part V

further information and reference material

annexes

ANNEX A: ENERGY UNITS, CONVERSION FACTORS, AND ABBREVIATIONS

TABLE A1. ENERGY CONVERSIONS*

To:	Terajoule (TJ)	Gigacalorie (Gcal)	Megatonne oil (equiv) (Mtoe)	Million British thermal units (Mbtu)	Gigawatt-hour (GWh)
From:	**Multiply by:**				
Terajoule (TJ)	1	238.8	2.388×10^{-5}	947.8	0.2778
Megatonne oil (equiv) (Mtoe)	4.1868×10^{4}	10^{7}	1	3.968×10^{7}	11,630
Million British thermal units (Mbtu)	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
Gigawatt-hour (GWh)	3.6	860	8.6×10^{-5}	3,412	1

* IEA figures. Additional conversion figures available at http://www.iea.org/stat.htm

TABLE A2. UNIT PREFIXES

k	kilo (10^{3})
M	mega (10^{6})
G	giga (10^{9})
T	tera (10^{12})
P	peta (10^{15})
E	exa (10^{18})

TABLE A3. ASSUMED EFFICIENCY IN ELECTRICITY GENERATION (FOR CALCULATING PRIMARY ENERGY)

Type of power	Assumed efficiency
Nuclear power	. 33
Hydroelectric	1.00
Wind and solar	1.00
Geothermal	.10

TABLE A4. UNIT ABBREVIATIONS

EJ	Exajoule
GJ	Gigajoule
Gtoe	Giga tonnes oil equivalent
GWe	Giga Watt electricity
GWth	Giga Watt thermal
ha	Hectare
km^2	Square kilometre
kWh	Kilo Watt hour
Mtoe	Million tonnes oil equivalent
MWe	Mega Watt electricity
PJ	Petajoule
t	Tonne
TWh	Tera Watt hour

ANNEX B: DATA CONSISTENCY

Energy is defined as the ability to do work and is measured in joules (J), where 1 joule is the work done when a force of 1 newton (N) is applied through a distance of 1 metre. (A newton is the unit of force that, acting on a mass of one kilogram, increases its velocity by one metre per second every second along the direction in which it acts.) Power is the rate at which energy is transferred and is commonly measured in watts (W), where 1 watt is 1 joule per second. Newton, joule, and watt are defined in the International System of Units. Other units used to measure energy are tonnes of oil equivalent (toe; 1 toe equals 41.87×10^9 J) and barrels of oil equivalent (boe; 1 boe equals 5.71×10^9 J), used by the oil industry; tonnes of coal equivalent (tce; 1 tce equals 29.31×10^9 J), used by the coal industry; and kilowatt-hour (kWh; 1 kWh equals 3.6×10^6 J), used to measure electricity. See also annex A, which provides conversion factors for energy units.)

Studies on national, regional, and global energy issues use a variety of technical terms for various types of energy. The same terminology may reflect different meanings or be used for different boundary conditions. Similarly, a particular form of energy may be defined differently. For example, when referring to total primary energy use, most studies mean *commercial energy*—that is, energy that is traded in the marketplace and exchanged at the going market price. Although non-commercial energy is often the primary energy supply in many developing countries, it is usually ignored. Non-commercial energy includes wood, agricultural residues, and dung, which are collected by the user or the extended family without involving any financial transaction. Because there are no records and a lack of data on actual use, most energy statistics do not report non-commercial energy use. Estimates of global non-commercial energy use range from 23-35 exajoules a year. In contrast, wood and other biomass sold in the marketplace is reported as solids (often lumped together with coal) and becomes part of commercial energy.

Traditional energy is another term closely related to non-commercial energy. This term generally refers to biomass used in traditional ways—that is, in the simplest cooking stoves and fireplaces—and is often meant as a proxy for inefficient energy conversion with substantial indoor and local air pollution. But traditional does not always mean non-commercial: wood burned in a kitchen stove may have been bought commercially and be reflected in commercial data. Estimates of biomass used in traditional ways range from 28-48 exajoules per year.

The term *modern* (or *new*) *renewables* is used to distinguish between traditional renewables used directly with low conversion technology and renewables using capital-intensive high-tech energy conversion such as solar, wind, geothermal, biomass, or ocean energy to produce state-of-the-art fuels and energy services.

Another issue concerns the heating value of chemical fuels assumed in statistics and analyses. The difference between the higher heating value (HHV) and the lower heating value (LHV) is that the higher heating value includes the energy of condensation of the water vapour contained in the combustion products. The difference for coal and oil is about 5 percent and for natural gas 10 percent. Most energy production and use are reported on the basis of the lower heating value.

Yet another source of inconsistency comes from different conversion factors to the primary energy equivalent of electricity generated by hydropower, nuclear, wind, solar, and geothermal energy. In the past, non-combustion-based electricity sources were converted to their primary equivalents by applying a universal conversion efficiency of 38.5 percent. More recently, hydropower, solar, and wind electricity in OECD statistics are converted with a factor of 100 percent, nuclear electricity with 33 percent, and geothermal with 10 percent.

The quality of data differs considerably between regions. Statistical bureaus in developing countries often lack the resources of their counterparts in industrialised countries, or data are simply not collected. Countries of the former Soviet Union used to have different classifications for sectoral energy use. Data reported by different government institutions in the same country can differ greatly, often reflecting specific priorities.

The composition of regions also varies in statistical compendiums and energy studies. At times, North America is composed of Canada and the United States—but it might also include Mexico. Except where otherwise noted, the following countries joined the Organisation for Economic Co-operation and Development (OECD) in 1961: Australia (1971), Austria, Belgium, Canada, the Czech Republic (1995), Denmark, Finland (1969), France, Germany, Greece, Hungary (1996), Iceland, Ireland, Italy, Japan (1964), Korea (1996), Luxembourg, Mexico (1994), the Netherlands, New Zealand (1973), Norway, Poland (1996), Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. Depending on when the data was collected, OECD data may or may not include the Czech Republic, Hungary, the Republic of Korea, Mexico, or Poland.

Finally, a word on the efficiency of energy conversion. Energy efficiency is a measure of the energy used in providing a particular energy service and is defined as the ratio of the desired (usable) energy output to the energy input. For example, for an electric motor this is the ratio of the shaft power to the energy (electricity) input. Or in the case of a natural gas furnace for space heating, energy efficiency is the ratio of heat energy supplied to the home to the energy of the natural gas entering the furnace. Because energy is conserved (the first law of thermodynamics), the difference between the energy entering a device and the desirable output is dissipated to the environment in the form of heat. Thus energy is not consumed but conserved. What is consumed is its quality to do useful work (as described by the second law of thermodynamics).

What this means is that a 90 percent efficient gas furnace for space heating has limited potential for further efficiency improvements. While this is correct for the furnace, it is not the case for delivering space heat. For example, a heat pump operating on electricity extracts heat from a local environment—outdoor air, indoor exhaust air, groundwater—and may deliver three units of heat for one unit of electrical energy to the building, for a coefficient of performance of 3. Not accounted for in this example, however, are the energy losses during electricity generation. Assuming a modern gas-fired combined cycle power plant with 50 percent efficiency, the overall coefficient of performance is 1.5—still significantly higher than the gas furnace heating system. ■

TABLE C.1. PRIMARY ENERGY USE PER CAPITA BY REGION, 1971–97

Region	1971 (gigajoules)	1980 (gigajoules)	1985 (gigajoules)	1990 (gigajoules)	1997 (gigajoules)	Change, 1990– 97 (percent)	Change, 1971– 97 (percent)	Annual growth rate, 1990–97 (percent)	Annual growth rate, 1971–97 (percent)
North America	266	276	258	263	272	3.7	2.4	0.5	0.3
Latin America	36	42	39	40	47	15.4	27.7	2.1	3.6
OECD Europe[a]	118	134	134	137	141	3.3	19.9	0.5	2.6
Non-OECD Europe[b]	76	108	112	108	84	-21.8	10.6	-3.4	1.5
Former Soviet Union	135	178	192	195	129	-33.9	-4.2	-5.7	-0.6
Middle East	35	61	72	77	95	23.9	175.9	3.1	15.6
Africa	23	26	27	27	27	0.1	17.1	0.0	2.3
China	20	25	28	32	38	18.8	93.6	2.5	9.9
Asia[c]	15	17	19	21	26	18.9	66.3	2.5	7.5
Pacific OECD[d]	94	113	117	142	174	23.2	85.1	3.0	9.2
World total	**62**	**69**	**69**	**70**	**70**	**-0.1**	**12.5**	**0.0**	**1.7**
Memorandum items									
OECD countries	161	177	173	181	194	7.0	20.4	1.0	2.7
Transition economies	124	165	177	180	121	-32.4	-2.0	-5.4	-0.3
Developing countries	20	25	27	29	34	16.0	66.2	2.1	7.5

a. Includes Czech Republic, Hungary, and Poland. b. Excludes the former Soviet Union. c. Excludes China. d. Includes Republic of Korea. *Source: IEA, 1999a.*

TABLE C.2. ELECTRICITY USE PER CAPITA BY REGION, 1980–96 (KILOWATT-HOURS)

Region	1980	1985	1990	1996
North America	8,986	9,359	20,509	11,330
OECD	5,686	6,277	7,177	8,053
East Asia	243	314	426	624
South Asia	116	157	228	313
Sub-Saharan Africa	444	440	448	439
Middle East	485	781	925	1,166
China	253	331	450	687
Transition economies	2,925	3,553	3,823	2,788
Least developed countries[a]	74	66	60	83
World	**1,576**	**1,741**	**1,927**	**2,027**

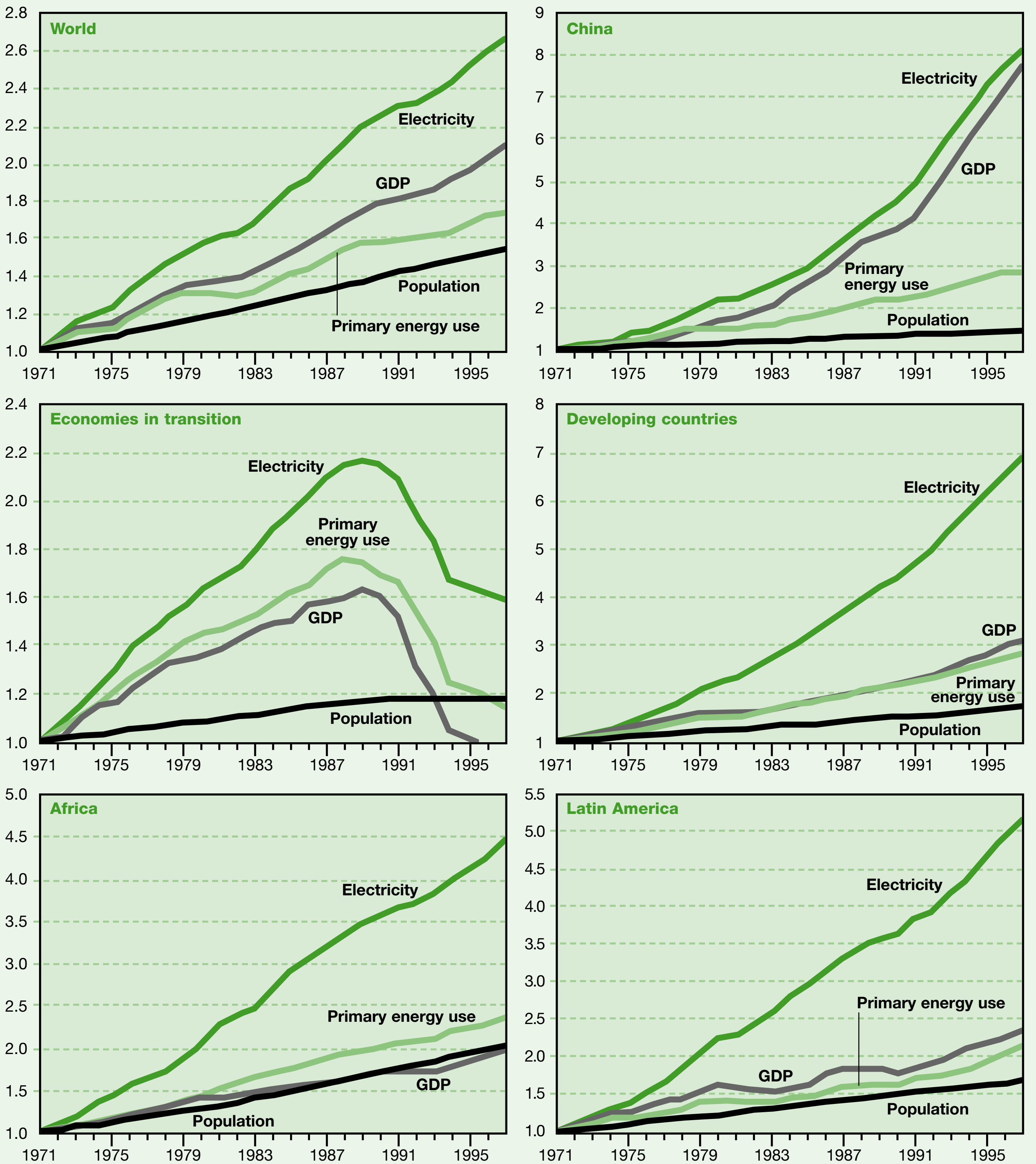
a. As defined by the United Nations. *Source: World Bank, 1999.*

TABLE C.3. ELECTRICITY DISTRIBUTION LOSSES BY REGION, 1980–96 (PERCENT)

Region	1980	1985	1990	1996
North America	6.9	6.8	7.0	7.6
OECD	7.6	6.8	7.2	6.4
East Asia	8.4	8.8	8.2	10.1
South Asia	19.4	19.1	18.8	18.7
Sub-Saharan Africa	9.2	8.6	8.8	9.6
Transition economies	8.4	8.9	8.4	11.0
Least developed countries[a]	11.0	15.8	20.3	20.9
World	**8.3**	**8.0**	**8.3**	**8.5**

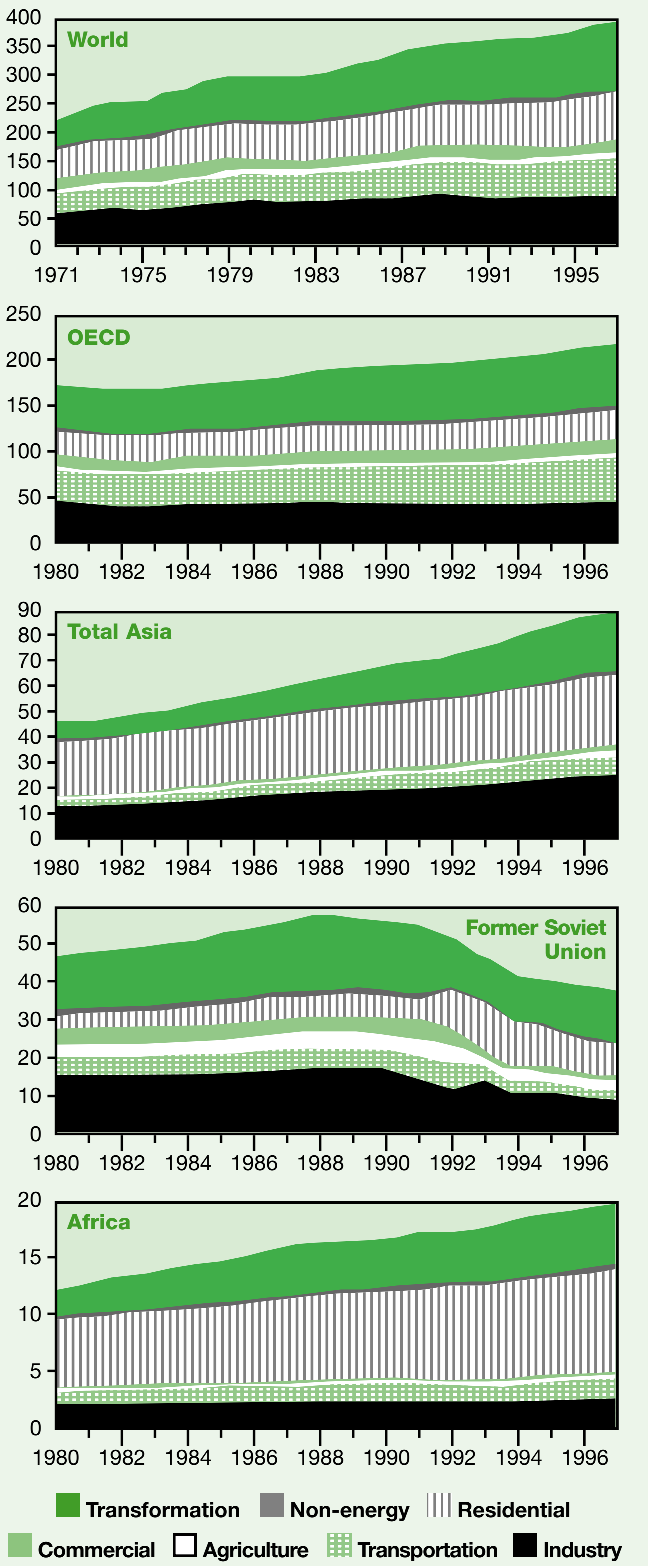
a. As defined by the United Nations. *Source: World Bank, 1999.*

FIGURE C.1. CHANGES IN GDP, POPULATION, PRIMARY ENERGY USE, AND ELECTRICITY USE BY REGION, 1971–97 (INDEX: 1971=1)



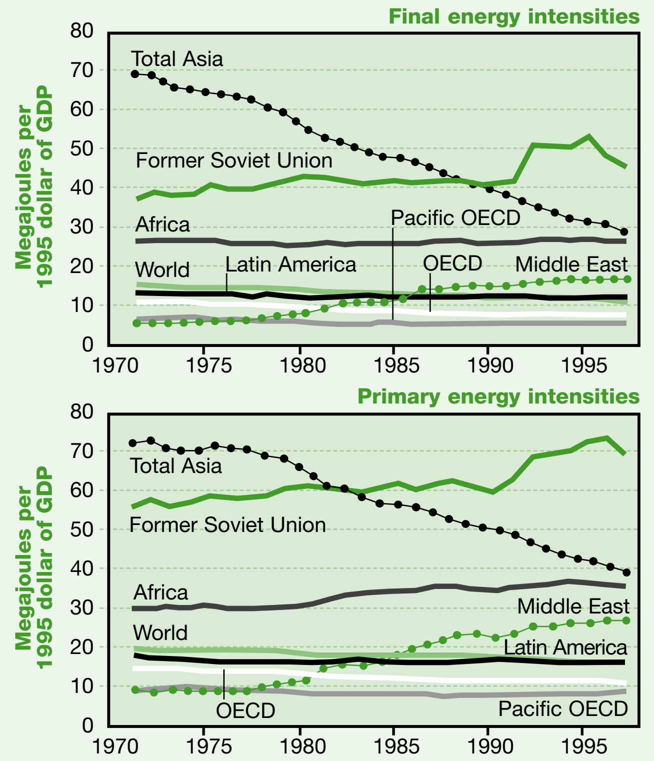
Source: IEA, 1999a.

FIGURE C.2. ENERGY USE BY SECTOR IN SELECTED REGIONS, 1980–97 (EXAJOULES)



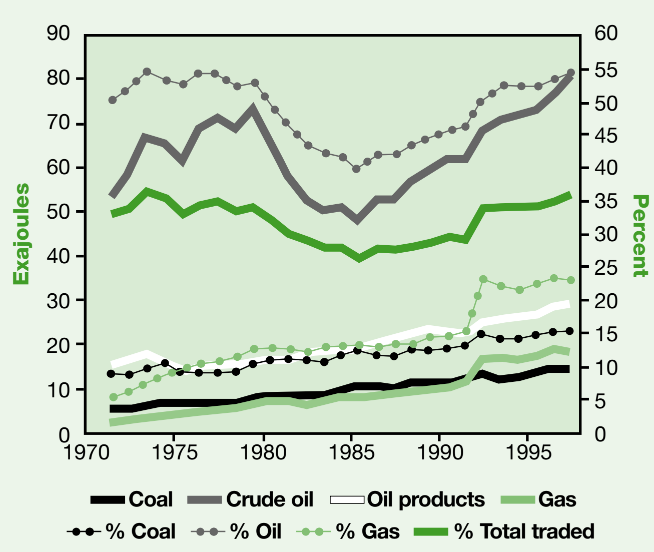
Source: IEA, 1999a.

FIGURE C.3. DEVELOPMENT OF PRIMARY AND FINAL ENERGY INTENSITIES BY REGION, 1971–1997



Source: IEA, 1999a.

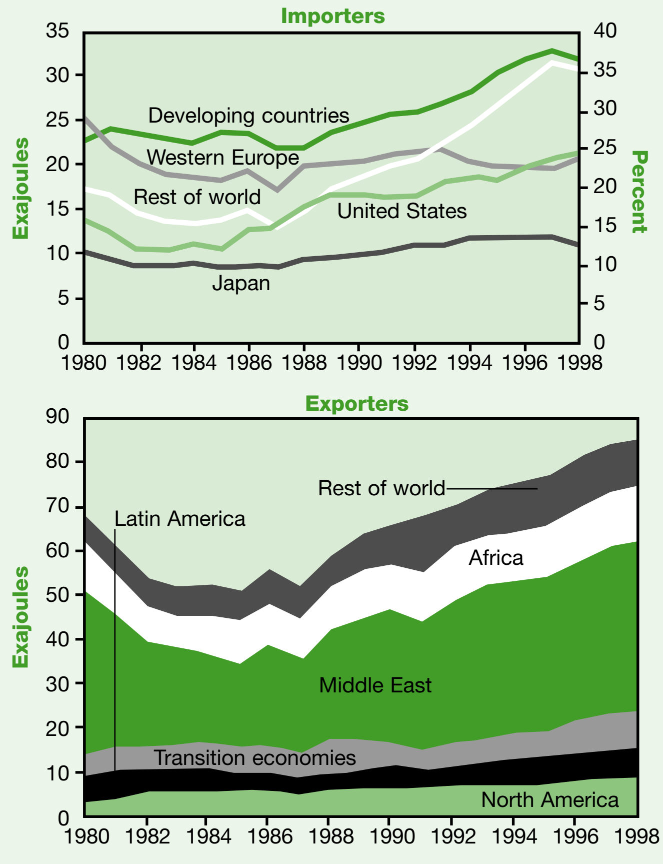
FIGURE C.4. GLOBAL TRADE IN CRUDE OIL, OIL PRODUCTS, COAL, AND NATURAL GAS, IN ABSOLUTE AND RELATIVE TERMS



Note: Total traded shows share of total specific fuel use that is traded, that is total traded energy/primary energy.

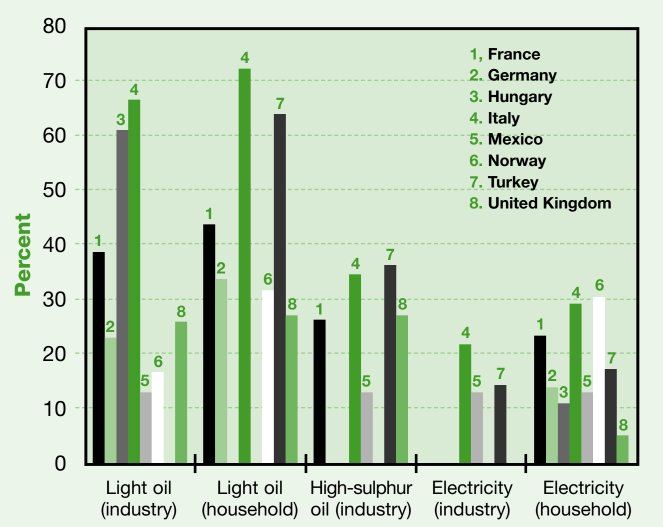
Source: BP, 1999, IEA, 1999a, World Bank, 1999.

FIGURE C.5. MAJOR OIL IMPORTERS AND EXPORTERS, 1980–98



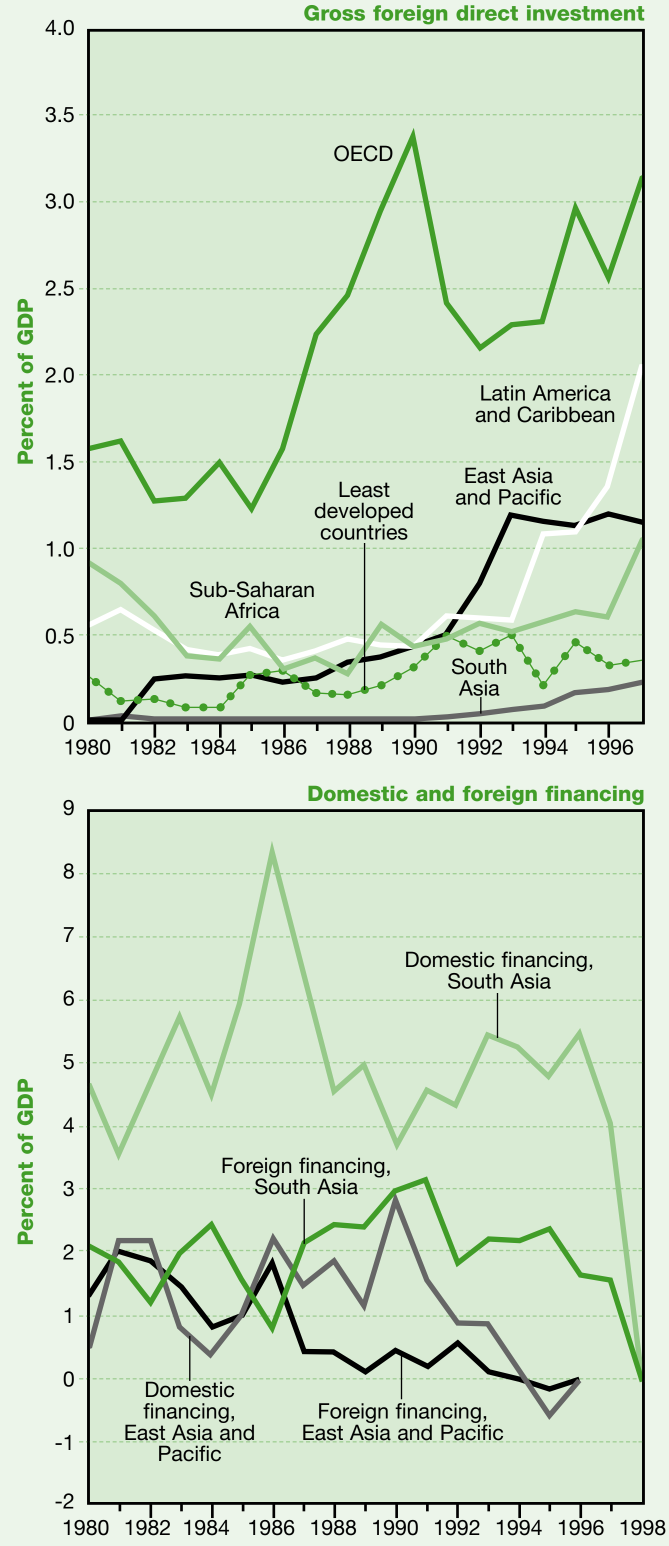
Source: BP, 1999.

FIGURE C.7. ENERGY TAXES IN SELECTED COUNTRIES, 1998



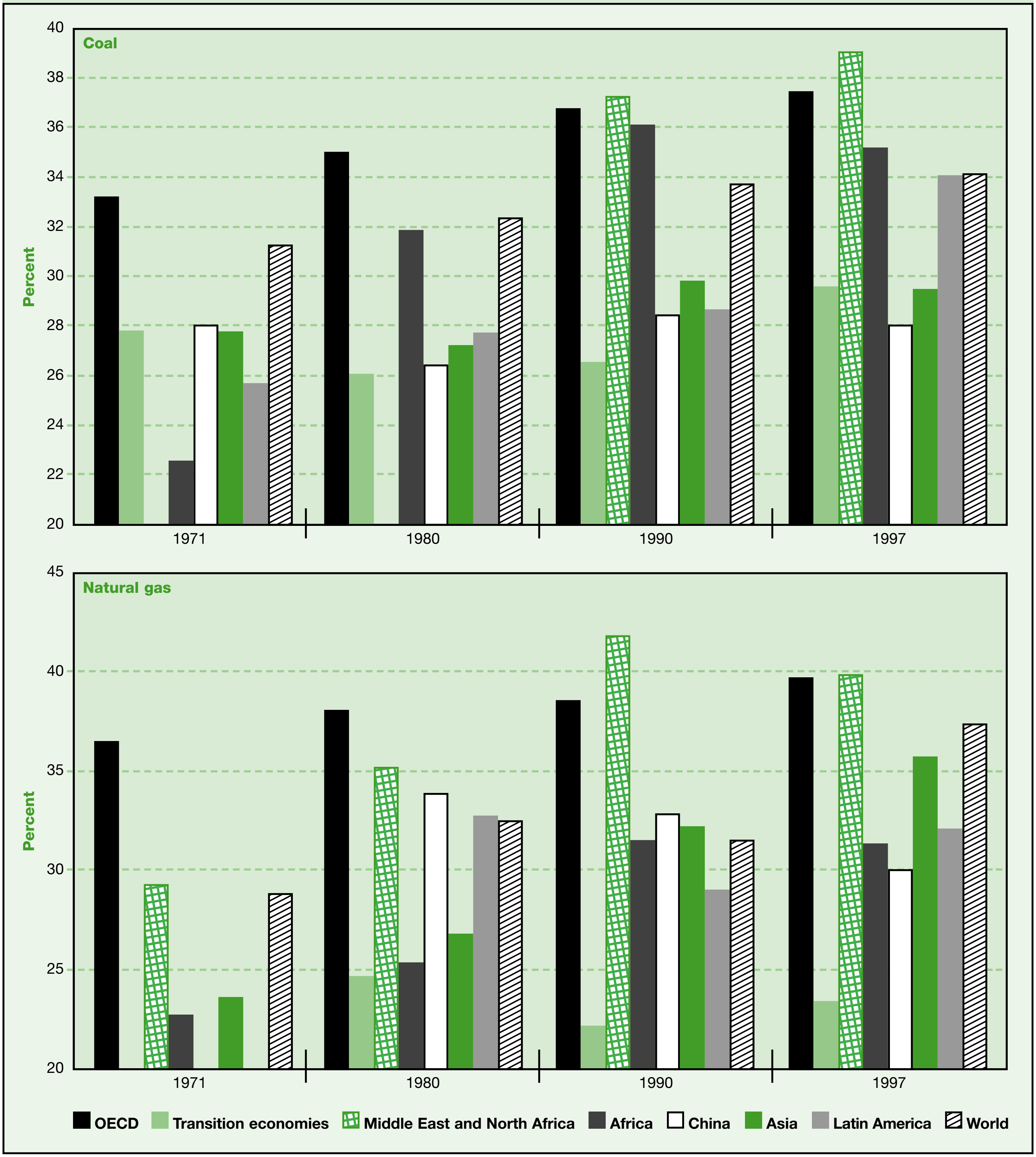
Source: IEA, 1999b.

FIGURE C.6. GROSS FOREIGN DIRECT INVESTMENT AND DOMESTIC AND FOREIGN FINANCING BY REGION, 1980–97



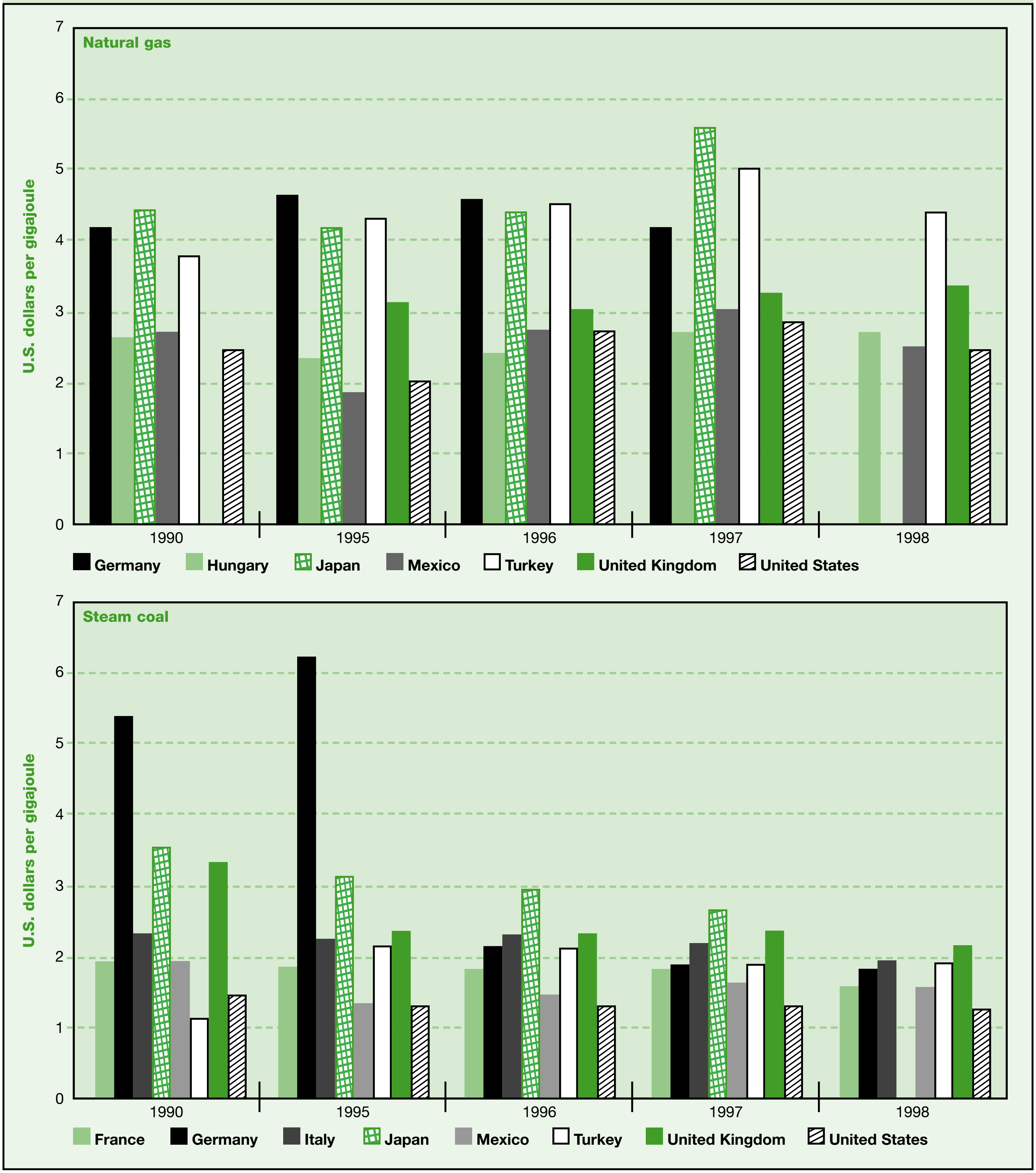
Source: World Bank, 1999.

FIGURE C.8. EFFICIENCY OF COAL-FUELLED AND NATURAL GAS-FUELLED ELECTRICITY GENERATION BY REGION, 1971–97



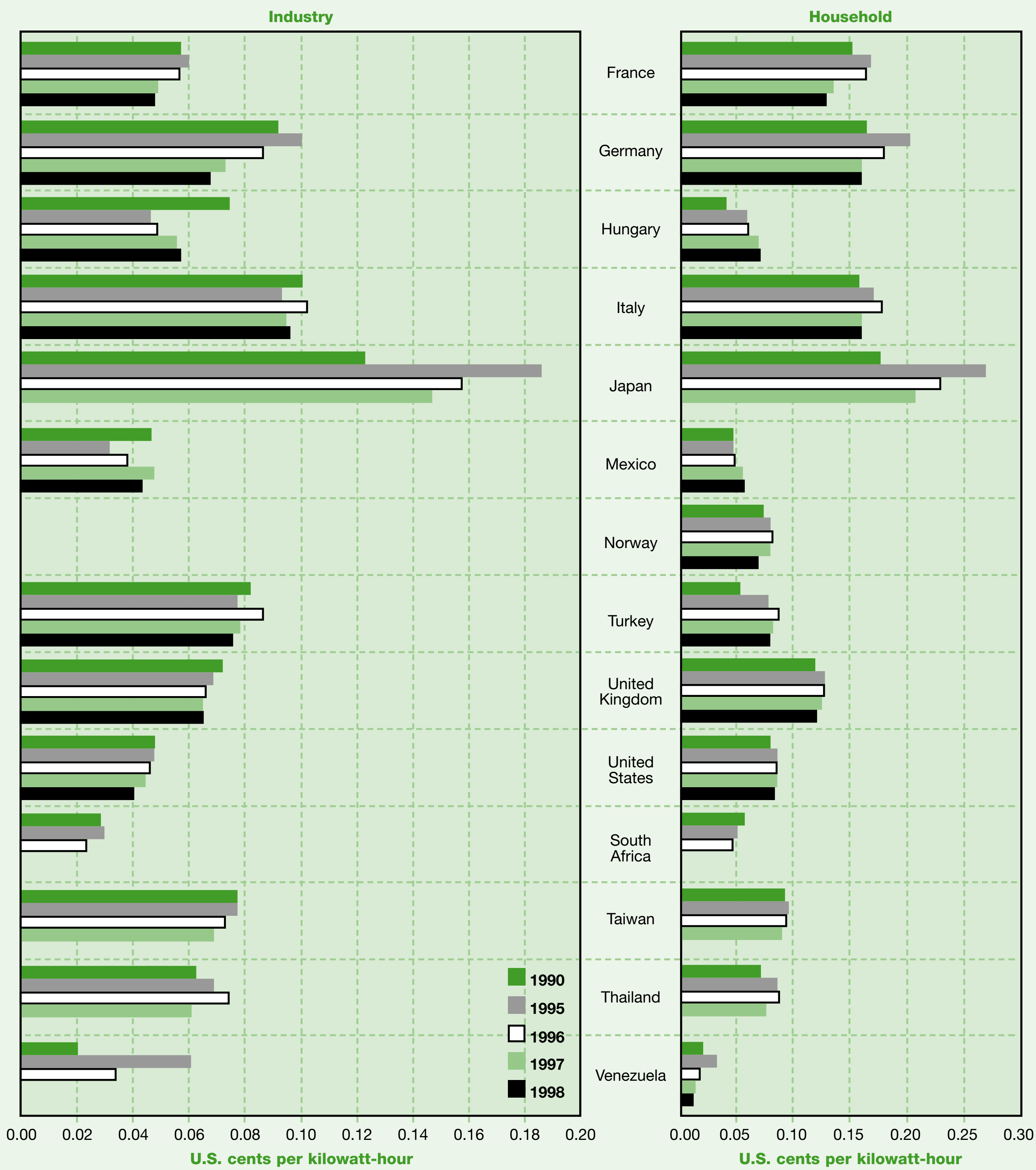
Source: Adapted from IEA, 1999a.

FIGURE C.9. NATURAL GAS AND STEAM COAL PRICES FOR ELECTRICITY GENERATION BY REGION, 1990–98



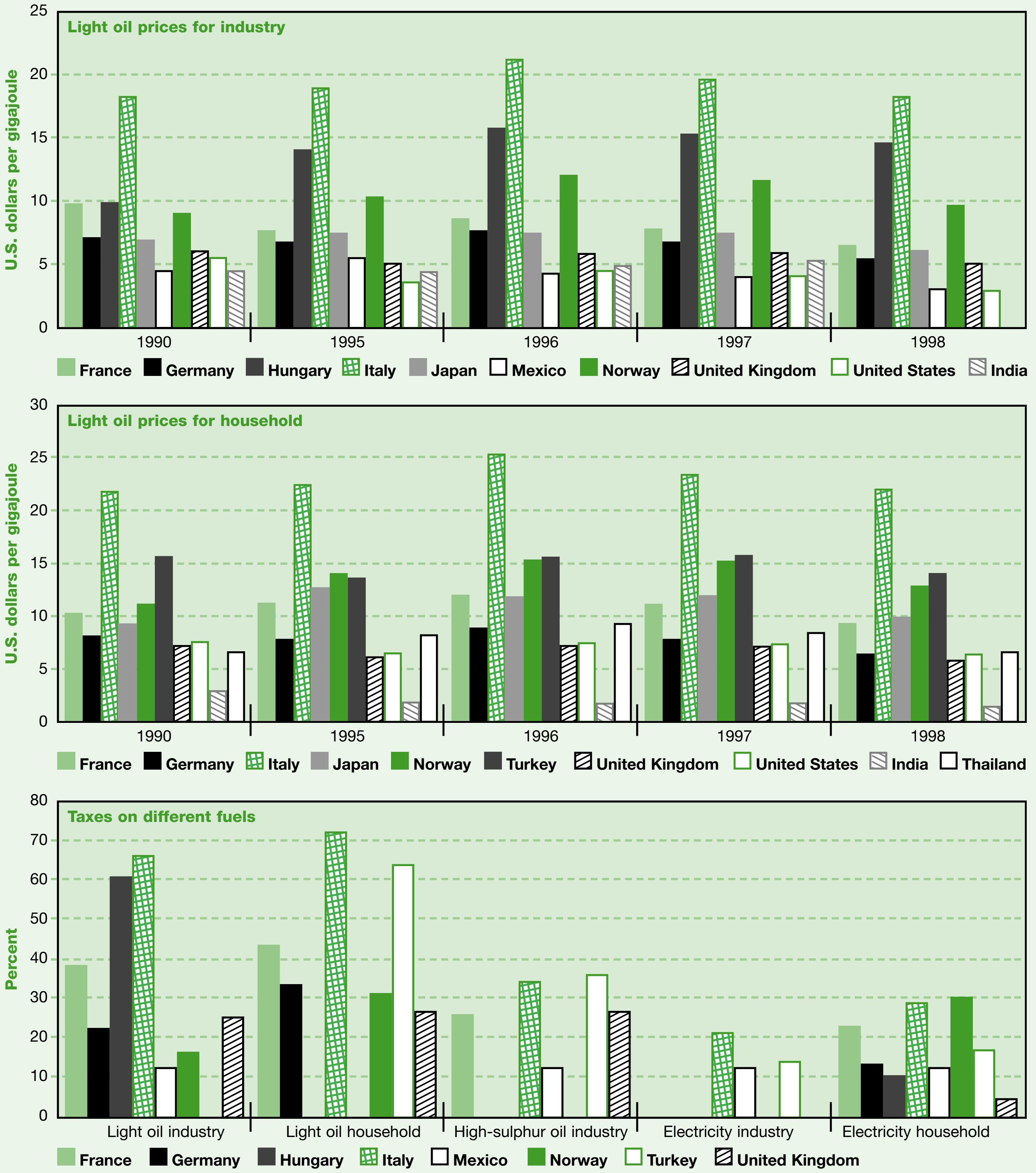
Source: IEA, 1999b.

FIGURE C.10. ELECTRICITY PICES IN SELECTED COUNTRIES, 1990–98



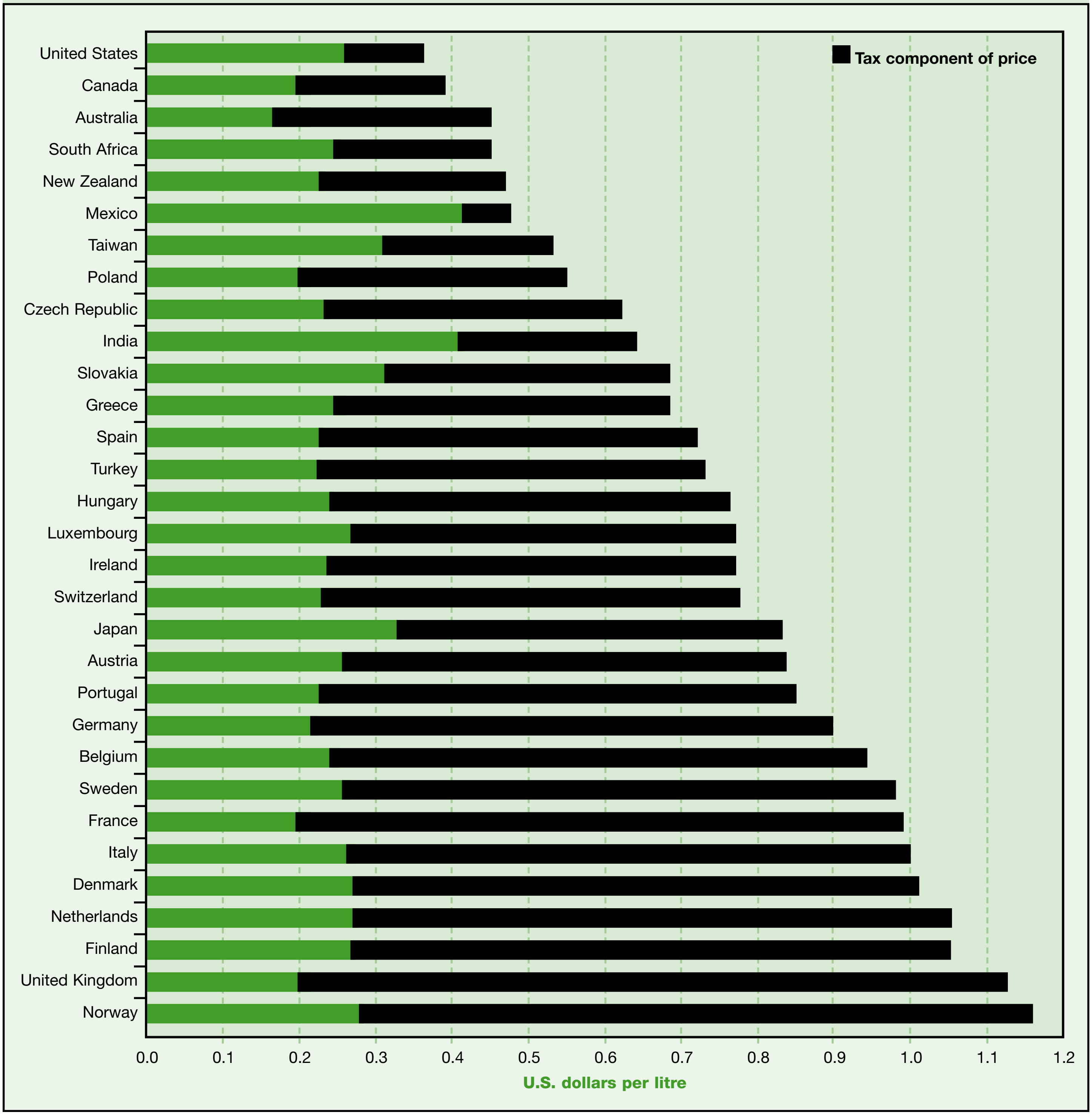
Source: IEA, 1999b.

FIGURE C.11. OIL PRODUCT PRICES IN SELECTED COUNTRIES, 1990–98



Source: IEA, 1999b.

FIGURE C.12. UNLEADED GASOLINE PRICES IN SELECTED COUNTRIES, 1998



Source: IEA, 1999b.

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ANNEX D: CARBON EMISSIONS

The fossil energy used in 1998 contained about 6.5 gigatonnes of carbon, down slightly from 1997. The slight reduction was caused by the economic crisis in East Asia, which curbed energy use in this fast-growing region, and China's closure of inefficient and coal-intensive heavy industry enterprises. All this carbon essentially ends up in the atmosphere in the form of carbon dioxide, the inevitable by-product of any combustion process involving hydrocarbon fuels.

The energy sector emitted about 2.8 gigatonnes of carbon during the extraction and conversion of primary energy to fuels and electricity, and during transmission and distribution to final use. The rest, about 3.7 gigatonnes of carbon, was emitted at the point of end use. Included are 0.4 gigatonnes of carbon embodied in durable hydrocarbon-based materials and products such as plastics, asphalt, lubricants, and pharmaceuticals. Although these materials do not necessarily contribute to carbon emissions in the year they are statistically accounted for as energy or non-energy use, most materials manufactured from hydrocarbons are eventually oxidised to carbon dioxide.

Carbon is also released from the combustion of biomass. Annual net emissions from biomass conversion are difficult to determine and depend on the extent to which the biomass use is truly renewable. The information presented here assumes that biomass-based energy services are renewable and so do not result in net additions to atmospheric concentrations of carbon dioxide.

Box D.1 reports the range of carbon emission factors found in the literature and the IPCC factors used to calculate the past and current carbon emissions shown in figure D.1. Global carbon

BOX D.1. CARBON DIOXIDE EMISSION FACTORS

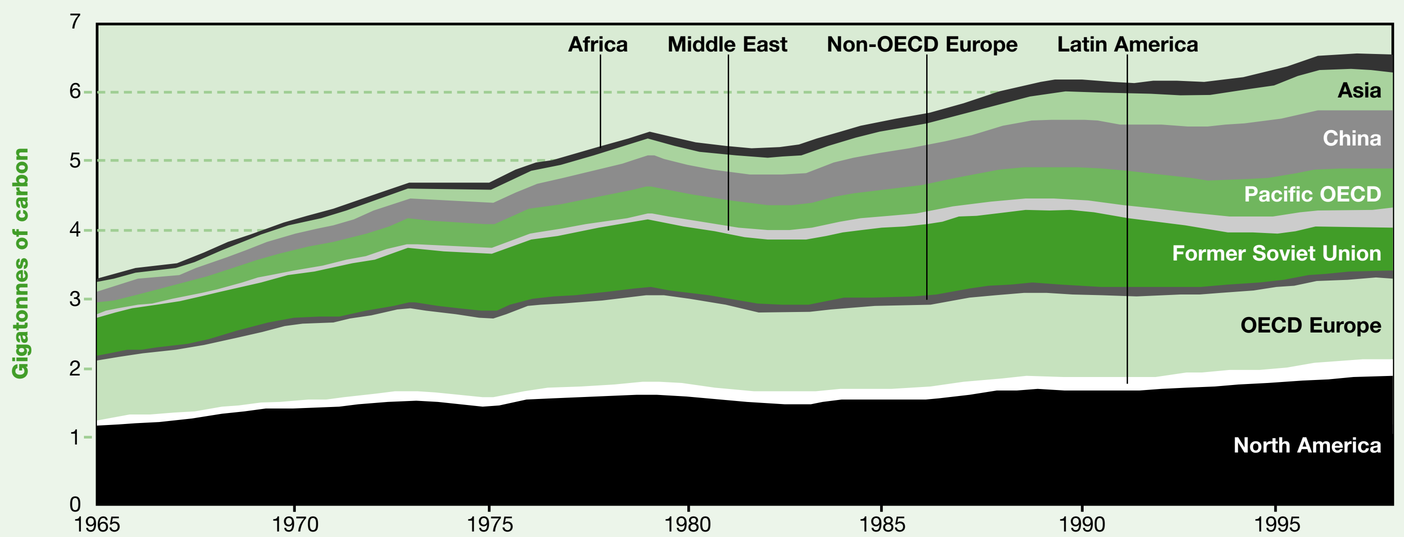
Carbon dioxide emissions are measured in units of elemental carbon. For example, in 1998 global carbon dioxide emissions were 6.5 gigatonnes (billion tonnes) of carbon. In the literature carbon dioxide emissions are often reported as the mass of the carbon dioxide molecules (1 kilogram of carbon corresponds to 3.67 kilograms of carbon dioxide).

Carbon emission factors for some primary energy sources (kilograms of carbon per gigajoule)

Source	Heating value	OECD and IPCC, 1995	Literature range
Wood	HHV LHV		26.8–28.4 28.1–29.9
Peat	HHV LHV	 28.9	30.3
Coal (bituminous)	HHV LHV	 25.8	23.9–24.5 25.1–25.8
Crude oil	HHV LHV	 20.0	19.0–20.3 20.0–21.4
Natural gas	HHV LHV	 15.3	13.6–14.0 15.0–15.4

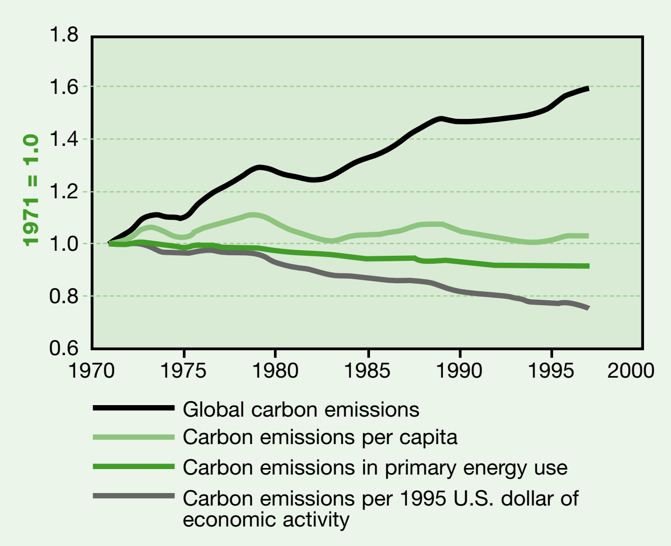
Note: HHV is the higher heating value, LHV is the lower heating value. The difference is that the higher heating value includes the energy of condensation of the water vapour contained in the combustion products (see annex A). *Source: IPCC, 1996.*

FIGURE D.1. CARBON EMISSIONS BY REGION, 1965–98



Source: Calculated from BP, 1999 data using carbon emission factors of IPCC, 1996.

FIGURE D.2. GLOBAL CARBON EMISSIONS, CARBON EMISSIONS PER CAPITA, AND DECARBONISATION OF THE ENERGY SYSTEM AND OF ECONOMIC PRODUCTION, 1971–97



Source: IEA, 1999.

TABLE D.1. CARBON EMISSIONS PER CAPITA BY REGION, 1975–97 (TONNES OF CARBON)

Region	1975	1980	1985	1990	1995	1997
North America[a]	4.84	4.96	4.54	4.54	4.55	4.70
OECD Europe	2.42	2.59	2.41	2.35	2.26	2.29
Pacific OECD[b]	2.06	2.19	2.14	2.52	2.86	3.02
Non-OECD Europe	1.71	2.05	2.10	1.99	1.45	1.44
Former Soviet Union	3.16	3.47	3.53	3.50	2.36	2.15
Latin America	0.53	0.57	0.50	0.53	0.57	0.63
Middle East	0.78	1.13	1.34	1.41	1.62	1.73
Asia[c]	0.15	0.18	0.20	0.25	0.31	0.34
China	0.35	0.42	0.50	0.59	0.72	0.73
Africa	0.21	0.25	0.29	0.28	0.28	0.28
World	1.14	1.21	1.16	1.17	1.13	1.15

a. Includes Mexico. b. Includes the Republic of Korea. c. Excludes China.

Source: Calculated from IEA, 1999 energy data and IPCC carbon emission factors (see box D.1).

emissions effectively doubled between 1965 and 1998, corresponding to an average increase of 2.1 percent a year—not surprisingly, a mirror image of the fossil fuel–dominated global energy use. Since 1990 the average rate of increase has slowed to 0.7 percent a year, not because of carbon emission mitigation efforts but because of the economic collapse of the former Soviet Union and the financial crisis in East Asia. Although figure D.1 clearly identifies industrialised countries as the main source of carbon emissions, it also shows the growing emissions from developing countries.

The carbon intensity (carbon per unit of primary energy) of the global energy system fell by 0.3 percent a year in the 20th century because of substitutions of oil and gas for coal, the expansion of hydropower, and the introduction of nuclear power. Figure D.2 shows carbon intensities for 1971–97. The drop in the carbon intensity of the energy system and the decline in the energy intensity of economic production have reduced the carbon intensity of GDP by 1 percent a year. Carbon emissions per capita have not changed much since 1971. In 1997 the average carbon intensity was 16.3 grams of carbon per megajoule, the carbon intensity per unit of economic activity was 258 grams of carbon per 1995 U.S. dollar, and carbon emissions per capita were 1.15 tonnes.

Regional carbon emissions per capita vary considerably around the average of 1.15 tonnes. In 1997 the average North American emitted 4.70 tonnes of carbon, while the average African emitted just 0.28 tonnes—6 percent of the North American's emissions (table D.1). ■

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editorial board

Brief biographies of Editorial Board members

Dennis Anderson is a Professor and the Director of the Imperial College Centre of Energy Policy and Technology, London, and a visiting Professor at the University College, London. Anderson holds degrees in economics from the London School of Economics (1967) and in engineering from the University of Manchester (1963). He is a Research Associate at the Oxford University Centre for the Study of African Economies and a Member of St. Antony's College. A former Senior Economist for the World Bank and Chief Economist for Shell, Anderson has published several works on rural energy and development, economic and environmental interactions, and climate change technology. His current research interests include economic and environmental interactions, energy pricing and regulation, and development policy. ■

Safiatou Franciose Ba-N'Daw is a former Minister of Economic Infrastructure in the Ministry of Energy of Côte d'Ivoire. She holds an M.Sc. in Economic Sciences from the University of Abidjan, studied statistics at Georgetown University, Washington, D.C., and received an MBA from Harvard University. She is also a Certified Public Accountant. Ba-N'Daw has worked as Financial Analyst for the World Bank, and has extensive experience in the development of small and medium-sized businesses in Hungary, Turkey and Tunisia. She has served as Senior Financial Specialist with the Central Bank of Pakistan and the Government of Pakistan on the development of financial institutions in that country. She also worked on financial issues in Sri Lanka until her promotion to the Ministry of Energy. ■

John W. Baker, Chairman of the World Energy Council from 1995-98, currently serves as the Deputy Chairman of Celltech Group, a pharmaceuticals company, and is a non-executive director for several other companies. He is also a member of the Education Standards Task Force and the Welfare to Work Task Force for the British Government. An arts graduate of Oxford University, he spent ten years dealing with transport policy and finance, and another decade in the field of urban renewal and public housing. In 1979 he moved into the energy sector to become the Corporate Managing Director of the Central Electricity Generating Board, and later led the man-agement of the UK electricity privatisation and restructuring programme. He was Chief Executive Officer of National Power since its establishment in 1990, then serving as its Chairman from 1995 to 1997. ■

JoAnne DiSano is the Director of the Division for Sustainable Development for the UN Department of Economic and Social Affairs. DiSano has a degree in psychology and sociology from the University of Windsor, Ontario, and a Masters of Education from Wayne State University (U.S.). Before joining the United Nations, she held several senior management positions with the Government of Canada, culminating in her work with the Department of Arts, Sport, the Environment, Tourism and Territories, where she served as the First Assistant Secretary, Environment and Conservation Policy Division, and as Deputy Executive Director, Environment Strategies Directorate. From 1996 to 1998, DiSano was the Deputy Head of the Environment Protection Group of that department. She has also held positions with the Canadian Employment and Immigration Commission and the Treasury Board in Ottawa. ■

Gerald Doucet is the Secretary General of the World Energy Council, a position he has held since September 1998. A graduate of Ottawa University, with a Masters in Economics from Carlton University, Doucet worked for the Government of Canada in various economic and policy roles from 1967-1981. He then joined the Retail Council of Canada as Senior Vice President, and in 1988 he became the Agent General for Ontario in Europe for the Province of Ontario. From 1992 to 1994 he served as President and a Founding Director of the Europe-Canada Development Association, and from 1994 – 98 as President and CEO of the Canadian Gas Association. ■

Emad El-Sharkawi is chairman of the Egyptian National Committee of the World Energy Council, vice-chair of WEC's executive assembly for Africa, general coordinator for UN-financed energy projects in Egypt, and advisor to numerous energy organizations and commissions. He has a post-graduate diploma in electrical power engineering from King's College, University of Durham, and a Ph.D. in electrical power systems from the University of Manchester. After supervising engineering projects in Egypt early in his career, he taught and led research on electrical power systems and energy at universities in Iraq. Returning to Egypt, El-Sharkawi joined the Ministry of Electricity and Energy and later the Nuclear Power Plants Authority as Manager of Technical Affairs (1977-78). Since that time he has supervised many renewable energy programmes in Egypt and served as a member of the country's specialised councils on energies. In 1986 he was named Chairman of the Board of Directors for the Egyptian Electricity Authority. El-Sharkawi has co-authored many papers on energy and systems planning, and his efforts in the field of energy led to his election to the Royal Swedish Academy for Engineering Sciences. ■

José Goldemberg is a member of the Brazilian Academy of Sciences and the Third World Academy of Sciences. Trained in physics at the University of Saskatchewan (Canada) and the University of Illinois, Goldemberg holds a Ph.D. in Physical Sciences from the University of São Paulo. During his long academic career, he has taught at the University of São Paulo (where he also served as Rector from 1986–89), Stanford University, and the University of Paris (Orsay). He was a Visiting Professor at Princeton University in 1993–94, at the International Academy of the Environment in Geneva in 1995, and at Stanford University in 1996–97. He served the Federal Government in Brazil as Secretary of State of Science and Technology in 1990–91, Minister of Education in 1991–92, and Acting Secretary of State of the Environment in 1992. The author of several books and technical papers, Goldemberg is an internationally respected expert on nuclear physics, the environment, and energy.

In 1991 Goldemberg was the co-winner of the Mitchell Prize for Sustainable Development, and in 1994 he was honoured with the establishment of the José Goldemberg Chair in Atmospheric Physics at Tel Aviv University. In 2000, he was awarded the Volvo Environmental Prize, along with three of his colleagues on the World Energy Assessment. ■

John P. Holdren is the Teresa and John Heinz Professor of Environmental Policy and Director of the Program on Science, Technology, and Public Policy in the John F. Kennedy School of Government, and a Professor of Environmental Science and Public Policy in the Department of Earth and Planetary Sciences at Harvard University. Trained in engineering and plasma physics at MIT and Stanford, from 1973–96 Holdren co-founded and co-led the interdisciplinary graduate programme in energy and resources at the University of California, Berkeley. He is a member of the President's Committee of Advisors on Science and Technology (PCAST) and has chaired PCAST panels on protection of nuclear bomb materials, the U.S. fusion-energy R&D program, U.S. energy R&D strategy for the climate-change challenge, and international cooperation on energy. He is also a member of the U.S. National Academy of Sciences (NAS) and National Academy of Engineering (NAE), Chairman of the NAS Committee on International Security and Arms Control, and Chairman of the NAS/NAE Committee on U.S.-India Cooperation on Energy. ■

Michael Jefferson runs a consulting firm, Global Energy and Environment Consultants, in the United Kingdom. A graduate of the Universities of Oxford and the London School of Economics, Jefferson has worked extensively in the private sector, from merchant banking to head of oil supply strategy and planning for Europe at the Royal Dutch/Shell Group of Companies. In 1990 Jefferson was seconded to the World Energy Council (WEC) as Deputy Secretary General, and he later became director of studies and policy development for WEC. He is the author of numerous books and articles related to energy and climate change, including *Energy for Tomorrow's World* (written for a WEC commission in 1993). He was a lead author and contributing author for the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report, a member of the drafting team for the IPCC's Synthesis Report, and an IPCC peer review editor for the Third Assessment Report. He is technical coordinator and lead consultant to the G8 Renewable Energy Task Force. He also participated in the UNDP report, *Energy after Rio,* written in 1997. ■

Eberhard Jochem is the Senior Scientist at the Fraunhofer Institute of Systems and Innovation Research (Karlsruhe, Germany) and Co-director of the Centre for Energy Policy and Economics (Zurich, Switzerland). Jochem holds degrees in chemical engineering (Aachen, 1967) and economics (Munich, 1971), and a Ph.D. in technical chemistry (Munich, 1971). He was a research fellow at Munich University and Harvard University. As an internationally acknowledged expert in systems analysis, technical and socio-economic research, and policy evaluation, Jochem is a member of several national and international scientific organizations and advisory committees, including the IPCC Bureau and the Enquête Commission on "Sustainable Energy, Liberalization, and Globalization" of the German Parliament. He presented lectures at the universities in Karlsruhe and Kassel until 1999 and since then in Zurich and Lausanne, Switzerland. He is a member of the Editorial Advisory Board of *Energy Environment* and *Climate Policy.* ■

Thomas B. Johansson, who is on leave from the University of Lund in Sweden, is the Director of the Energy and Atmosphere Programme of the Bureau for Development Policy of UNDP. Johansson, who holds a Ph.D. in nuclear physics from the Lund Institute of Technology, is International Co-Chairman of the Working Group on Energy Strategies and Technologies of the China Council for International Cooperation on Environment and Development. He has served as Convening Lead Author, Energy Supply Mitigation Options (Working Group IIA of the Intergovernmental Panel on Climate Change); Vice-Chairman, UN Committee on New and Renewable Sources of Energy and on Energy for Development; Chairman, UN Solar Energy Group for Environment and Development; and Director of Vattenfall, the Swedish State Power Board. He is has authored or co-authored numerous books and articles including *Energy after Rio; Renewable Energy: Sources for Fuels and Electricity; Electricity-Efficient End Use and New Generation Technologies and their Planning Implications;* and *Energy for a Sustainable World.* Along with three other members of the editorial board, he was awarded the Volvo Environment Prize in 2000. ■

Hisham Khatib, an engineer and economist, serves as honorary Vice Chairman of the World Energy Council, as a member of the Roster of Experts for the Global Environment Facility's Scientific and Advisory Panel, and as the Advisory Editor to the *Utilities Policy* and *Energy Policy* journals (U.K.) and the *Natural Resources Forum* (U.S.). Khatib received an M.Sc. from the University of Birmingham, and a Ph.D. in electrical engineering from the University of London, where he also received a B.Sc. in economics. Khatib has more than 40 years' experience in matters relating to electricity, energy, water, and environmental issues. He has consulted to the United Nations, UNDP, UNEP, Global Environment Facility, UNIDO, World Bank, Arab Fund, Islamic Development Bank, and many other regional and international development agencies. Khatib also served as Minister of Planning, Minister of Water and Irrigation, and Minister of Energy and Mineral Resources for the government of Jordan. He is the author of two books, *Economics of Reliability in Electrical Power Systems* and *Financial and Economic Evaluation of Projects,* and of more than 100 articles and papers. In 1998 he was honoured with the "Achievement Medal" of the Institution of Electrical Engineers. ■

Kui-Nang Mak has been chief of the Energy and Transport Branch of the Division for Sustainable Development, UN Department of Economic and Social Affairs (DESA) since 1990. He holds a M.Sc. in electrical engineering from the University of Illinois, where he has completed all requirements except dissertation for a Ph.D. in electrical engineering; an I.E. degree in industrial economics and management from Columbia University and a Certificate from the Executive Programme on Climate Change and Development from Harvard University. He has worked for the United Nations since 1975, acting as an Economic Affairs Officer specializing in energy for DESA from 1978 to 1990. He is the author of several papers and reports on global energy issues, particularly on international cooperation and financing. His professional affiliations include serving as a member of the Sub-Committee on International Practices, Institute of Electrical and Electronics Engineers; a member of the Committee on Cleaner Fossil Fuel Systems of the World Energy Council; and an advisor for the China Coal Preparation Association. ■

Nebojsa Nakićenović is the Project Leader of the Transitions to New Technologies Project at the International Institute for Applied Systems Analysis (IIASA). He is also the Convening Lead Author of the Special Report on Emissions Scenarios by the Intergovernmental Panel on Climate Change, and Guest Professor at the Technical University of Graz. Nakićenović holds bachelor's and master's degrees in economics and computer science from Princeton University and the University of Vienna, where he completed his Ph.D. He also received an *honoris causa* Ph.D degree in engineering from the Russian Academy of Sciences. Before joining IIASA, Nakićenović worked with the Research Centre (Karlsruhe, Germany) in the field of nuclear materials accountability. He is the author or co-author of many scientific papers and books on the dynamics of technological and social change, economic restructuring, mitigation of anthropogenic impacts on the environment, and response strategies to global change. Nakićenović has been Associate Editor of the *International Journal on Technological Forecasting and Social Change* and of the *International Journal on Energy,* and he serves as an advisor to many groups, including the United Nations Commission on Sustainable Development. Currently, his research focuses on the diffusion of new technologies and their interactions with the environment. ■

Anca Popescu is the Director of the Institute of Power Studies and Design in Romania. Popescu holds a B.Sc. in electrical engineering and a Ph.D. University in high-voltage technique from the Bucharest Polytechnic. An expert in energy policy, integrated resources planning, and power sector development and investment planning, she has served as a scientific and technical expert to the UN Framework Convention on Climate Change and was the Chief Scientific Investigator on the role of nuclear power plants in greenhouse gas emission reductions in Romania in a study sponsored by the International Atomic Energy Agency. The author of numerous papers on energy planning, policy, and development, Popescu has also served as a guest lecturer at Bucharest Polytechnic University and at the National Electricity Company Training Centre. ■

Amulya Reddy was President of the International Energy Initiative until April 2000. Reddy received his Ph.D. in applied physical chemistry from the University of London in 1958. From 1970–91 he was a professor at the Indian Institute of Science, in Bangalore, India, and was a visiting Senior Research Scientist at the Center for Energy and Environmental Studies at Princeton University in 1984. From 1990–93, Reddy was a member of the Scientific and Technical Advisory Panel of the Global Environment Facility. He has also been a member of the Energy Research Group of the International Development Research Centre in Canada; the Economic and Planning Council, Government of Karnataka; and a member of the Panel of Eminent Persons on Power for the Minister of Power, India. He is the author of more than 250 papers, and co-author and editor of several books on energy, rural technology, and science and technology policy. Reddy was awarded the Volvo Environmental Prize for 2000, along with three other members of the World Energy Assessment editorial board. ■

Hans-Holger Rogner is the Head of the Planning and Economic Studies Section in the Department of Nuclear Energy in the International Atomic Energy Agency. He holds an industrial engineering degree and a Ph.D. in energy economics from the Technical University of Karlsruhe. He specialised in applying systems analysis to long-term energy demand and supply issues and in identifying technologically and economically feasible paths to sustainable energy systems. At the International Atomic Energy Agency, Rogner's activities focus on sustainable energy development and technology change. He contributes to UN efforts targeted at Agenda 21, including combating climate change. ■

Kirk R. Smith is Professor of Environment Health Sciences, Associate Director for International Programs at the Center for Occupational and Environment Health, and Deputy Director of the Institute for Global Health at the University of California, Berkeley. Smith holds a Ph.D. and M.P.H. in biomedical and environmental health sciences from Berkeley. He has been a Senior Fellow at the East-West Center's Program on Environment (Honolulu), and was the founding head of the East-West Center's Energy Program (1978-1985). Smith is the author of more than 200 articles and 7 books, sits on the boards of 7 international scientific journals, and is advisor to the governments of several developing countries on environment. He is also a member of the India-U.S. Academies of Science Energy/Environment Program and of the World Health Organisation's Comparative Risk Assessment and Air Quality Guidelines committees. In 1997, he was elected to the US National Academy of Sciences. ■

Wim C. Turkenburg is Professor and Head of the Department of Science, Technology, and Society at Utrecht University. He is also a member of the Council on Housing, Physical Planning, and Environment of the Netherlands, Vice Chairperson of the UN Committee on Energy and Natural Resources for Development (UN-CENRD), and Chairperson of the Subcommittee on Energy of the

UN-CENRD. He studied physics, mathematics, and astronomy at Leiden University and the University of Amsterdam, and received his Ph.D. in science and mathematics from the University of Amsterdam in 1971. Turkenburg is an expert on energy, the environment, and systema analysis. He is author or co-author of many articles on renewables (wind energy, photovoltaics, biomass energy), energy efficiency improvement, cleaner use of fossil fuels (decarbonization technologies), and energy and climate change. He has been member of a number of national and international boards, committees and working groups on energy, energy research, and energy and environmental policy development, serving inter alia the International Solar Energy Society, the World Energy Council, the Intergovernmental Panel on Climate Change, and the Government of the Netherlands. ■

Francisco Lopez Viray is the Secretary of Energy in the Philippines, and chairs its subsidiary agencies, including the National Power Corporation, the Philippine National Oil Company, and the National Electrification Administration. Viray holds an M.Sc. in electrical engineering from the University of the Philippines and a Ph.D. in engineering from West Virginia University. His extensive career has included advisory and research positions on a number of energy and power planning projects. A specialist in the areas of power system engineering, computer applications in engineering and energy planning and management, Viray has received several citations and awards, including the ASEAN Achievement Award in Engineering, and the Outstanding Professional in Electrical Engineering from the Professional Regulation Committee of the Philippines. ■

Robert H. Williams is a Senior Research Scientist at Princeton University's Center for Energy and Environmental Studies, with a Ph.D. in physics from the University of California, Berkeley (1967). He served on two panels of the President's Committee of Advisors on Science and Technology: the Energy R&D Panel (1997), as chair of its Renewable Energy Task Force; and the International Energy Research, Development, Demonstration, and Deployment Panel (1999), as chair of its Energy Supply Task Force. Since 1993 he has been a member of the Working Group on Energy Strategies and Technologies of the China Council for International Cooperation on Environment and Development. He was a member of the Scientific and Technical Advisory Panel for the Global Environment Facility and chaired its Climate and Energy Working Group (1995-1998). He has written many articles and coauthored several books on a wide range of energy topics. He is recipient of the American Physical Society's Leo Szilard Award for Physics in the Public Interest (1988), the U.S. Department of Energy's Sadi Carnot Award (1991) for his work on energy efficiency, and a MacArthur Foundation Prize (1993). In 2000, along with three other members of the World Energy Assessment editorial board, he received the Volvo Environmental Prize. ■

glossary

Selected terminology

Acid deposition: fallout of substances from the atmosphere (through rain, snow, fog or dry particles) that have the potential to increase the acidity of the receptor medium. They are primarily the result of the discharge of gaseous sulphur oxides and nitrogen oxides from the burning of coal and oil e.g. in electricity generation, smelting industries and transport. "Acid rain" is the result of the combination of these gases in the air with vapor. Acidifying deposition can be responsible for acidification of lakes, rivers and groundwater, with resulting damage to fish and other components of aquatic ecosystems, and for damage to forests and other harmful effects on plants. (Note: precipitation is naturally acid as a result of the absorption of carbon dioxide from the atmosphere.)

Agenda 21: a comprehensive plan of action to be taken globally, nationally and locally in every area in which human impacts on the environment. It was adopted by more than 175 governments at the UN Conference on Environment and Development in 1992 (also known as the Rio Earth Summit).

Animate energy: energy derived from human or animal power.

Anthropogenic emissions: the share of emissions attributed to human activities.

API degree: the American Petroleum Institute has adopted a scale of measurement for the specific gravity of crude oils and petroleum products that is expressed in degrees.

Biofuels: fuels obtained as a product of biomass conversion (such as alcohol or gasohol).

Biomass: organic, non-fossil material oil of biological origin, a part of which constitutes an exploitable energy resource. Although the different forms of energy from biomass are always considered as renewable, it must be noted that their rates of renewability are different. These rates depend on the seasonal or daily cycles of solar flux, the vagaries of climate, agricultural techniques or cycles of plant growth, and may be affected by intensive exploitation.

Biogas: a gas composed principally of a mixture of methane and carbon dioxide produced by anaerobic digestion of biomass.

Breeder reactor: a reactor which produces a fissile substance identical to the one it consumes and in greater quantity than the one it has consumed, that is, it has a conversion ratio greater than unity.

Business-as-usual: the projected future state of energy and economic variables in the event that current technological, economic, political, and social trends persist.

Capacity building: developing skills and capabilities for technology innovation and deployment in the relevant government, private-sector, academic, and civil institutions.

Carbon sequestration: the capture and secure storage of carbon that would otherwise be emitted or remain in the atmosphere, either by (1) diverting carbon from reaching the atmosphere; or (2) removing carbon already in the atmosphere. Examples of the first type are trapping the CO_2 in power plant flue gases, and capturing CO_2 during the production of decarbonised fuels. The common approach to the second type is to increase or enhance carbon sinks.

Carbon tax: a levy exacted by a government on the use of carbon-containing fuel for the purpose of influencing human behavior (specifically economic behavior) to use less fossil fuels (and thus limit greenhouse gas emissions).

Carbon sinks: places where CO_2 can be absorbed, such as forests, oceans and soil.

Clean Development Mechanism (CDM): is one of four 'flexibility' mechanisms adopted in the Kyoto Protocol to the UN Framework Convention on Climate Change. It is a cooperative arrangement through which certified greenhouse gas emission reductions accruing from sustainable development projects in developing countries can help industrialized countries meet part of their reduction commitments as specified in Annex B of the Protocol.

Cogeneration: see combined heat and power

Combined cycle plant: electricity generating plant comprising a gas-turbine generator unit, whose exhaust gases are fed to a waste-heat boiler, which may or may not have a supplementary burner, and the steam raised by the boiler is used to drive a steam-turbine generator.

Combined heat and power (CHP) station: also referred to as a cogeneration plant. A thermal power station in which all the steam generated in the boilers passes to turbo-generators for electricity generation, but designed so that steam may be extracted at points on the turbine and/or from the turbine exhaust as back-pressure steam and used to supply heat, typically for industrial processes or district heating.

Commercial energy: energy that is subject to a commercial transaction and that can thus be accounted for. This contrasts to non-commercial energy, which is not subject to a commercial exchange, and thus difficult to account for in energy balances. The term non-commercial energy thus is technically distinct from traditional energy, but in practice they are often used interchangeably.

Commission on Sustainable Development (CSD): was created in December 1992 to ensure effective follow-up of the United Nations Conference on Environment and Development, to monitor and report on implementation of the agreements at the local, national, regional and international levels.

Compressed natural gas (CNG): natural gas stored under pressure in cylinders and used as fuel for automotive engines.

Cost buy-down: the process of paying the difference in unit cost (price) between an innovative energy technology and a conventional energy technology in order to increase sales volume, thus stimulating cost reductions through manufacturing scale-up and economies of learning throughout the production, distribution, deployment, use, and maintenance cycle.

Developing countries: generally used in this report to refer to the countries that are members of the Group of 77 Countries and China.

Digester: a tank designed for the anaerobic fermentation of biomass.

Dimethyl ether (DME): an oxygenated fuel that can be produced from any carbonaceous feedstock by a process that begins with syngas production.

Discount rate: the annual rate at which the effects of future events are reduced so as to be comparable to the effect of present events.

Economies in transition: national economies that are moving from a period of heavy government control toward lessened intervention, increased privatization, and greater use of competition.

Energy innovation chain: the linked process by which an energy-supply or energy-end-use technology moves from its conception in theory and the laboratory to its feasibility testing through demonstration projects, small-scale implementation and finally large-scale deployment.

Energy intensity: ratio between the consumption of energy to a given quantity, usually refers to the amount of primary or final energy consumed per unit of gross domestic or national product.

Energy efficiency: the amount of utility or energy service provided by a unit of energy *(U/E),* which can be used as a measure of energy efficiency in end-use applications. An increase in energy efficiency enables consumers to enjoy an increase in utility or energy service for the same amount of energy consumed or to enjoy the same utility of energy services with reduced energy consumption, $U = (U/E)\,E$. The usual situation is one in which an increase in energy efficiency *(U/E)* boosts both energy use and the utility derived from each unit of energy consumed.

Energy payback/time: the time of exploitation of an energy installation, necessary for recuperating all the energy consumed in its construction and operation during the projected lifespan of the installation.

Energy sector restructuring and reform: encouraging market competition in energy supply (often by transfer of ownership from the public to the private sector), while removing subsidies and other distortions in energy pricing and preserving public benefits.

Energy services: the utility of energy is often referred to by engineers as *energy services,* although that term can be confusing since units vary between applications and sometimes are not defined at all. For example, lumens is a natural unit in lighting services, and Thomas Edison proposed charging for lumens rather than kilowatt hours when electricity was first used for lighting; for practical reasons he eventually settled on charging by the kilowatt hour instead. James Watt charged for his steam engines not by their motive power, but by the difference in the costs of fuel he and his customers saved when they substituted his engine for their old one. However, when the utility or 'services' provided by energy are felt through a hot shower, chilled drinks, refrigerated food, a comfortably warm or cool house, increased transport miles, or labour saved in washing and ironing or in producing an innumerable array of industrial goods and services, it is only practicable to charge for energy in energy units.

Environmental taxes (ecotaxes): levies on products or services collected to account for environmental impacts associated with them.

Ethanol (ethyl alcohol): alcohol produced by the fermentation of glucose. The glucose may be derived from sugary plants such as sugar cane and beets or from starchy and cellulosic materials by hydrolysis. The ethanol may be concentrated by distillation, and can be blended with petroleum products to produce motor fuel.

Exergy: the maximum amount of energy that can be converted into any other form or energy under given thermodynamic conditions; also known as availability of work potential.

Externalities: benefits or costs resulting as an unintended byproduct of an economic activity that accrue to someone other than the parties involved in the activity. While energy is an economic 'good' that sustains growth and development and human well-being, there are by-products of energy production and use that have an undesirable effect on the environment (economic 'bads'). Most of these are emissions from the combustion of fossil fuels.

Final energy: is the energy transported and distributed to the point of final use. Examples include gasoline at the service station, electricity at the socket, or fuelwood in the barn. The next energy transformation is the conversion of final energy in end-use devices, such as appliances, machines, and vehicles, into useful energy, such as work and heat. Useful energy is measured at the crankshaft of an automobile engine or an industrial electric motor, by the heat of a household radiator or an industrial boiler, or by the luminosity of a light bulb. The application of useful energy provides energy services, such as a moving vehicle, a warm room, process heat, or illumination.

Foreign direct investment (FDI): is net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. Gross foreign direct investment is the sum of the absolute values of inflows and outflows of foreign direct investment recorded in the balance of payments financial account. It includes equity capital, reinvestment of earnings, other long-term capital, and short-term capital. Note that this indicator differs from the standard measure of foreign direct investment, which captures only inward investment.

Fuel cells: devices that enable chemical energy to be converted directly into electrical energy without the intervention of the heat engine cycle, in which electrical power is produced in a controlled reaction involving a fuel, generally hydrogen, methanol or a hydrocarbon.

Fuelwood: wood and wood products, possibly including coppices, scrubs, and branches, bought or gathered, and used by direct combustion.

Global Environment Facility (GEF): a financial institution that provides grants and concessionary financing to developing countries and economies-in-transition for projects and activities that provide global benefits in four topical areas: climate change; biological diversity; international waters; and stratospheric ozone. The GEF was established for the purpose of implementing agreements stemming from the 1992 UN Conference on Environment and Development including the UN Framework Convention on Climate Change. The World Bank Group is one of the three implementing agencies for the GEF, together with the United Nations Development Program and the United Nations Environment Program.

Green pricing: labelling and pricing schemes that allow consumers to pay a premium for environmentally friendly services and products if they choose.

Greenfield investment: starting up an entirely new plant, in contrast to rebuilding an older one.

Greenhouse Gases (GHGs): heat-trapping gases in the atmosphere that warm the Earth's surface by absorbing outgoing infrared radiation and re-radiating part of it downward. Water vapour is the most important naturally occurring greenhouse gas, but the principal greenhouse gases, whose atmospheric concentrations are being augmented by emission from human activities are carbon dioxide, methane, nitrous oxide, and halocarbons.

Grid extension: extending the infrastructural network that supplies energy, such as transmission wires for electricity.

Gross National Product (GNP): total production of goods and services by the subjects of a country at home and abroad. In national income accounting, it is a measure of the performance of the nation's economy, within a specific accounting period (usually a year).

Higher heating value (HHV): quantity of heat liberated by the complete combustion of a unit volume or weight of a fuel in the determination of which the water produced is assumed completely condensed and the heat recovered. Contrast to lower heating value.

Industrialized countries: for purposes of this report, this term refers primarily to high-income OECD countries. While many transitional economies are also characterized by a high degree of industrialization, they are often considered and discussed separately because of their specific development requirements.

Infrastructure: the physical structures and delivery systems necessary to supply energy and end-users. In the case of power plants, the infrastructure is the high-tension wires needed to carry the electricity to consumers; in the case of natural gas, it is the pipeline network; in the case of liquid fuels, it is the fueling stations.

Intergovernmental Panel on Climate Change (IPCC): a multilateral scientific organization established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization to assess the available scientific, technical, and socio-economic information in the field of climate change and to assess technical and policy options for reducing climate change and its impacts.

Irradiance: the quantity of solar energy falling per area of plane surface and time.

Kyoto Protocol (to the UN Framework Convention on Climate Change): contains legally binding emissions targets for industrialized (Annex I) countries for the post-2000 period. Together they must reduce their combined emissions of six key greenhouse gases by at least 5% by the period 2008-2012, calculated as an average over these five years. The Protocol will enter into force 90 days after it has been ratified by at least 55 Parties to the Climate Change Convention; these Parties must include industrialized countries representing at least 55% of this group's total 1990 carbon dioxide emissions. See also Clean Development Mechanism.

Leapfrogging: moving directly to most cleanest, most advanced technologies possible, rather than making incremental technological progress.

Liberalisation: the doctrine that advocates the greatest possible use of markets and the forces of competition to co-ordinate economic activity. It allows to the state only those activities which the market cannot perform (e.g. the provision of public goods) or those that are necessary to establish the framework within which the private enterprise economy cannot operate efficiently (e.g. the establishment of the legal framework on property and contract and the adoption of such policies and anti-monopoly legislation).

Lifecycle cost: the cost of a good or service over its entire lifetime.

Light water reactor (LWR): a nuclear reactor in which ordinary water, as opposed to heavy-water, or a steam/water mixture is used as reactor coolant and moderator. The boiling water reactor (BWR) and the pressurized water reactor (PWR) are examples of light water reactors.

Liquefied natural gas (LNG): natural gas made up mainly of methane and ethane and which, generally to facilitate its transport, has been converted to the liquid phase by having its temperature lowered.

Liquefied petroleum gas (LPG): light hydrocarbons, principally propane and butane, which are gaseous under normal conditions, but are maintained in a liquid state by an increase of pressure or lowering of temperature.

Lower heating value (LHV): quantity of heat liberated by the complete combustion of a unit volume or weight of a fuel in the determination of which the water produced is assumed to remain as a vapour and the heat not recovered. Contrast to higher heating value.

Macroeconomic: pertaining to a study of economics in terms of whole systems, especially with reference to general levels of output and income and to the interrelations among sectors of the economy.

Marginal cost: the cost of one additional unit of effort. In terms of reducing emissions, it represents the cost of reducing emission by one more unit.

Marginal cost pricing: a system of setting the price of energy equal to the marginal cost of providing the energy to a class of consumer.

Market barriers: conditions that prevent or impede the diffusion of cost-effective technologies or practices.

Market penetration: the percentage of all its potential purchasers to which a good or service is sold per unit time.

Market potential (or currently realizable potential): the portion of the economic potential for GHG emissions reductions or energy-efficiency improvements that could be achieved under existing market conditions, assuming no new policies and measures.

Methanol (methyl alcohol): alcohol primarily produced by chemical synthesis but also by the destructive distillation of wood. Methanol is regarded as a marketable synthetic motor fuel.

New renewables: used in this report to refer to modern biofuels, wind, solar, small hydropower, marine and geothermal energy. Geothermal energy cannot be strictly considered renewable, but is included for practical reasons.

Nitrogen oxides (NO_x): oxides formed an released in all common types of combustion at high temperature. Direct harmful effects of nitrogen oxides include human respiratory tract irritation and damage to plants. Indirect effects arise from their essential role in photochemical smog reactions and their contribution to acid rain problems.

Nuclear fuel cycle: a group of processes connected with nuclear power production; using, storing, reprocessing and disposing of nuclear materials used in the operation of nuclear reactors. The closed fuel cycle concept involves the reprocessing and reuse of fissionable material from the spent fuel. The once-through fuel cycle concept involves the disposal of the spent fuel following its use in the reactor.

Opportunity cost: the cost of an economic activity foregone by the choice of another activity.

Organisation for Economic Co-operation and Development (OECD): a multilateral organization of 29 industrialized nations, producing among them two-thirds of the world's goods and services. The objective of the OECD is the development of social and economic policies and the coordination of domestic and international activities.

Pollution associated with energy use. This is usually measured as pollution per unit of energy use, or $P = (P/E)E$. Modern methods of pollution control and emerging energy technologies are capable of reducing the ratio P/E—and thus P—to very low levels, sometimes to zero. This means that if environmental policies focus on P rather than E, there is no reason why high levels of energy use (and the utility derived from it) cannot be enjoyed and pollution virtually eliminated in the long term, a process known as delinking environmental concerns from energy use.

Primary energy is the energy that is embodied in resources as they exist in nature: chemical energy embodied in fossil fuels (coal, oil, and natural gas) or biomass, the potential energy of a water reservoir, the electromagnetic energy of solar radiation, and the energy released in nuclear reactions. For the most part, primary energy is not used directly but is first mined, harvested or converted and transformed into electricity and fuels such as gasoline, jet fuel, heating oil, or charcoal.

Public Benefits Fund (PBF): a financial mechanism created to serve the greater public interest by funding programs for environment and public health, services to the poor and disenfranchised, energy technology innovation, or other public goods not accounted for by a restructured energy sector.

Purchasing power parity (PPP): GDP estimates based on the purchasing power of currencies rather than on current exchange rates. Such estimates are a blend of extrapolated and regression-based numbers, using the result of the International Comparison Program. PPP estimates tend to lower per capita GDPs in industrialized countries and raise per capita GDPs in developing countries.

Research and development (R&D): the first two stages in the energy innovation chain. R, D & D refers to demonstration projects as well.

Reserves: those occurrences of energy sources or mineral that are identified and measured as economically and technically recoverable with current technologies and prices (see chapter 5).

Resources: those occurrences of energy sources or minerals with less certain geological and/or economic/technical recoverability characteristics, but that are considered to become potentially recoverable with foreseeable technological and economic development (see chapter 5).

Revenue neutral taxes: governmental levies placed on certain goods or services that replace other taxes and thus do not add to total revenues collected, but rather attempt to change behaviours.

Scenario: a plausible description of how the future may develop based on analysis of a coherent and internally consistent set of assumptions about key relationships and driving forces (e.g. rate of technology changes, prices). Note that scenarios are neither predictions nor forecasts.

Standards/performance criteria: a set of rules or codes mandating or defining product performance (e.g. grades, dimensions, characteristics, test methods, rules for use).

Structural changes: changes in the relative share of GDP produced by the industrial, agricultural or services sectors of an economy; or, more generally, systems transformations whereby some components are either replaced or partially substituted by other ones.

Subsidies: publicly supported cost reductions that may be granted to producers and consumers – directly, through price reductions, or in less visible forms, through tax breaks, market support or inadequate metering.

Sulphur oxides (SO_x): oxides produced by the combustion of fossil fuels containing sulphur. Sulphur oxides, the most widespread of which is sulphur dioxide, a colorless gas having a strong and acrid odor, are toxic at a given concentration for the respiratory system and gave harmful effects on the environment, in particular on buildings and vegetation. They contribute to the acid rain problem.

Sustainable energy: as the term is used in this document, is not meant to suggest simply a continual supply of energy. Rather it means environmentally sound, safe, reliable, affordable energy; in other words, energy that supports sustainable development in all its economic, environmental, social and security dimensions.

Syngas: a gaseous mixture composed mainly of carbon monoxide and hydrogen and synthesized from a carbonaceous feedstock such as coal or biomass. It is used as a building block for the production of synthetic liquid fuels. Syngas-based systems can make it possible to extract energy services from carbonaceous feedstocks with very low levels of pollutant or greenhouse gas emissions.

Transitional economies: see economies in transition

Unproven reserves: the estimated quantities, at a given date, which analysis of geologic and engineering data indicates might be economically recoverable from already discovered deposits, with a sufficient degree of probability to suggest their existence. Because of uncertainties as to whether, and to what extent, such unproven reserves may be expected to be recoverable in the future, the estimates should be given as a range but may be given as a single intermediate figure in which all uncertainties have been incorporated. Unproven reserves may be further categorized as probable reserves or possible reserves.

United Nations Framework Convention on Climate Change (UNFCCC): a major global convention adopted in 1992 that establishes a framework for progress in stabilizing atmospheric concentrations of greenhouse gases at safe levels. It directs that "such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner". It also recognizes the right of developing countries to economic development, their vulnerability to the effects of climate change, and that rich countries should shoulder greater responsibility for the problem.

United Nations Conference on Environment and Development (UNCED): also known as the Rio Earth Summit. The first of a series of major United Nations conferences on global issues that were convened in the 1990s.

World Bank Group: a multilateral, United Nations affiliated lending institution which annually makes available roughly $20 billion in loans to developing countries, mainly but not exclusively for large scale infrastructure projects. The World Bank Group comprises five agencies: the International Bank for Reconstruction and Development, the International Development Association, the International Finance Corporation (IFC), the Multilateral Investment Guarantee Agency (MIGA), and the International Centre for Settlement of Investment Disputes (ICSID). The World Bank Group raises capital from both public sources and financial markets.

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World Energy Assessment
Advisory Panel and peer reviewers

An initial draft of the World Energy Assessment formed the basis for the first round of peer review at an Advisory Panel meeting that took place in July, 1999 in Geneva. Based on comments from working groups at that meeting, as well as comments received from hundreds of experts around the world, a second draft was prepared.

The second draft of the report was circulated to the Advisory Panel, energy experts, governments and NGOs by mail and via a website. With input from that second round of comments, as well as from careful scrutiny by the Editorial Board, the final versions of the chapters were produced. A list of Advisory Panel members and peer reviewers appears below.

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