (1992). Development and the global environment. *The Energy-Environment Connection* (ed. J.M. Hollander), 3-14. Washington: Island Press.

Table1. Selected Data for Energy-Resource Use and Energy-Related Emissions and Impacts[a]

Culture is usually loosely thought of as the form and stage of intellectual development or civilization. Energy choices are sometimes dependent on a society's culture, while at other times energy-related factors contribute to cultural changes and development.

Standard of life is often taken to be the degree of material comfort available to a community. The availability of energy resources (of sufficient quantity, quality and type) and the ability to utilize those resources have a strong influence on a society's standard of life. Yet the standard of life attained has a feedback effect on energy issues. For example, societies with a high standard of life are likely to have good education systems and extensive research and development undertakings that permit the development of energy technologies capable of harnessing energy resources more efficiently and with less environmental impact.

Environmental impact is often a significant consequence of energy use and strongly affects culture and standard of life. Environmental issues also affect the sustainability of a country's development in the longer term and thus are an important consideration.

In this chapter, the relations between energy, culture and standard of life are examined. First, culture and standard of life are described. Then, energy use, in the world and in countries, is described and its relation to population and urbanization are covered. The main energy forms and sources discussed are fossil fuels, non-fossil resources, renewable energy and electricity. Environmental concerns are discussed and the environmental impact of energy use is described. Then, the impact of energy use on society, culture, standard of life and sustainability is discussed, and needs for achieving sustainable development in countries are described. Finally, possible energy-use modifications to improve standard of life and culture are covered. The differences between developing and developed countries are addressed throughout the chapter.

This is the lead chapter for a series of chapters on energy, culture and standard of life (see *Natural and Additional Energy*). The chapter is intended to present a broad summary and evaluation of each of these areas and the interactions between them. For context, it is noted that this series of chapters on energy, culture and standard of life fall within the general theme of "basics of energy and energy-related education and training, organizations and standards." Topics in this theme include fundamentals such as thermodynamics, electromagnetism and nuclear physics, as well as more general subjects such as energy-related education and training, international information systems and codes and standards.

2. Culture and Standard of Life

An understanding of culture and standard of life is crucial to this chapter. However, these concepts often have different meanings to different people, and are imprecisely understood. Thus, for clarity, some definitions of these concepts are presented and discussed here.

Culture is a concept not easy to explain. Culture is defined in a general sense by the Oxford dictionary as the "particular form, stage, or type of intellectual development or civilization." The Webster's dictionary defines culture more specifically as "the concepts, habits, skills, art, instruments, institutions, etc. of a given people in a given period" or, more simply, "civilization." Some of the many factors that contribute to a culture include its standards for greetings and dress, social taboos, customs and traditions, crafts, local foods and dishes, and architecture.

Standard of life (or living) is a relative measure and not easily quantified. Standard of living is defined as the "degree of material comfort available to person or class or community" (Oxford dictionary), and as "a level of subsistence, as of a nation, social class, or person, with reference to the adequacy of necessities and comforts in daily life"

(Webster's dictionary). Some of the many factors that contribute to standard of life are listed in Table 2. In that table, some key social and economic indicators for selected countries are given.

	Argentina	Bolivia	Brazil	Colombia	Dominican Republic	Haiti	Hond-uras	Mexico	Nicara-gua
Social Indicators[a]									
Population									
Total population (millions)	36.1	7.9	165.9	40.8	8.3	7.6	6.2	95.8	4.8
Average annual growth (1992-98)	1.3	2.4	1.4	1.9	1.8	2.1	2.9	1.7	2.8
Urban Population									
% of total population	89	61	80	73	64	34	51	74	55
Annual growth	1.6	3.3	2.0	2.5	2.8	3.9	4.9	1.9	3.2
Poverty (% of population below poverty line)	18	n.a.	n.a.	18	21	n.a.	53	n.a.	50
Life expectancy at birth (years)	73	62	67	70	71	54	69	72	68
Infant mortality (per 1,000 live births)	19	60	33	23	40	71	36	30	36
Child malnutrition (% of children under 5)	2	8	6	8	6	28	25	n.a.	12
Access to safe water									
Urban[b] (% of population)	71	78	85	88	74	37	81	91	81
Rural[b] (% of population)	24	22	31	48	67	23	53	62	27
Illiteracy (% of population over age 14)	3	16	16	9	17	52	27	9	32
Economic Indicators[a]									
GNP/capita (Atlas method US$)	8,030	1,010	4,630	2,470	1,770	410	740	3,840	370
GNP (Atlas method, US$)	290.3	8.0	767.6	100.7	14.6	3.2	4.6	368.1	1.8
Industry contribution to GNP									
% of GNP	28.7	28.7	28.8	25.1	32.8	20.1	30.9	26.6	21.5
Average annual growth	3.2	n.a.	0.5	-2.3	8.8	6.1	9.0	6.6	4.6
Services contribution to GNP									
% of GNP	65.6	55.9	62.8	61.4	55.6	49.6	48.8	68.4	44.4
Average annual growth	4.7	n.a.	1.3	2.0	7.7	2.4	5.9	4.5	3.6

[a] n.a. = Not available
[b] Year of information varies (1991 to 1995).
Source: The World Bank. (2000). *World Development Indicators 2000*. Virginia: The World Bank Group.

Table 2. Key Socio-Economic Indicators for Selected Latin and Caribbean Countries (1998)

Culture and standard of life are not independent. They are related and details of either can affect the other. For example, a society with a high standard of life may have ample free time to devote to cultural development and consequently may develop a wide range of arts and skills, while a society with a lower standard of life may focus on the development of practical skills associated with basic necessities. Also, the cultural choices made by a society (e.g., placing a high value on economic wealth) can affect the standard of life achieved.

Energy issues clearly have an impact on culture and standard of life, while these topics in turn often affect energy choices. An abundance of energy resources can help a society achieve a high standard of living in terms of wealth, simply through harvesting the resources, although problems such as energy-related environmental degradation can also result in such situations. By extension, cultural choices, directions and development each can be affected by availability of energy resources. Yet the possession of abundant energy resources does not always lead to high living standards, and countries that have little or no domestic energy resources can often achieve high standards of life, often through developing a culture that highly values learning, knowledge and innovation.

We further examine the impact of energy use on culture and standard of life in Section 5. First, however, energy use and its impact on the environment are discussed in detail in the next two sections.

3. Energy Use

3.1. Population and Energy Use

3.1.1. The World

The world population is expected to increase, even if the birth rates decline so that the world population becomes stable, from 5.3 billion in 1990 and 6.0 billion in 2000, to about 10.5 billion in 2050. Thus, compared to 1990, world population is expected to double by the middle of the 21st century.

Economic development will almost certainly continue to grow in the future. Global demand for energy services is expected to increase from 1990 levels by as much as an order of magnitude by 2050, while primary-energy demands are expected to increase by 1.5 to 3 times.

In addition to increasing energy requirements, this anticipated population growth is likely to lead to increasing energy-related environmental problems such as acid precipitation, stratospheric ozone depletion and global climate change (the greenhouse effect). Simultaneously, concern regarding these energy-related environmental impacts is likely to increase.

These discussions demonstrate that energy is one of the main factors that must be considered in discussions of sustainable development, along with population and environmental degradation.

3.1.2. Developing Countries

The world population share of developing countries, which was less than 70% in 1960, is about 77% today, and is expected to reach about 85% by 2050. Although developing countries, with their present population of over four billion, represent about over three-quarters of the world's population, they are responsible for only a quarter of global energy use. Demographers predict that the total world population will top eight billion by 2005, and that roughly three-quarters of these people will continue to live in developing countries. The ability to provide energy services for the developing world must grow considerably to meet the extra demands expected in these countries and to ensure that their economic development is not constrained.

The population growth in developing countries is likely to lead not only to increasing energy requirements, but also to increasing energy-related environmental impact. Much of the population growth for developing countries will occur in metropolitan areas where there is a concentration of vehicles, industries and other emission sources, as well as significant deforestation.

3.2. Effect of Urbanization on Energy Use

In order to develop an understanding of the issues associated with global CO_2 emissions and other environmental impacts, the relationship between urban growth and energy use must be appreciated. The energy needs of cities are large and increase with both urban growth and industrial development.

Energy needs, however, are not the same everywhere. Energy policies and programs should account for this spatial differentiation. In some locations where wood is used as a fuel, increased efficiencies of wood stoves and charcoal kilns are required to make wood supplies sustainable. Such innovations may require greater education and information-dissemination efforts in many smaller cities, which appear to face greater wood fuel shortages.

In general, urbanization entails not only major changes in land-use patterns, but also shifts in the ways societies use energy. The transition away from “traditional fuels” (e.g., firewood, charcoal, crop residues) to such modern fuels and energy forms as petroleum, coal, natural gas and electricity is accelerated with urbanization. Urbanization is a growing trend in many developing countries, along with increased urban energy demand.

3.3. Energy-Use Growth Patterns

3.3.1. Worldwide Trends

Energy demand has grown rapidly since the sudden decrease in oil prices in the mid-1980s, e.g., world energy demand grew by 17% between 1986 and 1992. Even allowing for potential new energy resources, many feel that present growth in energy demand may not be sustainable.

Many methods are used to predict future energy use patterns. One widely recognized method is that of the International Energy Agency (IEA). The IEA uses two cases to project future energy use:
- the capacity constraints case, in which trends in past behavior are assumed to continue to dominate future energy-consumption patterns, and
- the energy savings case, in which greater energy-efficiency improvements are assumed to occur than suggested by past behavior.

World energy use projected using the IEA’s capacity constraints case is shown in Table 3. In this case, world demand for primary energy increases by more than 44% between 1992 and 2010, corresponding to an average annual rate of about 2.1%, to 11,489 million tonnes of oil equivalent (Mtoe). The average annual growth rate through this period for natural gas is 2.5%, the fastest among all fossil fuels.

	Year			
	1971	1992	2000	2010
Primary energy (Mtoe)				
Solids	1510	2301	2612	3280
Oil	2327	3109	3549	4394
Gas	896	1745	1979	2708
Nuclear	29	554	658	705
Hydro	104	192	245	312
Geothermal/others/renewables	4	34	57	90
Total	4870	7935	9100	11489
Final energy (Mtoe)				
Solids	814	915	1040	1255
Oil	1899	2602	3019	1780
Gas	582	1002	1128	1438
Electricity	461	1048	1276	1747
Total	1756	5567	6463	8220
Transformation and losses (Mtoe)	1114	2368	2637	3269
Electricity generation, by source (TWh)				
Solids	2165	4774	5946	7991
Oil	1100	1387	1313	1406
Gas	717	1652	2358	4423
Nuclear	111	2126	2520	2707
Hydro	1210	2235	2846	3630
Geothermal/others/renewables	5	46	83	166
Total	5308	12220	15066	20323
CO_2 emissions (Mt)	14707	21114	24073	30726
CO_2 emissions (% change since 1990)		-2.4	11.3	42.1
GDP per capita (1987 US$)		3511	3938	4699
Energy use per capita (toe)	1.30	1.46	1.48	1.64
Energy intensity (toe/1000$)		0.43	0.39	0.36

Source: *World Energy Outlook*. (1995). Paris: Organization for Economic Cooperation and Development and International Energy Agency.

Table3. Past and Projected Global Energy Consumption and Related Data (based on the Capacity-Constraints Case)

For the IEA's energy savings case, the projected values in Table 3 decrease by about 5-10%. World energy demand is projected to grow by less than 35% between 1992 and 2010 for the energy savings case, compared to the value of 44% predicted for the capacity constraints case. In the same period, world consumption of coal and other solid fuels is projected to increase annually at an average rate of 2% to 3280 Mtoe for the energy savings case, compared to an average rate of 1.6% to 3067 Mtoe for the capacity constraints case.

3.3.2. Fossil Fuels

Fossil fuels, particularly oil, natural gas and coal, are expected to continue to play an important role for at least the next century.

Average annual oil production rates are expected to range from as low as 1000 Mtoe, to as high as 3000 Mtoe using unconventional oil resources throughout the 21st century. If conventional oil resources are used, but with improved technologies, the average annual oil production rate is projected to take on an intermediate value of approximately 2000 Mtoe.

The next few decades should be a time of relative and absolute growth for natural gas. The resource base of natural gas is estimated to have more than doubled over the 20 years ending in 1990. Proven natural gas reserves are 100,000 Mtoe, which is equivalent to two-thirds of the proven oil reserves. Annual worldwide natural gas consumption is presently 1700 Mtoe. This value is likely to grow steadily to as high as 3000 Mtoe per annum as natural gas is increasingly substituted for oil, especially for electricity generation. The competition between natural gas and oil is likely to stabilize world oil demand close to current levels. Greater adoption of natural gas is expected in the transportation sector, in which over 700,000 natural gas vehicles already exist in the world, and in the electric power sector, especially if access to gas pipelines is improved.
The contribution of solid fuels to world energy supply is expected to remain close to the 1992 value of 29% of primary energy. A breakdown of worldwide consumption of solid fuels in 1992 indicates that hard coal accounted for 70%, lignite for 12.3% and other solid fuels for 15.5%. The contribution of solid fuels to world energy supply over the next century is projected to reach 8000 Mtoe under normal circumstances. This value is likely to decrease if additional environmental constraints are applied.

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Biographical Sketch

Dr. Marc A. Rosen is a professor in the Department of Mechanical Engineering at Ryerson Polytechnic University in Toronto, Canada. He recently completed a term as Department chair, and has served as Director of the Department's School of Aerospace Engineering. He has worked for such organizations as Imatra Power Company in Helsinki, Finland, Argonne National Laboratory outside Chicago, U.S.A. and the Institute for Hydrogen Systems, near Toronto.

Dr. Rosen obtained a B.A.Sc. (1981) in Engineering Science, and a M.A.Sc. (1983) and Ph.D. (1987) in Mechanical Engineering, all from the University of Toronto. He is a registered Professional Engineer in Ontario, and a founding associate editor for the "International Journal of Exergy." Dr. Rosen is a fellow of the Canadian Society for Mechanical Engineering, vice president of its Thermo-Fluids Engineering Technical Division and an editorial-board member of that society's journal *Transactions of the CSME*.

With over 40 research grants and contracts and 170 technical publications, Dr. Rosen is an active teacher and researcher in thermodynamics (particularly second-law, or exergy, analysis), energy-conversion technologies (e.g., cogeneration, district energy, thermal storage, renewable energy), and the environmental impact of energy and industrial systems.

Dr. Rosen has received many honours, including an Award of Excellence in Research and Technology Development from the Ontario Ministry of Environment and Energy in 1997, and the Sarwan Sahota/Ryerson distinguished scholar award in 1998.