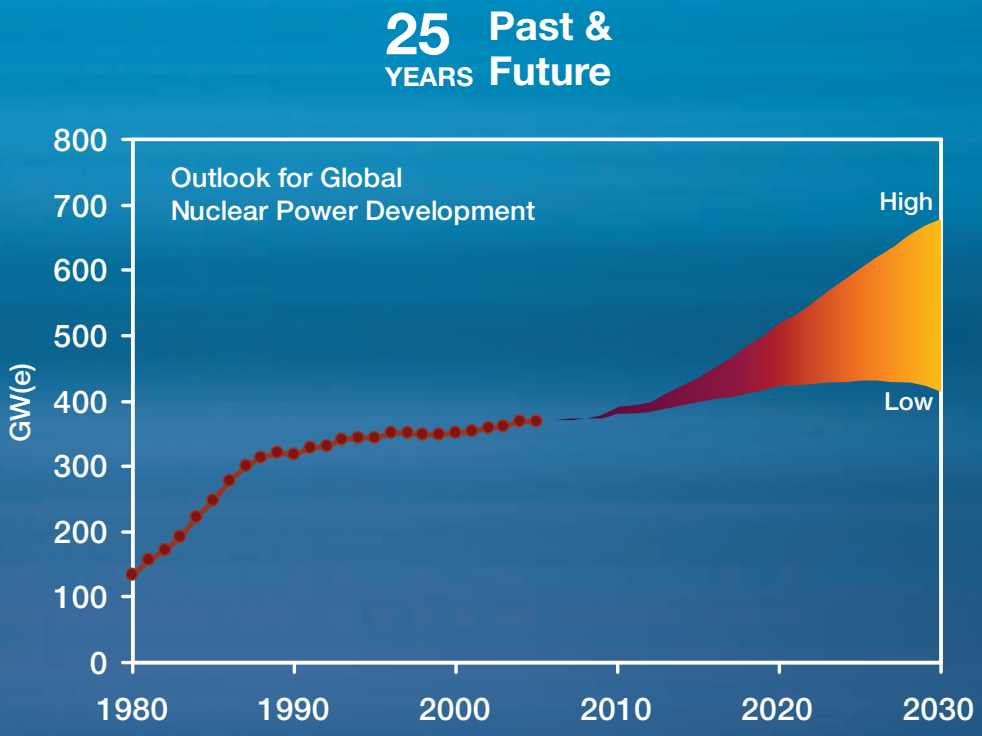
Energy, Electricity and Nuclear Power: Developments and Projections



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ENERGY, ELECTRICITY AND NUCLEAR POWER: DEVELOPMENTS AND PROJECTIONS — 25 YEARS PAST AND FUTURE

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ENERGY, ELECTRICITY AND NUCLEAR POWER: DEVELOPMENTS AND PROJECTIONS — 25 YEARS PAST AND FUTURE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2007

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Sales and Promotion, Publishing Section
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1400 Vienna, Austria
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tel.: +43 1 2600 22417
email: sales.publications@iaea.org
http://www.iaea.org/books

Printed by the IAEA in Austria
December 2007
STI/PUB/1304

IAEA Library Cataloguing in Publication Data

Energy, electricity and nuclear power : developments over 25 years and future projections. — Vienna : International Atomic Energy Agency, 2007.
p. ; 24 cm.
STI/PUB/1304
ISBN 978-92-0-107407-2
Includes bibliographical references.
1. Nuclear energy — Statistics. 2. Power resources — Statistics. 3. Electric power — Statistics. 4. Energy consumption — Statistics. I. International Atomic Energy Agency.

IAEAL 07–00498

FOREWORD

This report is based on the annual IAEA publication, Energy, Electricity and Nuclear Power Estimates for the Period up to 2030, Reference Data Series No. 1 (RDS-1). The IAEA has been publishing RDS-1 since 1981. It reports on the current status and estimates of energy use, electricity generation and nuclear power generation in various regions of the world for the medium to long term. The estimates are prepared in close collaboration and consultation with several international, regional and national organizations dealing with energy related statistics, such as the United Nations Department of Economic Affairs, the International Energy Agency (IEA), the OECD Nuclear Energy Agency (OECD/NEA), the World Bank, the World Nuclear Agency (WNA), the US Department of Energy (DOE) and the French Atomic Energy Commission (CEA), as well as several international energy experts. The latest issue is the 27th edition, reporting estimates for the next 24 years using 2006 as the base year.

During its 26 years of regular publication, several adjustments were made to the definitions and methodology for compiling the energy data, in order to improve the quality of the data. These adjustments were in line with the overall efforts at the international level to harmonize energy statistics. For example, the United Nations Statistical Commission has been making efforts to synchronize its data series under various programmes. For RDS-1, one such adjustment was made in 2005 when the average thermal efficiency method was adopted to convert electricity produced by nuclear power plants from kilowatt-hours to joules. This had a significant impact on the values of total energy use. At this stage, the entire historical data series was also adjusted. This report provides these harmonized data series on energy use, electricity generation and nuclear power generation for the 25 year period (1980–2005). The report also compares the nuclear power projections made in the past with the projections made in 2006 on the basis of 2005, the last year of that period.

The IAEA officers responsible for this publication were F. Naqvi and A. Irej Jalal of the Department of Nuclear Energy.

EDITORIAL NOTE

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CONTENTS

1. INTRODUCTION

Although only 30 countries have nuclear power plants in operation, nuclear electricity contributes about 15% of the world's electricity generation. This is as much as the electricity generation by hydropower worldwide, despite the fact that hydropower is very widely used.

Many industrialized countries generate substantial portions of their electricity from nuclear power, for example France 78%, Belgium 54%, Sweden 48%, Republic of Korea 39%, Switzerland 37%, Japan 30%, Finland 28%, USA 19% and UK 18%. Some countries with transitional economies also have very high contributions of nuclear power in their electricity generation mixes, for example Lithuania 72%, Slovakia 57%, Ukraine 48%, Bulgaria 44%, Armenia 42%, Slovenia 40%, and Hungary 38%. Among the 30 nuclear power countries, nine countries generate more than 40% of their total electricity from nuclear power, while seven additional countries have around a 30% nuclear share in their electricity generation.

The developing countries with nuclear power, by contrast, have only 2–9% of their electricity generated by nuclear power. In particular, the large developing countries, Brazil, China and India, generate only 2–3% of their electricity from nuclear power.

Worldwide, there are 438 nuclear power units in operation (see Table 1). They constitute 372 GW(e) of installed electricity generating capacity. About one half of these units are in three industrialized countries: USA 104, France 59 and Japan 55 (see Table 1).

Most of the world's nuclear power development took place in the 1970s and 1980s, when the number of nuclear power units in operation increased by 332 units with a total capacity of 301 GW(e). After the Three Mile Island (TMI) and Chernobyl accidents there was a considerable slowdown in nuclear power expansion. During the 1990s the number of nuclear power plants in operation increased by only 19 units, equal to 31 GW(e) of capacity. From 2000 to 2005, 6 nuclear power units totalling 18 GW(e) capacity were connected or reconnected to the grid. However, nuclear power generation has been increasing continually as a result of improved performance. In 1990, the world average annual capacity factor for nuclear power plants was 67.7%. In 2005 this figure stood at 81.4% — an improvement equivalent to some 74 new nuclear power units of 1 GW(e) each (see the annex for details of calculation).

TABLE 1. WORLDWIDE NUCLEAR POWER CAPACITY AS OF JULY 2007 AND GENERATION IN 2006

Countries	Reactors in operation		Nuclear electricity supplied in 2006	
	No. of units	MW(e)	TW·h	% of Total
ARGENTINA	2	935	7.2	6.9
ARMENIA	1	376	2.4	42.0
BELGIUM	7	5 824	44.3	54.4
BRAZIL	2	1 795	13.0	3.3
BULGARIA	2	1 906	18.2	43.6
CANADA	18	12 589	92.4	15.8
CHINA	11	8 572	51.8	1.9
CZECH REPUBLIC	6	3 523	24.5	31.5
FINLAND	4	2 696	22.0	28.0
FRANCE	59	63 260	429.8	78.1
GERMANY	17	20 339	158.7	31.8
HUNGARY	4	1 755	12.5	37.7
INDIA	17	3 779	15.6	2.6
JAPAN	55	47 587	291.5	30.0
KOREA, REPUBLIC OF	20	17 454	141.2	38.6
LITHUANIA	1	1 185	7.9	72.3
MEXICO	2	1 360	10.4	4.9
NETHERLANDS	1	482	3.3	3.5
PAKISTAN	2	425	2.6	2.7
ROMANIA	1	655	5.2	9.0
RUSSIAN FEDERATION	31	21 743	144.6	15.9
SLOVAKIA	5	2 034	16.6	57.2
SLOVENIA	1	666	5.3	40.3
SOUTH AFRICA	2	1 800	10.1	4.4
SPAIN	8	7 450	57.4	19.8
SWEDEN	10	9 048	65.1	48.0
SWITZERLAND	5	3 220	26.4	37.4
UKRAINE	15	13 107	84.9	47.5
UNITED KINGDOM	19	10 965	69.4	18.4
UNITED STATES OF AMERICA	104	100 322	788.3	19.4
World Total	438	371 773	2 660.9	

Notes: Data are from Ref. [5].
The world total includes data in Taiwan, China: 6 units in operation, of 4921 MW(e) capacity, 38.4 TW·h generation.
This list does not include 6 units in long term shutdown (4 in Canada, 1 in Japan and 1 in the USA).

The future expansion of nuclear power globally will depend upon a number of factors such as fossil fuel prices, energy security concerns, environmental and climate change considerations, nuclear safety concerns and concerns about nuclear proliferation. Various global energy studies have projected a range of possible futures for nuclear power. Some paint an optimistic picture, while others envisage essentially no expansion. Nonetheless, many of the global studies point to a need for substantial expansion in nuclear power by 2030 [1, 2].

From 1981, the IAEA has been publishing estimates for the future development of nuclear power in various regions of the world, as well as the expected contribution from nuclear power to the projected total electricity generation and total energy use. The estimates of nuclear power capacities and generation have been prepared using the bottom-up approach. Every year, nuclear power programmes and plans of the IAEA's Member States are reviewed to prepare the low and high estimates of nuclear power capacity expansion for the medium to long term. These two sets of estimates represent plausible ranges of expansion in nuclear power generation capacities based on the judgement of energy experts.

The low estimates are based on the number of units under construction or firmly planned, current retirement and life extension plans, and the experts' judgement on expansion of nuclear power capacity under the long term expansion plans announced by governments and power utilities. The high estimates are based on upward revision of the low estimates based on experts' judgement assuming, essentially, full implementation of the announced long term plans of nuclear power development.

This report presents global and regional trends of energy use, electricity generation and nuclear power development during the 25 year period (1980–2005). The current projections of nuclear power development for the next 25 years (2005–2030) are compared with the previous projections of nuclear power development made by the IAEA. The current projections of nuclear power are also presented in the context of energy use and electricity generation projected until 2030.

Section 2 presents the trends of energy use and the role of nuclear power over the last 25 year period (1980–2005), while Section 3 reviews the pattern of electricity generation and the contribution from nuclear power during this period. Section 4 reports the expansion of nuclear power capacity at the global and regional level from 1980 to 2005. Section 5 presents a set of the IAEA's previous projections made from 1985 to 2005 for nuclear power development, and reports the projections made in 2006 for the next 25 years based on the status in 2005. The report concludes with the current outlook for nuclear power

development in the next 25 years (2005–2030) and the factors contributing to enhancing this outlook.

The data presented in this report are based on two annual IAEA publications, Energy, Electricity and Nuclear Power Estimates for the Period up to 2030 (RDS-1) [3] and Nuclear Power Reactors in the World, April 2006 (RDS-2) [4], and on the IAEA's Power Reactor Information System [5]. In this report, all data are reported for eight regions of the world. The annex lists the countries included in each region, together with some definitions and notes on the data series.

2. TRENDS IN ENERGY USE

Growing at an average rate of 2% per annum, global energy use increased from 286 EJ in 1980 to 473 EJ in 2005 (Fig. 1). This growth rate was not significantly higher than the growth rate of the world's population, which was about 1.6% per annum over the same period. On a per capita basis, therefore, there was only a marginal increase in energy use over the 25 year period: 73 GJ per capita in 2005 compared to 65 GJ per capita in 1980.

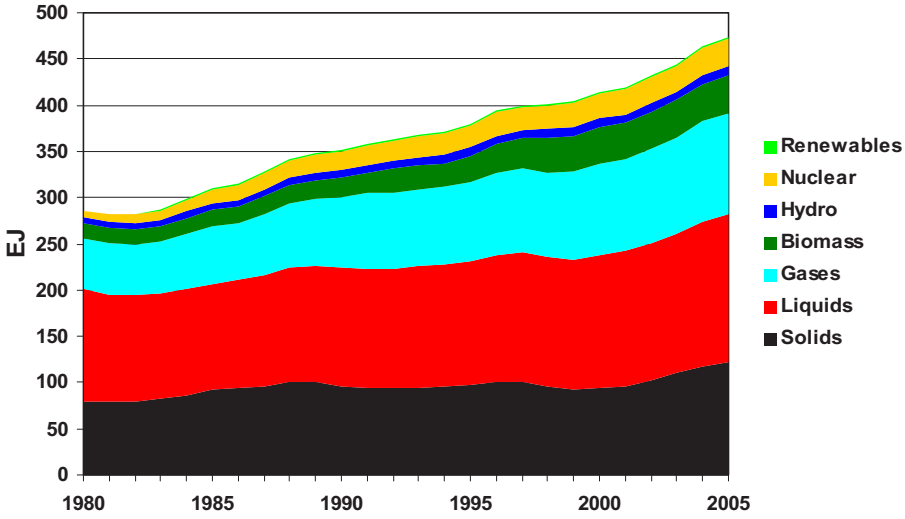

FIG. 1. Historical trends of world energy use by fuel type.

2.1. GLOBAL ENERGY USE BY FUEL TYPE

The trends of world energy use by fuel type show that there was a steady increase in energy use from all sources throughout the 25 year period, except in a few years, for example:

(a) A decline in the use of oil in the early 1980s;
(b) A decline in the use of coal in the late 1990s (1995–2000);
(c) A rapid increase in the use of biomass from 1991 to 1998, with the biggest jump in its use from 1997 to 1998.

Over the 25 year period, fossil fuels remained the main component of global energy use. Growing at an average annual rate of 1.7%, their use increased from 256 EJ in 1980 to 392 EJ in 2005, accounting for 83% of the total energy supply (see Tables 2, 3). This contribution was, however, 7% lower than that in 1980 (90%).

This decline in the share of fossil fuels was registered for both solid and liquid fuels, while the share of gases increased in the world's total energy use. The use of solid fuels increased from 79 EJ in 1980 to 122 EJ in 2005, registering a growth rate of 1.7% per annum, which was lower than the growth rate of total energy use, and the share of solid fuels declined from 28% in 1980 to 26% in 2005. The growth rate of liquid fuels (1.1% per annum) was about half of the growth rate of total energy use, and their share in global energy use declined

TABLE 2. WORLD ENERGY USE BY FUEL TYPE: 1980–2005 (EJ)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Solids	79	92	96	98	94	122	1.7
Liquids	122	114	128	133	144	160	1.1
Gases	55	63	75	86	99	110	2.8
Biomass	16	18	22	29	39	40	3.8
Hydro	6	7	8	9	10	11	2.1
Nuclear	7	14	21	24	26	29	5.8
Renewables	0.5	0.9	1.4	1.6	1.9	2.2	6.3
Total	286	310	351	380	414	473	2.0

Notes: Energy use = production of primary energy plus net trade (import–export) minus international bunkers and stock changes.
Solids do not include commercial wood.
'Biomass' includes commercial wood, combustible renewables, waste and other biomass products.
'Renewables' includes geothermal, wind, solar, tide energy and net electricity trade.

TABLE 3. WORLD ENERGY USE BY FUEL TYPE: 1980–2005 (SHARES (%)

	1980	1985	1990	1995	2000	2005
Solids	27.7	29.8	27.4	25.7	22.7	25.7
Liquids	42.8	36.9	36.5	34.9	34.8	33.7
Gases	19.2	20.2	21.4	22.5	23.9	23.2
Fossil Fuels (sub-total)	89.7	87.0	85.3	83.2	81.4	82.7
Biomass	5.5	5.7	6.2	7.7	9.4	8.5
Hydro	2.2	2.3	2.3	2.4	2.4	2.3
Nuclear	2.4	4.7	5.9	6.2	6.4	6.1
Renewables	0.2	0.3	0.4	0.4	0.5	0.5

from 43% in 1980 to 34% in 2005. Relatively higher growth in the use of gases (2.8% per annum) increased their share of global energy use from 19% in 1980 to 23% in 2005.

The decline in the share of fossil fuels was taken up by an increase in the use of nuclear power and biomass. The use of nuclear energy increased from 7 EJ in 1980 to 29 EJ in 2005. The growth in nuclear energy was much higher (5.8% per annum) than that for total energy use (2.0% per annum). Consequently, the share of nuclear power in total energy use increased from 2.4% in 1980 to 6.1% in 2005.

There was also a significant increase in the use of biomass during this period. Its use in 2005 was 40 EJ, compared to 16 EJ in 1980. The share of biomass increased from 5.5% of total energy use in 1980 to 8.5% in 2005.

Growing at a rate of 2.1% per annum, the use of hydropower increased to 11 EJ in 2005, and its share remained at about 2% of total energy use. The use of energy from renewable sources increased about 4 fold from 0.5 EJ in 1980 to 2.2 EJ in 2005, but its share is still very low in global energy use (i.e. 0.5% in 2005).

Two main changes can be observed in the composition of global energy use over the 25 year period: (i) a decline in the shares of solid and liquid fuels and (ii) an increase in the shares of gases, nuclear, biomass and renewables, with about equal percentage increases in the shares of gases and nuclear power.

2.2. REGIONAL DISTRIBUTION OF GLOBAL ENERGY USE

Figure 2 illustrates changes in the regional distribution of global energy use during the 25 year period in terms of shares. Highlights of these changes are as follows:

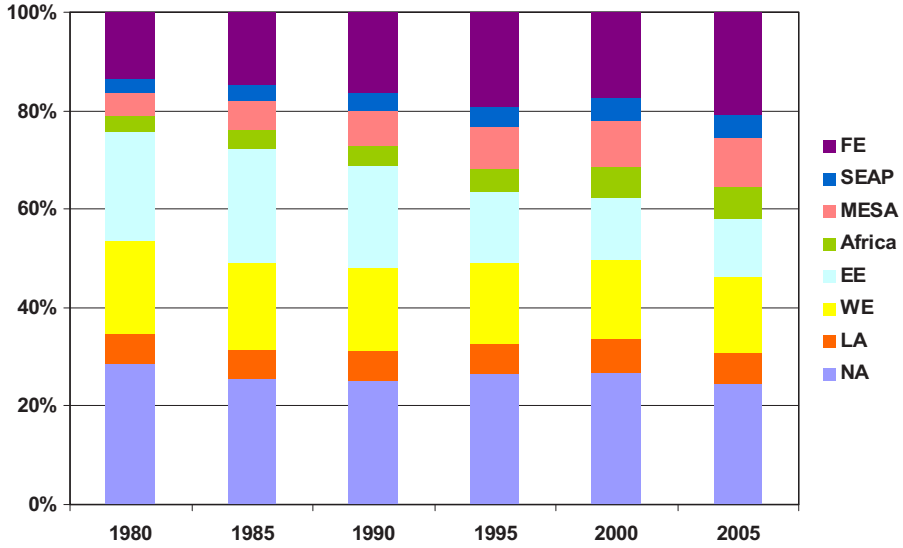

FIG. 2. Historical trends of regional shares in world energy use.

(a) The biggest decline (10%) was in the share of Eastern Europe (EE);
(b) The share of North America (NA) declined by 5% and the share of Western Europe (WE) dropped by 4%;
(c) The share of the Far East (FE) increased significantly (by 7%);
(d) There was no change in the share of Latin America (LA);
(e) The Middle East and South Asia (MESA), Southeast Asia and the Pacific (SEAP) and Africa had small increases in their shares.

In absolute terms:

(1) North America remained the largest energy user among all regions throughout this period.
(2) Eastern Europe was the second largest user of energy in 1980, but a rapid decline in energy use in the 1990s made it the fourth largest energy user in 2005, despite an increase in energy use from 2000 to 2005.
(3) With the largest regional population and fast growing economies, the Far East became the second largest energy user in 2005, while it had been the fourth largest energy user in 1980.
(4) Western Europe was the third largest energy user in 1980, and it remained so in 2005.

(5) Latin America registered almost the same growth in its energy use as the world. As such, its share remained more or less unchanged at around 6% over the 25 year period.

Comparison of the growth rates of the regions (Table 4) shows that:

(i) The greatest growth was experienced in the Middle East and South Asia. Energy use in this region increased over the 25 year period by about 3.8 times, doubling its share of world energy use over the 25 year period. However, the region accounted for only 10% of world energy in 2005.
(ii) Both Southeast Asia and the Pacific and Africa also had high growth in their energy use (between 4 and 5% per annum), but this growth was on a small base in 1980, i.e. only 8 EJ and 9 EJ, respectively. Their shares in global energy use increased from a mere 2.7% and 3.3% in 1980, respectively, to 4.8% and 6.3% in 2005.

In brief, energy use in all regions except Eastern Europe increased from 1980 to 2005. Two highlights of the regional distribution of world energy use in the 25 year period are:

— Declining shares of the regions that were major energy users (Table 5);
— A significant increase in the share of the Far East, which grew from the fourth largest energy user of 1980 to the second largest energy user in 2005.

2.3. COMPARISON OF ENERGY USE ON A PER CAPITA BASIS

Figure 3 shows that:

(a) There was an increase in per capita energy use in all the regions except Western Europe and Eastern Europe, which registered declines in their per capita energy use over the 25 year period;
(b) Per capita energy use in North America, Western Europe and Eastern Europe was significantly higher than that in other regions in both 1980 and 2005;
(c) The ranking of the three largest energy users on a per capita basis did not change over the period 1980 to 2005;
(d) Per capita energy use in the Middle East and South Asia was the lowest among all regions in 1980, and it remained so in 2005.

TABLE 4. WORLD ENERGY USE BY REGION: 1980–2005 (EJ)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
North America	82	79	88	100	111	113	1.3
Latin America	17	18	22	24	28	31	2.3
Western Europe	54	55	59	62	67	71	1.1
Eastern Europe	63	72	73	54	51	56	-0.5
Africa	9	12	15	18	26	30	4.7
Middle East and South Asia	13	18	25	32	39	49	5.3
South East Asia and Pacific	8	9	13	16	20	23	4.4
Far East	39	46	58	73	72	102	3.9
Total	286	310	351	380	414	473	2.0

TABLE 5. REGIONAL SHARES IN WORLD ENERGY USE 1980–2005 (%)

	1980	1985	1990	1995	2000	2005
North America	29	26	25	26	27	24
Latin America	6	6	6	6	7	6
Western Europe	19	18	17	16	16	15
Eastern Europe	22	23	21	14	12	12
Africa	3	4	4	5	6	6
Middle East and South Asia	5	6	7	8	9	10
South East Asia and Pacific	3	3	4	4	5	5
Far East	14	15	16	19	17	21

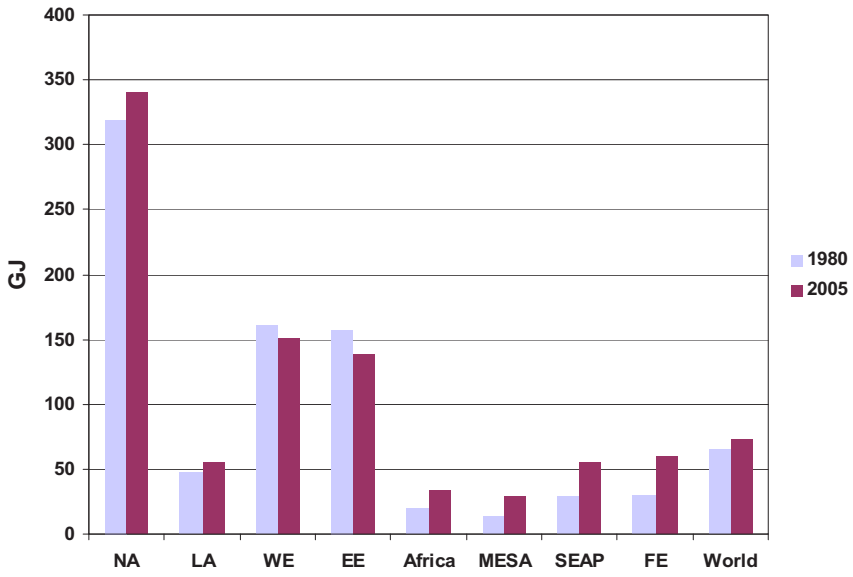

FIG. 3. Per capita energy use by region in 1980 and 2005.

Table 6 shows the percentage change in per capita energy use over the 25 year period in all regions and the wide differences in these changes:

(1) The Middle East and South Asia was the only region that had more than a twofold increase, but it did not improve its ranking in 2005, and its per capita energy use remained the lowest among all the regions;
(2) There was a 65% increase in per capita energy use in Africa, which remained the second lowest among all the regions in 2005;
(3) Among all the regions with low levels of energy use in 1980, Latin America had the smallest increase in per capita energy use, i.e. 15%, which lowered its ranking from fifth lowest per capita energy use in 1980 to third lowest in 2005;
(4) Per capita energy use in Southeast Asia and the Pacific and the Far East almost doubled, and their per capita energy use improved from the third and fourth lowest among all regions, respectively, to the fourth and fifth lowest in 2005, respectively.

A comparison of the per capita energy use of the regions in absolute terms shows that:

(i) The gap between North America and other regions was in the range of 159 GJ to 306 GJ in 1980 (Table 6). This gap increased to be in the range of 189 GJ to 311 GJ in 2005.
(ii) The increase in this gap was experienced by all regions except Southeast Asia and the Pacific and the Far East.
(iii) This gap declined for Southeast Asia and the Pacific from 291 GJ to 284 GJ, and it declined from 290 GJ to 281 GJ for the Far East.

TABLE 6. PER CAPITA ENERGY USE BY REGION (GJ)

	1980	2005	Change (%) 1980-2005	Difference from NA in 1980	Difference from NA in 2005
North America	319	340	6.5	-	-
Latin America	48	55	15.2	272	285
Western Europe	161	151	-5.9	159	189
Eastern Europe	157	138	-11.9	163	202
Africa	20	33	65.0	299	307
Middle East and South Asia	14	29	113.6	306	311
South East Asia and Pacific	29	56	93.6	291	284
Far East	30	59	99.1	290	281
World Average	65	73	12.6	254	267

Highlights of changes in the regional pattern of world energy use on a per capita basis over the 25 years are as follows:

— Increases in per capita energy use in all regions except Western Europe and Eastern Europe;
— Widening gaps between per capita energy use in North America and that in all other regions except two, Southeast Asia and the Pacific and the Far East;
— Small decreases in the gaps between per capita energy use in North America, and in Southeast Asia and the Pacific and the Far East.

2.4. TRENDS IN ENERGY USE BY FUEL TYPE IN THE REGIONS

Figures 4–11 show trends in energy use by fuel type in the eight regions from 1980 to 2005. Tables 7(a)–14(a) report the energy use for these regions by fuel type at five-year intervals, while Tables 7(b)–14(b) give the composition of primary energy use in each region in terms of fuel shares. The following paragraphs give highlights of these trends in energy use and changes in the composition by fuel type for each region.

2.4.1. North America

Energy use in North America grew at an average rate of about 1.3% per annum during the 25 year period — increasing from 82 EJ to 113 EJ (Fig. 4). Use of all types of fuel increased continuously during this period, with the following significant fluctuations:

(a) A significant decline in the use of liquid fuels and gases during the early 1980s that led to a decline in total energy use between 1980 and 1985;
(b) Some peaks in the use of liquid fuels and gases in the late 1980s and late 1990s;
(c) A significant decline in the use of gases in early 2000 that resulted in a smaller increase in total energy use between 2000 and 2005, i.e. an increase of only 2 GJ in those five years compared to an increase of 11 GJ between 1995 and 2000.

Fossil fuels remained the major source of energy. However, their share declined from 92% in 1980 to 86% in 2005, while the share of nuclear power increased (Table 7(b)). Growing at the rate of 4.5% per annum, the nuclear power share increased from 4% in 1980 to 8% in 2005 of the total energy use in the region.

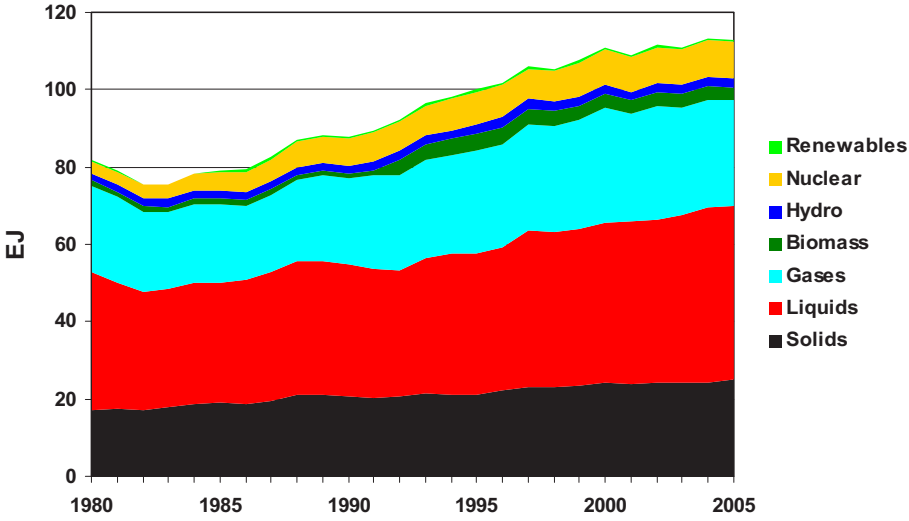

FIG. 4. Historical trend of energy use in North America by fuel type.

TABLE 7(a). ENERGY USE IN NORTH AMERICA (EJ)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Solids	17.2	19.2	20.7	21.2	24.1	24.8	1.5
Liquids	35.5	31.0	34.2	36.5	41.3	45.0	1.0
Gases	22.6	20.2	22.0	26.7	29.9	27.5	0.8
Biomass	1.3	1.4	1.3	4.3	3.7	3.2	3.8
Hydro	1.9	2.1	2.1	2.5	2.3	2.4	0.8
Nuclear	3.1	4.8	7.1	8.4	9.0	9.5	4.5
Renewables	0.2	0.4	0.6	0.5	0.5	0.6	4.4
Total	81.8	79.2	88.0	100.0	110.9	112.9	1.3

TABLE 7(b). PERCENTAGE CONTRIBUTION OF EACH FUEL TYPE TO THE ENERGY MIX IN NORTH AMERICA

	1980	1985	1990	1995	2000	2005
Solids	21.0	24.3	23.5	21.2	21.8	22.0
Liquids	43.4	39.2	38.9	36.5	37.3	39.8
Gases	27.6	25.5	25.1	26.6	27.0	24.3
Biomass	1.6	1.8	1.5	4.3	3.3	2.9
Hydro	2.3	2.7	2.4	2.5	2.1	2.1
Nuclear	3.8	6.0	8.0	8.4	8.1	8.4
Renewables	0.2	0.5	0.7	0.5	0.5	0.5

In brief, out of an increase of 31 EJ (the difference between 1980 and 2005), nuclear power was one of the four major contributors (solid fuels supplied 8 EJ, liquid fuels supplied 10 EJ, gases supplied 5 EJ and nuclear power supplied 6 EJ).

2.4.2. Latin America

The growth rate of 2.3% per annum in energy use by Latin America was above the world average growth rate over the 25 year period, which led to about a twofold increase in energy use from 17 EJ in 1980 to 31 EJ in 2005 (Fig. 5). Though fluctuating, total energy use and the use of all types of fuels were increasing throughout this period. The largest increase was in the use of gases, followed by the increase in the use of liquid fuels. The use of coal remained very low throughout the period.

The energy mix of the region changed in the 25 years. Though liquid fuels had a very high share in total energy use throughout the period, its share persistently declined from 59% in 1980 to 46% in 2005 (Table 8(b)). This share was taken up by the use of gases, which increased from 14% in 1980 to 25% in 2005, and the use of hydro, which increased from 5% in 1980 to 8% in 2005. In 1980, the second largest source of energy was biomass, and its share also declined from 19% to 16% in 2005 to become the third largest source of energy.

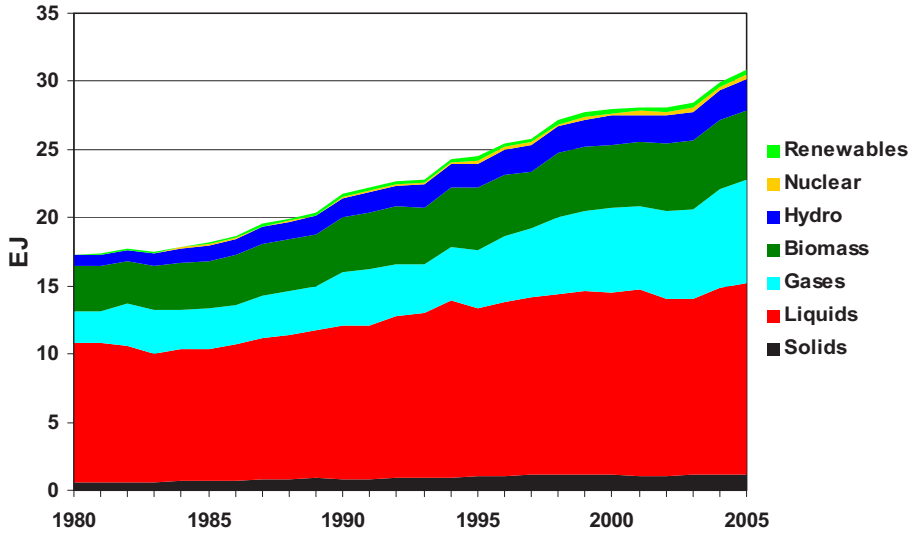

FIG. 5. Historical trend of energy use in Latin America by fuel type.

TABLE 8(a). ENERGY USE IN LATIN AMERICA (EJ)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Solids	0.6	0.7	0.8	1.0	1.1	1.1	2.9
Liquids	10.2	9.6	11.2	12.4	13.4	14.1	1.3
Gases	2.4	3.0	3.9	4.3	6.2	7.6	4.7
Biomass	3.3	3.5	4.1	4.5	4.7	5.1	1.8
Hydro	0.8	1.1	1.4	1.8	2.1	2.3	4.5
Nuclear	0.0	0.1	0.1	0.2	0.2	0.3	10.4
Renewables	0.0	0.1	0.2	0.3	0.3	0.3	7.7
Total	17.3	18.2	21.7	24.5	28.0	30.8	2.3

TABLE 8(b). PERCENTAGE CONTRIBUTION OF EACH FUEL TYPE TO THE ENERGY MIX IN LATIN AMERICA

	1980	1985	1990	1995	2000	2005
Solids	3.2	4.1	3.8	4.1	4.1	3.7
Liquids	59.1	52.9	51.5	50.5	47.9	45.7
Gases	13.8	16.4	18.0	17.6	22.0	24.6
Biomass	19.0	19.5	18.7	18.5	16.7	16.5
Hydro	4.5	6.2	6.5	7.3	7.5	7.6
Nuclear	0.1	0.5	0.6	0.7	0.8	0.9
Renewables	0.3	0.4	0.9	1.3	1.0	1.0

Briefly, the energy mix in Latin America changed towards more use of gases and hydro in place of liquid and biomass fuels.

2.4.3. Western Europe

Energy use in Western Europe grew slowly at the rate of 1.1% per annum, which was about half of the average growth rate in world energy use. The important feature of the growth pattern was negative growth in the use of solid and liquid fuels (Table 9(a)). From the early 1990s to 2005, use of solid fuels declined consistently. Unlike solid fuel, use of liquid fuels declined in the early 1980s and thereafter started increasing to come close to the level of 1980 in 2005. The increase in total energy use in Western Europe was mainly due to an increase in the use of gases and nuclear power. The biggest increase was in the use of gases from 9 EJ in 1980 to 19 EJ in 2005, followed by an increase in the use of nuclear power from 2 EJ in 1980 to 10 EJ in 2005.

There was a significant change in the energy mix of the region as the share of solid fuels in total energy use declined from 25% in 1980 to 14% in 2005 (Table 9(b)) and the share of liquid fuels came down from 50% in 1980 to 38% in 2005. The share of nuclear increased from 4% in 1980 to 14% in 2005, to be

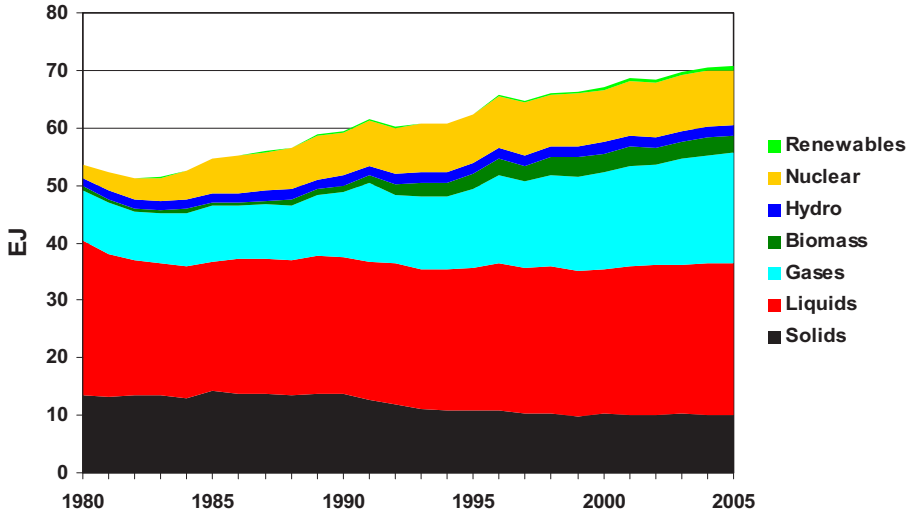

FIG. 6. Historical trend of energy use in Western Europe by fuel type.

TABLE 9(b). PERCENTAGE CONTRIBUTION OF EACH FUEL TYPE TO THE ENERGY MIX IN WESTERN EUROPE

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Solids	13.4	14.2	13.7	10.8	10.2	10.0	-1.2
Liquids	27.0	22.6	23.7	24.8	25.1	26.6	-0.1
Gases	8.9	9.6	11.4	13.8	16.9	19.1	3.1
Biomass	0.6	0.6	1.2	2.6	3.3	3.0	6.7
Hydro	1.5	1.6	1.7	1.8	2.0	1.8	0.7
Nuclear	2.2	6.0	7.6	8.3	9.0	9.6	6.1
Renewables	0.1	0.1	0.2	0.2	0.4	0.7	7.3
Total	53.6	54.8	59.4	62.4	67.0	70.7	1.1

TABLE 9(a). ENERGY USE IN WESTERN EUROPE (EJ)

	1980	1985	1990	1995	2000	2005
Solids	25.0	25.9	23.0	17.4	15.2	14.2
Liquids	50.3	41.3	39.9	39.7	37.5	37.6
Gases	16.5	17.6	19.2	22.2	25.3	27.0
Biomass	1.1	1.1	2.0	4.2	5.0	4.2
Hydro	2.8	3.0	2.8	2.9	3.1	2.6
Nuclear	4.1	10.9	12.8	13.4	13.4	13.6
Renewables	0.2	0.2	0.3	0.3	0.6	1.0

comparable to the share of solid fuels, and the share of gases increased from 17% in 1980 to 27% in 2005, to be closer to the share of liquid fuels. In brief, the energy mix in Western Europe changed significantly because of a big increase in the use of gases and nuclear power compared to the decline in the use of liquid and solid fuels.

2.4.4. Eastern Europe

Energy use in Eastern Europe went through three phases over 25 years, as the economies of the countries in this region passed through major changes. Energy use increased until the late 1980s. Then, between 1989 and 1998, energy use declined continuously, except for one year. After reaching the lowest level in 1998, energy use started increasing again, reaching the level of 1980 (Fig. 7).

Total energy use declined from 63 EJ to 56 EJ in 2005 (Table 10(a)), registering negative growth (–0.5% per annum) over the 25 year period. By fuel type, this decline was registered in the use of both solid and liquid fuels (–2.7% per annum growth in each). In 1980, solid and liquid fuels were two main components of energy use, accounting for a 72% share in total energy use. Use of solid and liquid fuels declined throughout the period, except during the late 1980s and early 2000s.

Registering 2.1% per annum growth, the use of gases increased from 16 EJ in 1980 to 27 EJ in 2005, and their share increased from 26% to 48% in total energy use of Eastern Europe in this period (Table 10(b)). Another

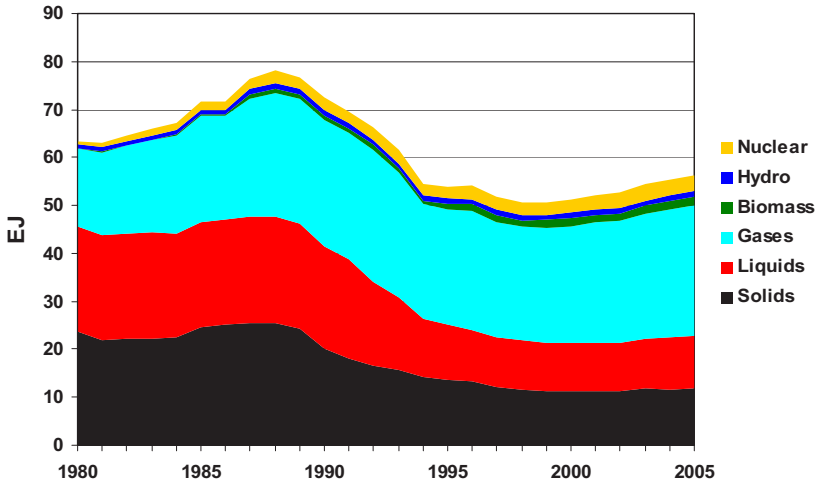

FIG. 7. Historical trend of energy use in Eastern Europe by fuel type.

TABLE 10(a). ENERGY USE IN EASTERN EUROPE (EJ)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Solids	23.5	24.7	20.3	13.6	11.4	11.8	-2.7
Liquids	22.1	21.9	21.1	11.4	9.9	11.1	-2.7
Gases	16.1	22.1	26.5	24.1	24.5	27.2	2.1
Biomass	0.2	0.2	1.0	1.3	1.7	1.8	10.3
Hydro	0.9	1.0	1.0	1.1	1.1	1.1	1.0
Nuclear	0.7	1.8	2.7	2.5	2.9	3.4	6.8
Total	63.4	71.5	72.5	53.9	51.3	56.2	-0.5

TABLE 10(b). PERCENTAGE CONTRIBUTION OF EACH FUEL TYPE TO ENERGY USE IN EASTERN EUROPE

	1980	1985	1990	1995	2000	2005
Solids	37.1	34.5	27.9	25.2	22.2	21.0
Liquids	34.8	30.6	29.0	21.1	19.2	19.7
Gases	25.5	30.9	36.6	44.7	47.7	48.4
Biomass	0.2	0.3	1.3	2.4	3.3	3.2
Hydro	1.4	1.3	1.4	2.0	2.1	2.0
Nuclear	1.0	2.5	3.8	4.6	5.7	6.1

significant increase was in the use of nuclear energy, which recorded a 6.8% per annum growth rate, and its share increased from 1% in 1980 to 6% in 2005.

In brief, the region experienced a drastic change in its energy mix in the 25 year period. Compared to a big contribution from solid and liquid fuels in 1980, there was a heavy reliance on gases in 2005, as almost half of total energy use was in the form of gases.

2.4.5. Africa

Africa recorded a growth rate of 4.7% per annum in energy use, which increased from 10 EJ in 1980 to 30 EJ in 2005 (Table 11(a)). This increase, however, was essentially due to a fivefold increase in the use of biomass (from 3 EJ in 1980 to 15 EJ in 2005). The share of biomass increased to 52% of total energy use in 2005 (Table 11(b)). This increase started from the mid-1990s (Fig. 8) and may be due to improvement in data on the use of biomass.

Aside from biomass, there was also a significant increase in the use of fossil fuels over the 25 year period, about a fourfold increase in the use of gases, more than a twofold increase in the use of liquid fuels and about a twofold increase in the use of solid fuels. In the aggregate, use of non-biomass energy registered about a twofold increase in this period. In absolute terms, the biggest

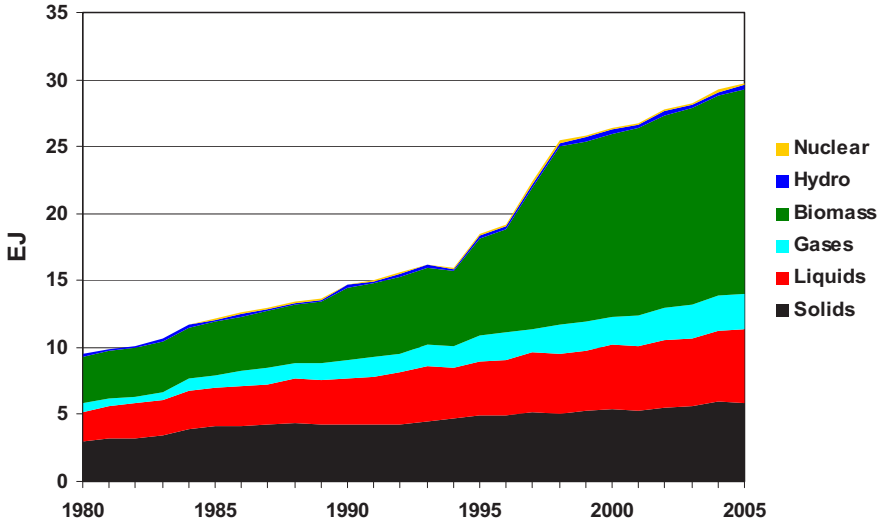

FIG. 8. Historical trend of energy use in Africa by fuel type.

TABLE 11(a). ENERGY USE IN AFRICA (EJ)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Solids	3.0	4.1	4.2	4.9	5.3	5.9	2.7
Liquids	2.1	2.9	3.4	4.0	4.8	5.4	3.8
Gases	0.7	0.9	1.4	2.0	2.1	2.7	5.6
Biomass	3.4	4.0	5.4	7.2	13.7	15.2	6.1
Hydro	0.2	0.2	0.2	0.2	0.3	0.3	1.8
Nuclear	-	0.1	0.1	0.1	0.1	0.1	-
Total	9.5	12.2	14.8	18.5	26.4	29.7	4.7

TABLE 11(b). PERCENTAGE CONTRIBUTION OF EACH FUEL TYPE TO ENERGY USE IN AFRICA

	1980	1985	1990	1995	2000	2005
Solids	32.0	33.5	28.6	26.5	20.2	19.8
Liquids	22.6	23.8	23.3	21.8	18.3	18.3
Gases	7.4	7.6	9.3	10.7	7.9	9.2
Biomass	36.1	33.1	36.7	39.0	52.0	51.0
Hydro	2.3	1.4	1.3	1.2	1.1	1.1
Nuclear	-	0.5	0.6	0.7	0.5	0.4

increases were in the use of solid and liquid fuels, each of which increased by 3 EJ.

In the total energy mix, the share of solid fuels declined from 32% to 20% and the share of liquid fuels declined from 23% to 18% over the 25 year period,

due to the increase in the share of biomass from 36% in 1980 to 50% in 2005. However, there was a small increase in the share of gases from 7% to 9% in these years.

In brief, the energy mix in Africa changed over the 25 year period, essentially because of an increase in the use of biomass that resulted in a significant decline in the share of solid and liquid fuels. Aside from this phenomenon, solid and liquid fuels remained the major fuels, accounting for about an 80% share in the non-biomass energy use.

2.4.6. Middle East and South Asia

The region of the Middle East and South Asia recorded a 5.3% per annum growth in energy use from 1980 to 2005, to reach the level of 49 EJ in 2005, with a more than threefold increase in the level of 1980 (Table 12(a)). It is one of the regions where energy use of three fossil fuels grew rapidly. There was a continuous increase in energy use during the 25 year period, except that:

(a) A rapid increase in the use of gases in 1994 was followed by a decline in 1995;
(b) A rapid increase in the use of biomass in 1995 was followed by a decline in 1996.

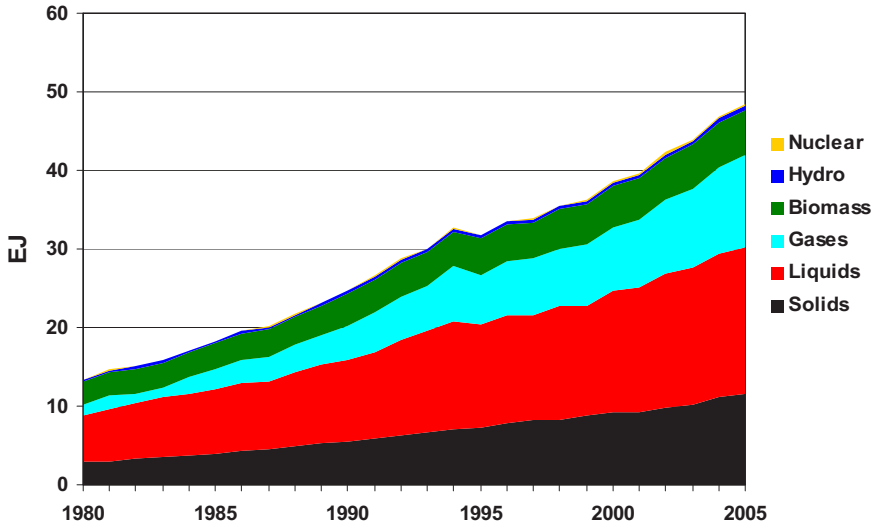

FIG. 9. Historical trend of energy use in the Middle East and South Asia by fuel type.

TABLE 12(a). ENERGY USE IN THE MIDDLE EAST AND SOUTH ASIA (EJ)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Solids	2.9	4.0	5.5	7.3	9.2	11.6	5.8
Liquids	6.0	8.2	10.4	13.2	15.5	18.7	4.7
Gases	1.4	2.5	4.4	6.1	8.2	11.7	8.9
Biomass	2.9	3.2	4.0	4.8	5.2	5.8	2.8
Hydro	0.2	0.3	0.4	0.4	0.4	0.6	3.5
Nuclear	0.03	0.05	0.06	0.08	0.16	0.20	7.7
Total	13.4	18.3	24.7	31.8	38.6	48.5	5.3

TABLE 12(b). PERCENTAGE CONTRIBUTION OF EACH FUEL TYPE TO ENERGY USE IN THE MIDDLE EAST AND SOUTH ASIA

	1980	1985	1990	1995	2000	2005
Solids	21.5	21.8	22.4	23.0	23.7	23.9
Liquids	44.7	44.9	42.0	41.3	40.1	38.5
Gases	10.3	13.9	17.7	19.2	21.2	24.0
Biomass	21.5	17.6	16.1	14.9	13.6	11.9
Hydro	1.8	1.5	1.5	1.3	1.0	1.2
Nuclear	0.2	0.2	0.3	0.3	0.4	0.4

In terms of growth rates, the use of liquid fuel registered less growth (4.7% per annum) compared to the highest growth rate in the use of gases (8.9% per annum) and 5.8% per annum growth in the use of solid fuels. This resulted in a significant decline in the share of liquid fuel in total energy use, to come down from 45% in 1980 to 39% in 2005 (Table 12(b)). Contrary to this, the share of gases increased significantly from 10% in 1980 to 24% in 2005, while the share of solids increased from 22% to 24% in 2005. Hence, the use of gases and solid fuels in the Middle East and South Asia became almost equal in 2005.

In 1980, the use of biomass and solid fuels was equal; a slower growth in the use of biomass (2.8% per annum) decreased its share in total energy use significantly from 22% in 1980 to 12% in 2005.

Over the 25 year period there was a change in the energy mix of this region from comparable use of biomass and solid fuels towards a comparable use of gases and solid fuels.

2.4.7. Southeast Asia and Pacific

In this region, energy use, growing at the rate of 4.4% per annum, recorded a little less than threefold increase over the 25 year period (Table 13(a)). The highlights of the expansion path are that:

(a) There was a rapid increase in the use of oil and gases from the late 1980s to the mid-1990s, which ended in a sharp decline from 1997 to 1998. However, the use of oil and gases returned to an increasing trend in 1999.
(b) There was a similar up and down movement in the use of solid and liquid fuels from 2002 to 2003, though on a smaller scale.

Over the 25 year period, the largest increase was in the use of liquid fuel, with the second largest increase in the use of gases. The use of fossil fuels outpaced the use of biomass. In 1980, the use of biomass was much greater than the use of gases and a little greater than the use of solid fuels. In 2005, the use of biomass decreased to only one-half and two-thirds of the use of gases and solid fuels, respectively.

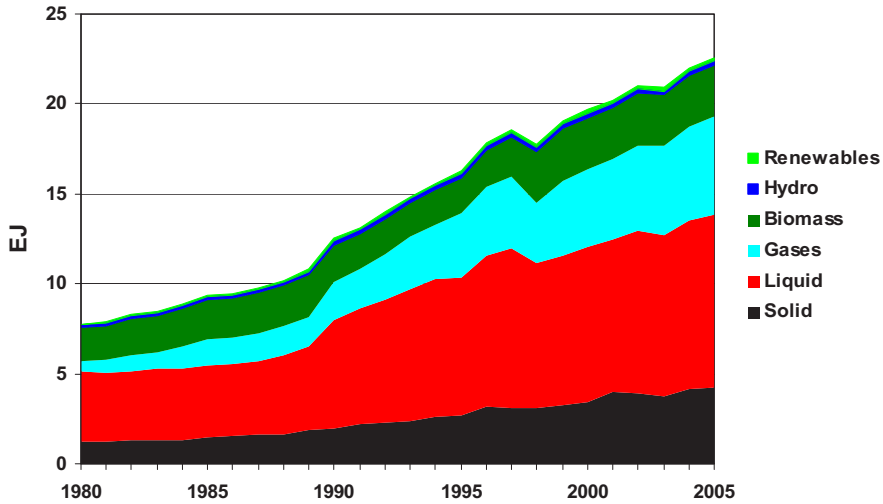

FIG. 10. Historical trend of energy use in Southeast Asia and the Pacific by fuel type.

TABLE 13(a). ENERGY USE IN SOUTHEAST ASIA AND THE PACIFIC

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Solids	1.2	1.5	1.9	2.7	3.4	4.3	5.2
Liquids	3.9	4.0	6.1	7.7	8.6	9.6	3.7
Gases	0.6	1.5	2.1	3.6	4.3	5.4	9.1
Biomass	1.9	2.2	2.0	1.9	2.9	2.8	1.7
Hydro	0.1	0.2	0.2	0.3	0.2	0.2	2.1
Renewables	0.05	0.1	0.1	0.2	0.2	0.2	6.5
Total	7.8	9.3	12.5	16.3	19.7	22.6	4.4

TABLE 13(b). PERCENTAGE CONTRIBUTION OF EACH FUEL TYPE TO ENERGY USE IN SOUTHEAST ASIA AND THE PACIFIC

	1980	1985	1990	1995	2000	2005
Solids	15.5	15.9	15.5	16.4	17.3	18.9
Liquids	50.1	42.8	48.6	47.4	43.8	42.4
Gases	8.0	15.7	16.9	22.1	21.9	24.1
Biomass	23.9	23.1	16.3	11.6	14.6	12.6
Hydro	1.8	1.9	1.7	1.6	1.3	1.1
Renewables	0.6	0.6	1.0	1.0	1.1	1.0

In terms of average annual growth rates, the use of gases registered the highest rate (9.1% per annum), which increased its share from 8% in 1980 to 24% in 2005. The second highest growth was in the use of solid fuels (5.2% per annum), leading to an increase of its share from 16% to 19% in this period. A relatively smaller growth in the use of liquid fuel (3.7% per annum) reduced its share in total energy use. The liquid fuels had a share of 50% in total energy use in 1980, which declined to 42% in 2005 after increasing and decreasing in the range of 43% to 49% during the period from 1985 to 2000 (Table 13(b)). The decline in the share of biomass was much greater, decreasing from 24% of total energy use in 1980 to 10% in 2005. In brief, the energy mix in Southeast Asia and the Pacific changed towards smaller shares of biomass and liquid fuels and larger contributions from gases and solid fuels.

2.4.8. Far East

Energy use in the Far East registered a 3.9% per annum growth rate, which was about two times the world average, and it increased from 39 EJ in 1980 to 102 EJ in 2005 (Table 14(a)). Figure 11 shows that there was a persistent growth in energy use from 1982 to 1997, which was followed by a sharp decline in 1998 and 1999. The decline in the use of energy in the late 1990s was attributable to financial crises in the region. Although energy use grew at a higher rate, 7% per annum from 2000 to 2005, the region was not able to return to the previous expansion path.

The decline in energy use in the late 1990s was mainly in the use of solid fuels, which declined continuously from 1997 to 2000, and it resumed the increasing trend during the 2001 to 2005 period. There was a decline in the use of liquid fuels in the early 1980s, which was partly compensated by the increase in the use of coal and nuclear power, and therefore there was no significant decline in total energy use. There was a more persistent increase in the use of gases, except for a small decline in 1981.

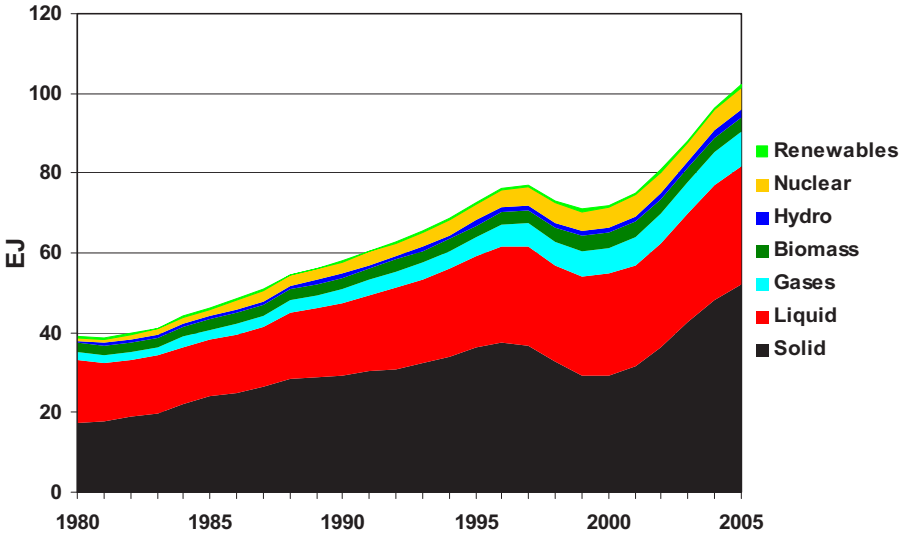

FIG. 11. Historical trend of energy use in the Far East by fuel type.

TABLE 14(a). ENERGY USE IN THE FAR EAST (EJ)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Solids	17.3	24.0	29.1	36.3	29.2	52.3	4.5
Liquids	15.7	14.1	18.3	22.8	25.5	29.4	2.5
Gases	2.1	2.7	3.6	4.9	6.7	8.9	6.0
Biomass	2.3	2.5	2.7	2.9	3.8	3.6	1.9
Hydro	0.7	0.8	1.0	1.2	1.3	2.0	4.5
Nuclear	0.9	1.7	2.9	4.2	4.9	5.5	7.5
Renewables	0.1	0.2	0.3	0.4	0.6	0.5	6.0
Total	39.0	46.1	57.9	72.6	71.9	102.1	3.9

TABLE 14(b). PERCENTAGE CONTRIBUTION OF EACH FUEL TYPE TO ENERGY USE IN THE FAR EAST

	1980	1985	1990	1995	2000	2005
Solids	44.5	52.1	50.3	50.0	40.5	51.2
Liquids	40.2	30.6	31.6	31.5	35.5	28.8
Gases	5.3	5.8	6.2	6.7	9.3	8.7
Biomass	5.8	5.5	4.6	4.0	5.2	3.5
Hydro	1.7	1.8	1.7	1.7	1.8	1.9
Nuclear	2.3	3.7	5.1	5.7	6.8	5.4
Renewables	0.3	0.5	0.4	0.5	0.8	0.5

Over the 25 year period, the most prominent features of the growth were:

(a) A sixfold increase in the use of nuclear energy;
(b) An approximately fourfold increase in the use of gases;
(c) A threefold increase in the use of solid fuels.

The Far East is the only region in which there was no big difference in the growth rates of gases and solid fuels (6.0% and 4.5%, respectively). The biggest increase was in the share of solid fuels, which rose from 45% to 51% over the 25 year period (Table 14(b)), followed by an increase in the share of gases from 5% to 9% and an increase in the share of nuclear energy from 2% to 5% (Fig. 11). While liquids remained the second largest contributor throughout the 25 year period, there was a decline in its share (from 40% in 1980 to 29% in 2005) as it recorded a slower growth (2.5% per annum) relative to other sources. In brief, the energy mix in the Far East changed towards a high reliance on solid fuels, which had more than a 50% share in total energy use in 2005, and a smaller contribution from liquid fuels, while the shares of both nuclear energy and gases increased.

3. ELECTRICITY GENERATION TRENDS

There was a twofold increase in global electricity generation over the 25 year period, which increased from 8191 TW·h in 1980 to 16 932 TW·h in 2005 (Fig. 12). The average growth rate of 2.9% per annum in electricity generation was higher than the growth rate of overall energy use worldwide (2.0% per annum).

3.1. SOURCES OF GLOBAL ELECTRICITY GENERATION

Figure 12 shows that thermal power remained the major source of electricity generation over the past 25 years. However, there was a change in the electricity generation mix in this period in terms of the contribution of nuclear power and renewable sources. There was a substantial increase in nuclear power generation and some expansion in generation from renewable sources. Nuclear electricity generation increased from 635 TW·h in 1980 to

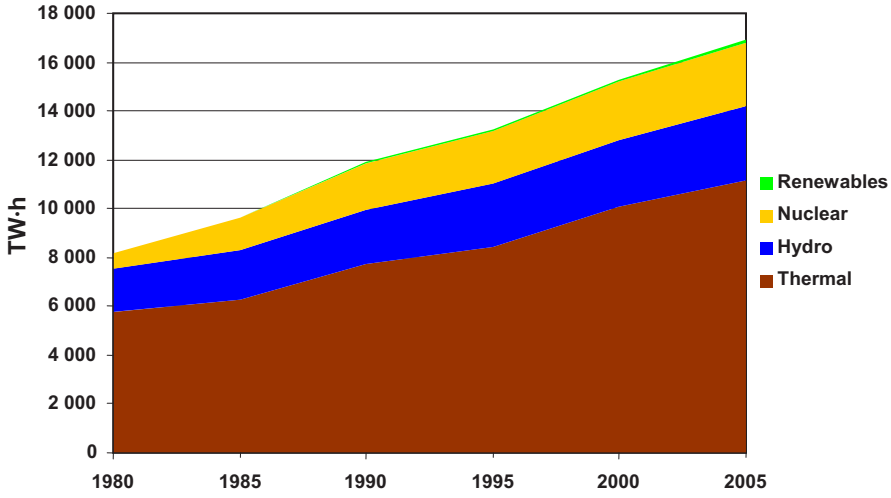

FIG. 12. Historical trend of world electricity generation by fuel type.

TABLE 15. WORLD ELECTRICITY GENERATION BY FUEL TYPE (TW·h)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Thermal	5 782	6 273	7 746	8 454	10 093	11 182	2.7
Hydro	1 759	2 018	2 208	2 578	2 710	2 989	2.1
Nuclear	635	1 324	1 890	2 174	2 415	2 626	5.8
Renewables	14	27	42	51	83	134	9.4
Total	8 191	9 642	11 887	13 258	15 301	16 932	2.9

2626 TW·h in 2005. This fourfold increase made nuclear power generation comparable to hydropower generation in 2005. The share of nuclear power in global generation increased from 7.8% in 1980 to 15.5% in 2005. On average, there was 5.8% per annum growth in electricity generation from nuclear power (Table 15). Generation from renewable sources had the highest growth rate (9.4% per annum) and it reached 134 TW·h in 2005, accounting for a share of 0.8% in total generation in 2005, compared to its share of 0.2% in 1980.

Thermal electricity generation doubled in 25 years (from 5782 TW·h in 1980 to 11 183 TW·h in 2005). However, its relatively slower growth rate (2.7% per annum) led to a decline in its share from 71% to 66% in this period (Table 16). Similarly, there was also a decline in the share of hydropower, which declined from 22% in 1980 to 18% in 2005. Hydropower generation increased from 1759 TW·h in 1980 to 2989 TW·h in 2005, and it registered an average

TABLE 16. PERCENTAGE CONTRIBUTION OF EACH FUEL TYPE TO ELECTRICITY GENERATION

	1980	1985	1990	1995	2000	2005
Thermal	70.6	65.1	65.2	63.8	66.0	66.0
Hydro	21.5	20.9	18.6	19.4	17.7	17.7
Nuclear	7.8	13.7	15.9	16.4	15.8	15.5
Renewables	0.2	0.3	0.4	0.4	0.5	0.8

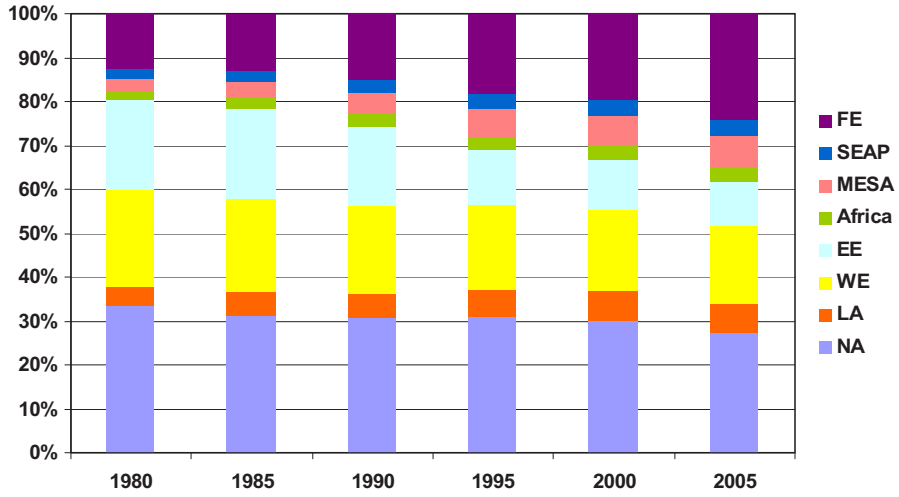

FIG. 13. World electricity generation by region.

growth rate of 2.1% per annum, which was the lowest among the growth rates for all sources of electricity generation.

3.2. REGIONAL DISTRIBUTION OF ELECTRICITY GENERATION IN THE WORLD

Figure 13 shows that there was a significant change in the regional distribution of global electricity generation from 1980 to 2005. Table 17 shows that the electricity growth rates in North America (2.1% per annum), Western Europe (2.0% per annum) and Eastern Europe (0.2% per annum) were much lower than the average growth rate of global electricity generation (2.9% per annum). This resulted in significant declines in the shares of these regions (6, 4 and 10%, respectively) in world electricity generation over this period.

There was an increase in the shares of all other regions in global electricity generation over the 25 year period (Table 18). The biggest increase

TABLE 17. ELECTRICITY GENERATION BY REGION (TW·h)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
North America	2 730	3 022	3 659	4 114	4 612	4 631	2.1
Latin America	380	500	630	800	1 006	1 116	4.4
Western Europe	1 809	2 053	2 376	2 558	2 889	2 995	2.0
Eastern Europe	1 655	1 957	2 189	1 712	1 709	1 723	0.2
Africa	189	247	319	369	441	510	4.1
Middle East and South Asia	234	374	588	830	1 111	1 240	6.9
South East Asia and Pacific	172	236	332	441	549	630	5.3
Far East	1 023	1 253	1 794	2 433	2 984	4 087	5.7
Total	8 191	9 642	11 887	13 258	15 301	16 932	2.9

TABLE 18. REGIONAL SHARES IN ELECTRICITY GENERATION (%)

	1980	1985	1990	1995	2000	2005
North America	33	31	31	31	30	27
Latin America	5	5	5	6	7	7
Western Europe	22	21	20	19	19	18
Eastern Europe	20	20	18	13	11	10
Africa	2	3	3	3	3	3
Middle East and South Asia	3	4	5	6	7	7
South East Asia and Pacific	2	2	3	3	4	4
Far East	12	13	15	18	20	24

was in the share of the Far East. With an increase of 12%, the Far East's share (24%) in 2005 became higher than the shares of Western Europe and Eastern Europe (18% and 10%, respectively). The growth rate of electricity generation in the Far East (5.7% per annum) was about two times the average world growth rate of electricity generation (2.9% per annum).

The second largest increase was in the share of the Middle East and South Asia, which registered a 6.9% per annum growth, and its share in the world's electricity generation increased by 4% over the 25 year period. Other regions (Latin America, Africa and Southeast Asia and the Pacific) recorded increases in their shares in the range of 1 to 2% from 1980 to 2005.

Table 17 shows that global electricity generation increased by 8741 TW·h from 8191 TW·h in 1980 to 16 932 TW·h in 2005, of which an increase of 3064 TW·h was in the Far East, compared to the increases of 1901 TW·h in North America and 1186 TW·h in Western Europe. The smallest increase in electricity generation was in Eastern Europe (68 TW·h) over the 25 year period

Four highlights of the changes in regional distribution of world electricity generation are the following:

(1) Increase in the shares of all regions in the world's electricity generation (Table 18), except the shares of North America, Western Europe and Eastern Europe (the three biggest electricity generators);
(2) The Far East becoming the second largest electricity generator in 2005, whereas it was the fourth largest producer in 1980;
(3) Electricity generation in the Far East becoming comparable to generation in North America in 2005;
(4) After the Far East, the second biggest increase being in the share of the Middle East and South Asia in the world's electricity generation.

3.3. ELECTRICITY GENERATION ON A PER CAPITA BASIS

The world's per capita electricity generation increased from 1.9 MW·h in 1980 to 2.6 MW·h in 2005, at an average annual rate of 1.4%. The increase in per capita electricity generation was registered in all regions (Fig. 14), but with a wide variation among the regions.

North America experienced the greatest increase, 3.3 MW·h, in its per capita electricity generation, while the increase in other regions was in the range of 0.15 to 1.6 MW·h. This pattern of increase further widened the gaps between North America and other regions in terms of per capita electricity

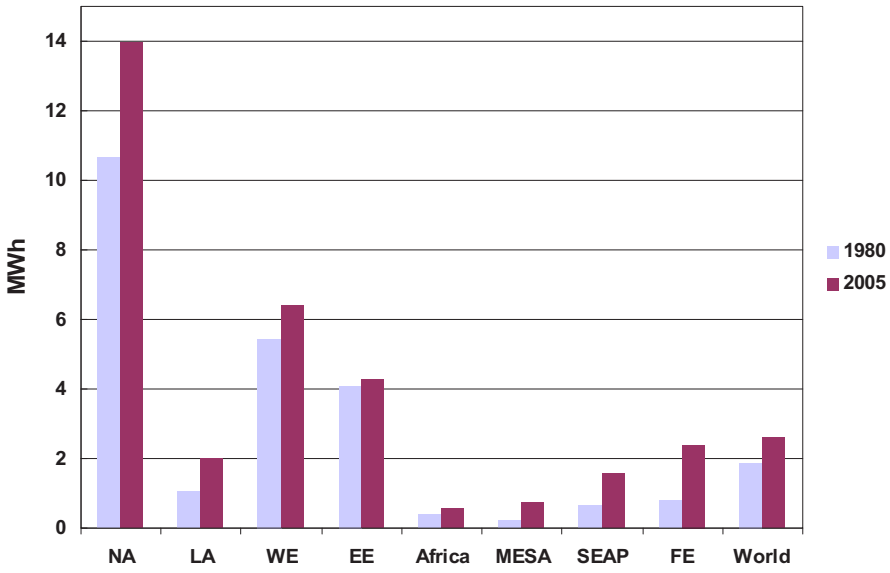

FIG. 14. Per capita electricity generation.

generation. In 1980, the gap between North America and other regions in per capita electricity generation was in the range of 5 MW·h to 10 MW·h. This gap increased to be in the range of 8 MW·h to 13 MW·h in 2005.

In 1980, among all the regions, the Middle East and South Asia had the lowest per capita electricity generation; however, the region was able to climb one step in the ranking and had the second lowest per capita electricity generation in 2005. Africa became the region with the lowest per capita generation in 2005. Per capita generation in the Middle East and South Asia increased from 0.24 MW·h in 1980 to 0.74 MW·h in 2005, while it increased from 0.40 MW·h in 1980 to 0.57 MW·h in 2005 in Africa.

In 2005:

(a) North America's per capita electricity generation of 13.9 MW·h was about 2 times that of Europe, 5 times the world average and 24 times the level in Africa.
(b) Per capita electricity generation of 6.4 MW·h in Western Europe was about 2 times the world average and 11 times per capita electricity generation in Africa.
(c) Eastern Europe's per capita electricity generation was 60% higher than the world average and 7 times the per capita electricity generation in Africa.
(d) There was a significant increase in per capita generation in the Far East, which increased from 0.8 MW·h in 1980 to 2.4 MW·h in 2005. Nevertheless, it was one sixth of per capita generation in North America in 2005, and the gap in per capita generation of North America and the Far East increased from 9 MW·h in 1980 to 11 MW·h in 2005.

3.4. TRENDS IN ELECTRICITY GENERATION BY FUEL TYPE IN THE REGIONS

Figures 15–22 show the 25 year historical trends of electricity generation by fuel type for each region, while Tables 19(a)–26(a) report generation by fuel type for each region at 5 year intervals. The following sections discuss the historical pattern of electricity generation by region.

3.4.1. North America

Electricity generation in North America increased from 2730 TW·h in 1980 to 4631 TW·h in 2005, growing at the rate of 2.1% per annum (Table 19(a)). There was an increase in the pace of growth between 1985 and

2000, mainly because of expansion in thermal generation. However, from 2000 to 2005 there was a decline in thermal electricity generation which was compensated by nuclear power generation, leading to a small increase in total generation in 2005 compared to 2000.

Over the 25 year period, there were changes in the electricity generation mix by fuel type (Table 19(b)):

(a) A relatively small growth in thermal electricity generation (1.9% per annum) led to a decline in its share from 70% in 1980 to 66% in 2005.
(b) In 1980, hydropower was the second largest source of electricity generation, accounting for 19% of total electricity generation. However, there was very slow growth in hydropower generation (0.8% per annum) over the 25 years. By 2005, hydropower became the third largest source of electricity generation and its share declined to 14%.

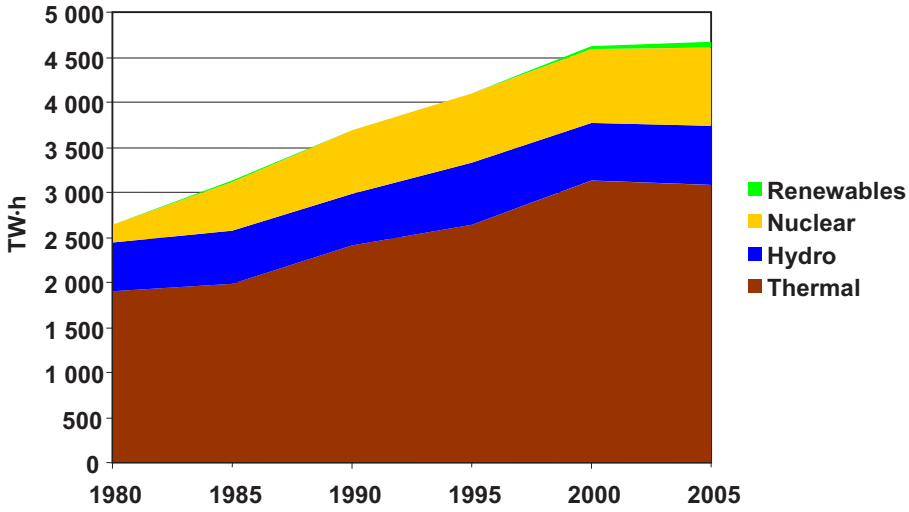

FIG. 15. Historical trend of electricity generation by fuel type in North America.

TABLE 19(a). ELECTRICITY GENERATION BY FUEL TYPE IN NORTH AMERICA (TW·h)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Thermal	1 906	1 982	2 409	2 640	3 128	3 076	1.9
Hydro	531	589	582	688	639	655	0.8
Nuclear	288	438	648	768	825	870	4.5
Renewables	5	12	20	18	21	30	7.1
Total	2 730	3 022	3 659	4 114	4 612	4 631	2.1

TABLE 19(b). COMPOSITION OF ELECTRICITY GENERATION BY FUEL TYPE IN NORTH AMERICA (% SHARE)

	1980	1985	1990	1995	2000	2005
Thermal	69.8	65.6	65.8	64.2	67.8	66.4
Hydro	19.4	19.5	15.9	16.7	13.8	14.1
Nuclear	10.5	14.5	17.7	18.7	17.9	18.8
Renewables	0.2	0.4	0.5	0.4	0.5	0.6

(c) In 2005, nuclear power became the second largest source of supply. Nuclear electricity generation increased from 288 TW·h to 870 TW·h in 2005 — recording an average growth rate of 4.5% per annum, and its share of total electricity generation increased from 11% in 1980 to 19% in 2005.

(5) Although electricity generation from renewable sources registered a high growth rate (7.1% per annum) over the 25 year period, its share of total generation in North America remained small, i.e. 0.6% in 2005.

3.4.2. Latin America

There was an approximately threefold increase in electricity generation from 1980 to 2005, 4.4% per annum. Total generation increased rapidly from 1980 to 2000 and slowed down during the next five years.

Throughout this period, electricity was generated mainly from two sources, hydro and thermal. The greatest expansion was in hydropower generation, with a rapid increase in the period from the late 1980s to the late 1990s and a smaller increase in the period from 2000 to 2005. There was also a persistent increase in thermal generation, with the greatest increase from 1995 to 2000. Although very little, the electricity generated from nuclear power increased continuously from 2 TW·h in 1980 to 26 TW·h in 2005, with the greatest increase from 2000 to 2005 (Table 20(a)).

The highlights of changes in the generation mix are as follows (Table 20(b)):

(a) The share of hydro generation remained the highest throughout the period. It increased from 57% in 1980 to 62% in 1985 and remained so until the mid-1990s. Thereafter it started declining, to reach 58% in 2005.

(b) The share of thermal electricity generation declined from 42% in 1980 to 38% in 2005. It was on the declining trend, except for a small increase in the period from 1995 to 2000.

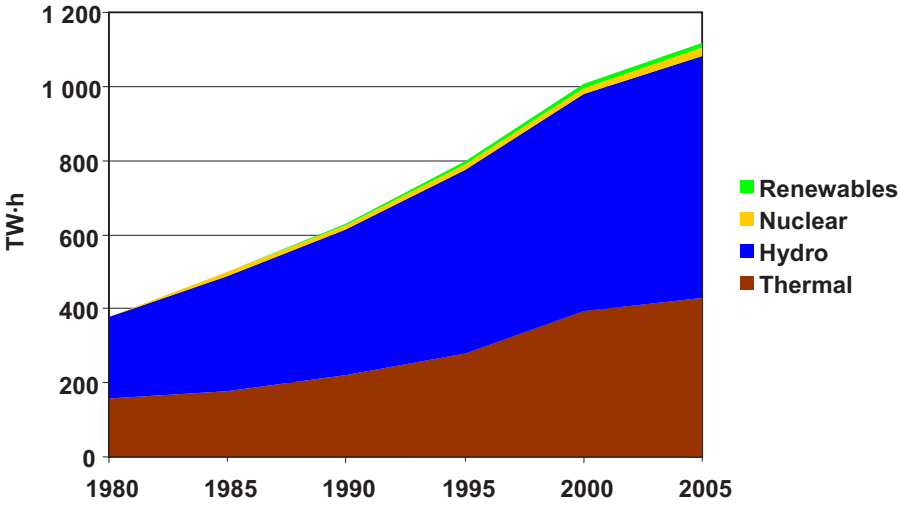

FIG. 16. Historical trend of electricity generation by fuel type in Latin America.

TABLE 20(a). ELECTRICITY GENERATION BY FUEL TYPE IN LATIN AMERICA (TW·h)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Thermal	159	178	222	278	392	429	4.0
Hydro	217	311	390	497	585	651	4.5
Nuclear	2	8	12	16	19	26	10.4
Renewables	1	2	6	9	9	10	8.6
Total	380	500	630	800	1 006	1 116	4.4

TABLE 20(b). COMPOSITION OF ELECTRICITY GENERATION BY FUEL TYPE IN LATIN AMERICA (% SHARE)

	1980	1985	1990	1995	2000	2005
Thermal	41.9	35.6	35.3	34.7	39.0	38.4
Hydro	57.1	62.2	62.0	62.1	58.2	58.3
Nuclear	0.6	1.7	1.8	2.1	1.9	2.3
Renewables	0.3	0.5	0.9	1.1	0.9	0.9

(c) The share of nuclear power in total electricity increased from 0.6% in 1980 to 2.3% in 2005.

This is the only region where the increase in hydropower generation was much larger than the expansion in thermal power generation and the share of hydro was above 57% throughout the 25 years, providing up to 62% of total generation for 10 years (1985–1995).

3.4.3. Western Europe

Electricity generation in Western Europe grew at an average annual rate of 2% per annum and increased by 65% from 1980 to 2005. There was a continuous expansion in generation with a relatively slower increase in the last five years.

It is one of the four regions that have significant electricity generation from three sources. In the 25 year period, the greatest expansion was in nuclear power generation, increasing by 679 TW·h (from 200 TW·h in 1980 to 879 TW·h in 2005), with a relatively smaller expansion in the last five years (Table 21(a)).

After a slight decline in the early 1980s, thermal generation also increased continuously until 2005, with a larger increase around 2000. There was an increase of 352 TW·h in the thermal generation level over the 25 year period (from 1187 TW·h in 1980 to 1539 TW·h in 2005). Compared to nuclear and thermal there was a smaller increase in hydropower generation, which had increased until 2000 and declined in the next five years.

In the generation mix over the 25 year period (Table 21(b)):

(a) A big increase (18%) in the share of nuclear power generation (11% in 1980 to 29% in 2005), which had fluctuated between 27% and 30% from 1985 to 2005.

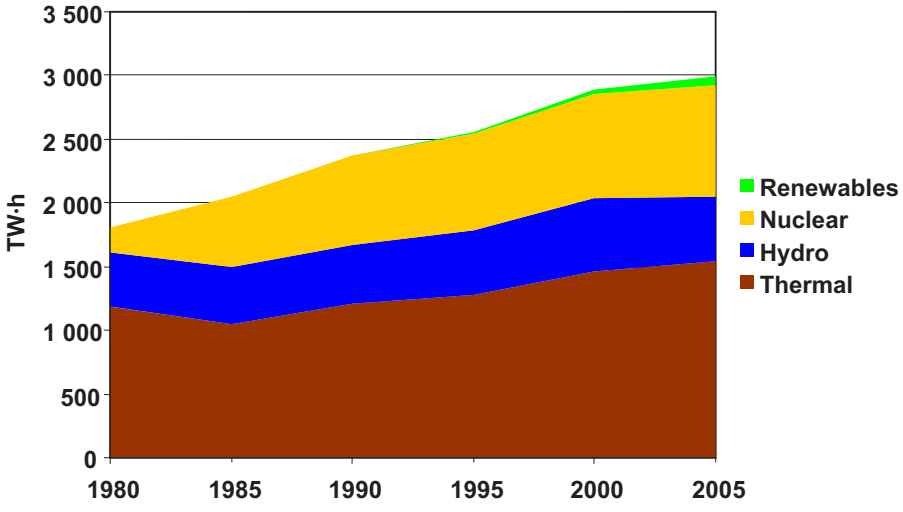

FIG. 17. Historical trend of electricity generation by fuel type in Western Europe.

TABLE 21(a). ELECTRICITY GENERATION BY FUEL TYPE IN WESTERN EUROPE (TW·h)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Thermal	1 187	1 049	1 212	1 273	1 466	1 539	1.0
Hydro	419	452	461	511	568	511	0.8
Nuclear	200	548	697	765	825	879	6.1
Renewables	3	4	5	9	29	66	12.8
Total	1 809	2 053	2 376	2 558	2 889	2 995	2.0

TABLE 21(b). COMPOSITION OF ELECTRICITY GENERATION BY FUEL TYPE IN WESTERN EUROPE (% SHARE)

	1980	1985	1990	1995	2000	2005
Thermal	65.6	51.1	51.0	49.8	50.8	51.4
Hydro	23.2	22.0	19.4	20.0	19.7	17.0
Nuclear	11.0	26.7	29.4	29.9	28.6	29.4
Renewables	0.2	0.2	0.2	0.4	1.0	2.2

(b) A 14% decline in the share of thermal power (from 66% in 1980 to 51% in 2005), and a small decline (6%) in the share of hydropower from 23% in 1980 to 17% in 2005, which had declined continuously, except in some years around 1995.
(c) A small increase in the share of electricity generation from renewable resources, which rose to 1% in 2000 and increased to 2% in 2005.

In brief, the electricity generation mix in Western Europe changed significantly in 25 years towards less contribution from thermal sources, mainly because of an expansion in nuclear power generation.

3.4.4. Eastern Europe

Electricity generation in Eastern Europe went through three distinct phases, first increasing rapidly, then declining, followed by a slower expansion which led to a small increase in electricity generation over the 25 year period (from 1655 TW·h in 1980 to 1723 TW·h in 2005) and a growth rate of only 0.2% per annum in this period (Table 22(a)).

Over this period, however, the generation mix changed as the rate of nuclear power generation became higher than hydropower generation towards the end of the 25 year period (Table 22(b)). Thermal electricity generation remained the largest source of generation over the 25 year period. It increased

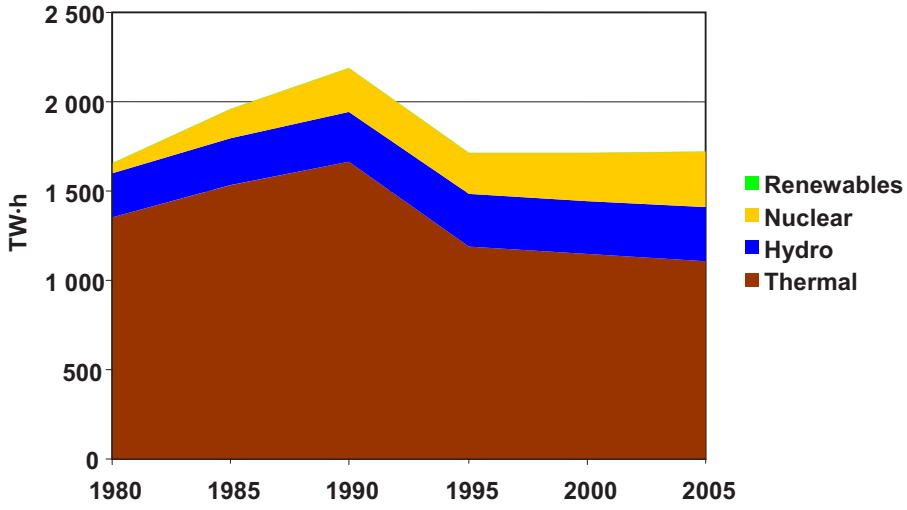

FIG. 18. Historical trend of electricity generation by fuel type in Eastern Europe.

TABLE 22(a). ELECTRICITY GENERATION BY FUEL TYPE IN EASTERN EUROPE (TW·h)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Thermal	1 355	1 531	1 663	1 187	1 147	1 104	-0.8
Hydro	240	265	276	299	293	305	1.0
Nuclear	60	162	250	226	270	314	6.8
Renewables	-	0.001	0.03	0.03	0.08	0.61	-
Total	1 655	1 957	2 189	1 712	1 709	1 723	0.2

TABLE 22(b). COMPOSITION OF ELECTRICITY GENERATION BY FUEL TYPE IN EASTERN EUROPE (% SHARE)

	1980	1985	1990	1995	2000	2005
Thermal	81.9	78.2	75.9	69.3	67.1	64.1
Hydro	14.5	13.5	12.6	17.5	17.1	17.7
Nuclear	3.6	8.3	11.4	13.2	15.8	18.2
Renewables	-	0.0001	0.001	0.002	0.005	0.04

until 1990, but recorded a rapid decline in the next five years, and thereafter continued to decline until 2005, which resulted in a negative growth of –0.8% per annum over the period.

Nuclear power generation recorded a high growth rate of 6.8% per annum over the 25 year period, but it went through the three phases: it

increased until 1990 and recorded a small decline in the mid-1990s, but continued to grow thereafter until 2005.

Although slowly, hydropower increased over 25 years, growing at 1.0% per annum. Apart from small annual fluctuations it also went through three phases of increase until 2000, decline in the next five years, followed by an increase from 2000 to 2005.

In the generation mix over the period:

(a) There was a continuous decline in the share of thermal electricity generation from 82% in 1980 to 64% in 2005;
(b) The share of nuclear power increased from 4% in 1980 to 18% in 2005 and became a little bit higher than the share of hydropower in 2005;
(c) The share of hydropower increased and decreased between 13% and 14% over the first 10 years (1980–1990) and was around 18% in the remaining period.

Along with North America and Western Europe, Eastern Europe was the third region where expansions in nuclear power generation led to significant change in the generation mix, towards less reliance on thermal power.

3.4.5. Africa

Total electricity generation grew at a rate of 4.1% per annum to increase from 189 TW·h in 1980 to 510 TW·h in 2005. Thermal electricity generation grew more rapidly, registering a 4.7% per annum growth rate, while hydropower generation grew at only 1.8% per annum (Table 23(a)).

Nuclear power generation started in the mid-1980s and continued to grow until 2000. There was no expansion in nuclear power capacity after the mid-1980s, and expansion in generation was due to an increase in the annual capacity factor until 2000, which declined a little bit thereafter.

Highlights of the composition of electricity generation by fuel type are as follows (Table 23(b)):

(a) There was a continuous increase in thermal electricity generation that brought an 11% increase in its share, to be quite high, i.e. 79%, in 2005;
(b) The share of hydropower declined by 14% to 18% in 2005;
(c) The share of nuclear power was in the range of 2% to 3% in the 20 year period from 1985 to 2005.

In 25 years the electricity generation mix in Africa changed towards greater reliance on thermal power sources.

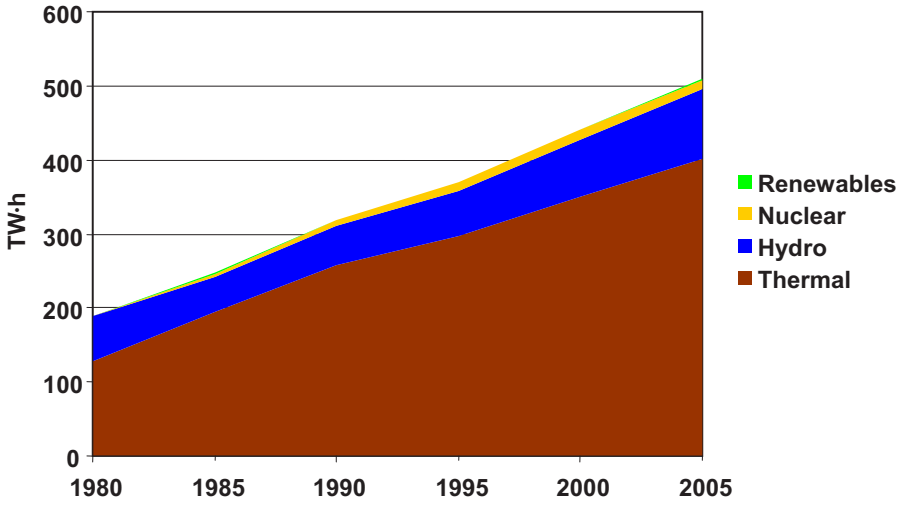

FIG. 19. Historical trend of electricity generation by fuel type in Africa.

TABLE 23(a). ELECTRICITY GENERATION BY FUEL TYPE IN AFRICA (TW·h)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Thermal	128	194	257	297	350	402	4.7
Hydro	61	47	53	60	77	94	1.8
Nuclear		5	8	11	13	12	-
Renewables	0.02	0.39	0.40	0.30	0.6	1.6	20.5
Total	189	247	319	369	441	510	4.1

TABLE 23(b). COMPOSITION OF ELECTRICITY GENERATION BY FUEL TYPE IN AFRICA (% SHARE)

	1980	1985	1990	1995	2000	2005
Thermal	67.7	78.6	80.5	80.5	79.4	78.8
Hydro	32.3	19.1	16.7	16.4	17.6	18.5
Nuclear		2.2	2.7	3.1	2.9	2.4
Renewables	0.01	0.16	0.13	0.08	0.13	0.31

3.4.6. Middle East and South Asia

Electricity generation in the region grew rapidly until 2000 and recorded slower growth thereafter. Thermal power was the major component of total electricity generation throughout the 25 year period, with some contribution from hydropower and a small contribution from nuclear power (Table 24(a)).

Total electricity generation increased from 234 TW·h in 1980 to 1240 TW·h in 2005, and recorded a growth rate of 6.9% per annum. This high growth rate was registered by both thermal and nuclear power, which registered 7.8% per annum and 7.7% per annum, respectively. There was a small increase in hydropower generation, which grew at 3.5% per annum.

Over the 25 year period, in the electricity generation mix of the region (Table 24(b)):

(a) The share of thermal generation increased by 15% to reach 85% in 2005;
(b) The hydropower share declined by 16% to 13% in 2005;
(c) Nuclear power was able to keep its share at around 1%.

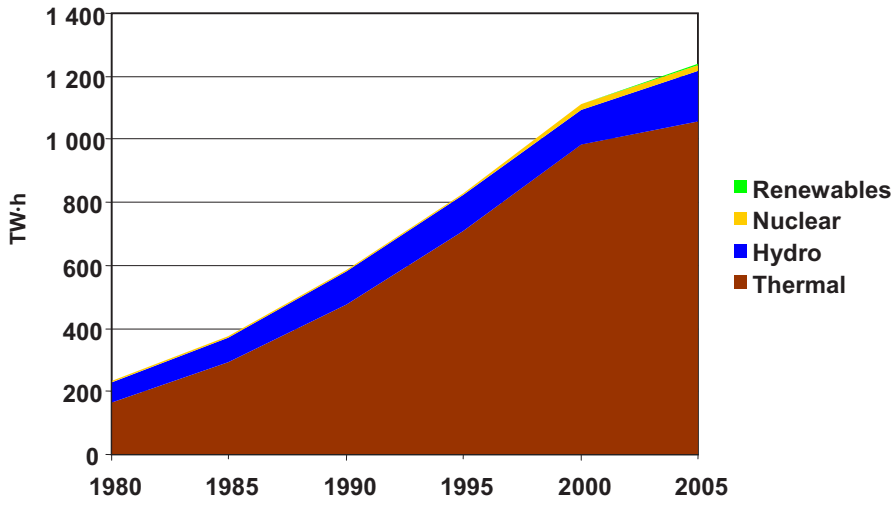

FIG. 20. Historical trend of electricity generation by fuel type in the Middle East and South Asia.

TABLE 24(a). ELECTRICITY GENERATION BY FUEL TYPE IN THE MIDDLE EAST AND SOUTH ASIA (TW·h)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Thermal	163	292	478	707	983	1 058	7.8
Hydro	68	77	104	114	111	159	3.5
Nuclear	3	4	6	7	15	18	7.7
Renewables		0.01	0.03	0.50	1.69	4.01	-
Total	234	374	588	830	1 111	1 240	6.9

TABLE 24(b). COMPOSITION OF ELECTRICITY GENERATION BY FUEL TYPE IN THE MIDDLE EAST AND SOUTH ASIA (% SHARE)

	1980	1985	1990	1995	2000	2005
Thermal	69.7	78.2	81.3	85.3	88.5	85.4
Hydro	29.1	20.6	17.7	13.8	10.0	12.9
Nuclear	1.2	1.1	1.0	0.9	1.4	1.5
Renewables	-	0.002	0.005	0.060	0.152	0.3

It is one of the four regions (the other three regions are Africa, Southeast Asia and the Pacific, and Latin America) that were relying on two main sources of electricity generation, and thermal electricity generation grew more rapidly than total electricity generation, leading to a decline in the share of hydropower in total electricity generation. Over 25 years the generation mix changed towards an extremely high reliance on thermal power sources.

3.4.7. Southeast Asia and Pacific

In this region, there was an expansion in both thermal and hydropower generation over the 25 year period, with relatively rapid growth in the former. Hydropower generation increased very slowly in the last 10 year period (from 1995 to 2005).

Total electricity generation had about a fourfold increase from 172 TW·h in 1980 to 630 TW·h in 2005 (Fig. 21). Growing at the rate of 6.0% per annum, thermal electricity generation outpaced the growth in total electricity generation, which grew at the rate of 5.3% per annum from 1980 to 2005 (Table 25(a)). On average there was a 2.1% per annum growth in hydropower generation.

In the generation mix (Table 25(b)):

(a) The share of thermal electricity generation increased by 12% to 88% in 2005;
(b) There was a continuous decline in the share of hydro generation, which declined by 12% to only 11% in 2005;
(c) There was a slow but continuous increase in generation from renewable resources, which maintained their 1% share in total electricity supply throughout the period.

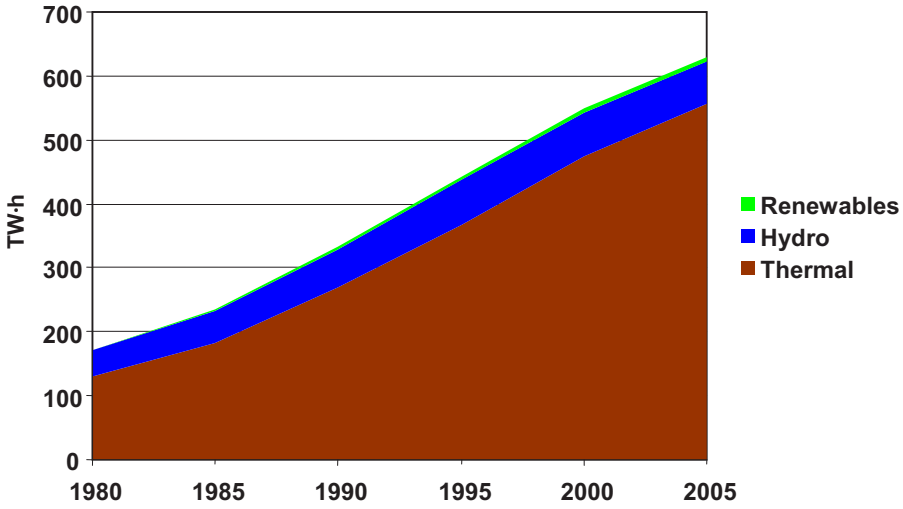

FIG. 21. Historical trend of electricity generation by fuel type in Southeast Asia and the Pacific.

TABLE 25(a). ELECTRICITY GENERATION BY FUEL TYPE IN SOUTHEAST ASIA AND THE PACIFIC (TW·h)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Thermal	131	184	268	366	474	556	6.0
Hydro	40	50	60	71	69	67	2.1
Renewables	1	2	3	4	6	7	7.2
Total	172	236	332	441	549	630	5.3

TABLE 25(b). COMPOSITION OF ELECTRICITY GENERATION BY FUEL TYPE IN SOUTHEAST ASIA AND THE PACIFIC (% SHARE)

	1980	1985	1990	1995	2000	2005
Thermal	76.1	77.8	80.9	83.0	86.4	88.2
Hydro	23.2	21.2	18.1	16.0	12.5	10.7
Nuclear	-	-	-	-	-	-
Renewables	0.7	1.0	1.0	1.0	1.0	1.1

In the 25 year period, this region's reliance on thermal power increased quite significantly. In 2005, its 88% share of thermal power in total electricity generation was the highest among all the regions.

3.4.8. Far East

In this region, electricity generation grew at an increasing rate and went through three phases over the 25 year period (Fig. 22). Compared to the first five years (1980–1985), power generation increased at a higher rate in the next 15 year period (1985–2000), and this growth rate further accelerated in the last five years. This pattern was reflected by thermal power generation, which had increasing growth rates in these three phases. Nuclear power generation grew rapidly in the first 5 years (14% per annum) but its growth rate fell in the remaining period. Hydropower generation recorded persistent expansion, except for a slower growth from 1995 to 2000.

Over the 25 year period there was a fourfold increase in electricity generation in the region, from 1023 TW·h in 1980 to 4087 TW·h in 2005 (Table 26(a)). All the sources of electricity generation registered high growth rates in the range of 4.5% to 7.5% per annum. Total electricity generation and thermal power generation grew at the same rate of 5.7% per annum from 1980 to 2005, while nuclear power registered a higher growth rate of 7.5% per annum. Highlights of the changes in the electricity generation mix (Table 26(b)) are as follows:

(a) The share of thermal electricity generation declined in the period between the early 1980s and the mid-1990s, but it started increasing to the level of the 1980s in 2005.

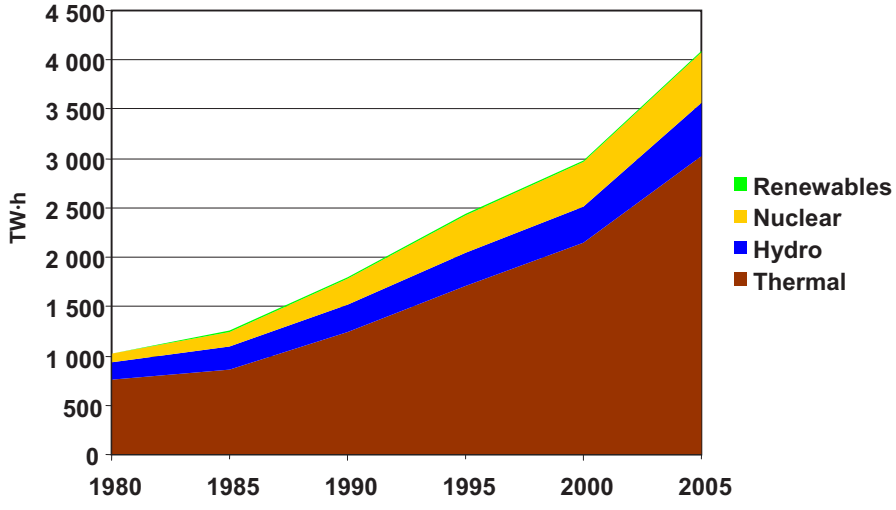

FIG. 22. Historical trend of electricity generation by fuel type in the Far East.

TABLE 26(a). ELECTRICITY GENERATION BY FUEL TYPE IN THE FAR EAST (TW·h)

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
Thermal	754	862	1 237	1 705	2 153	3 018	5.7
Hydro	183	227	281	337	368	547	4.5
Nuclear	82	158	269	381	448	507	7.5
Renewables	3	7	7	10	16	15	6.2
Total	1 023	1 253	1 794	2 433	2 984	4 087	5.7

TABLE 26(b). COMPOSITION OF ELECTRICITY GENERATION BY FUEL TYPE IN THE FAR EAST (% SHARE)

	1980	1985	1990	1995	2000	2005
Thermal	73.7	68.8	68.9	70.1	72.1	73.9
Hydro	17.9	18.1	15.7	13.9	12.3	13.4
Nuclear	8.1	12.6	15.0	15.7	15.0	12.4
Renewables	0.3	0.5	0.4	0.4	0.5	0.4

(b) The share of nuclear power increased from 8% in 1980 to 16% around the mid-1990s and started declining thereafter to reach 12% in 2005. However, the share of nuclear power came close to the share of hydropower in 2005.
(c) A relatively slower growth in hydropower generation kept its share declining from 18% in 1980 to 13% in 2005.

Although thermal power remained the major source of electricity generation throughout the period, a rapid development of nuclear power made its contribution comparable to that from hydropower by 2005. From the mid-1980s to mid-1990s, the share of thermal power generation declined to the lowest level of 69% due to a more than twofold increase in nuclear power generation.

4. NUCLEAR POWER EXPANSION

Worldwide, the number of nuclear power units in operation increased by 196 units over the 25 year period (1980–2005), from 245 units in 1980 to 441 units in 2005. The pattern of expansion was not uniform over this period.

The major increase took place in the early 1980s, when the units in operation increased by 118 between 1980 and 1985. The expansion in the number of nuclear power units slowed down during the next ten years, with an increment of 53 units and 19 units in the next two five-year intervals, respectively. There was no expansion at all in nuclear power units in operation between 1995 and 2000, but this trend was reversed in the later period, and the number of units in operation increased by six units between 2000 and 2005.

In 1980, the numbers of nuclear power units under construction and in operation were quite close. While the number of units in operation increased over the period, the nuclear power units under construction kept on declining. In the period from 1980 to 1985, 32 nuclear power projects were initiated, and the decline in units under construction was due to completion of 118 nuclear power projects. From 1985 onwards the decline was due to completion of the projects, as well as to discontinuation of work on some of the units under construction. From 2000 to 2005 there was no discontinuation of any project, and the decline was only due to completion of the projects and an increase in the units in operation (Fig. 23).

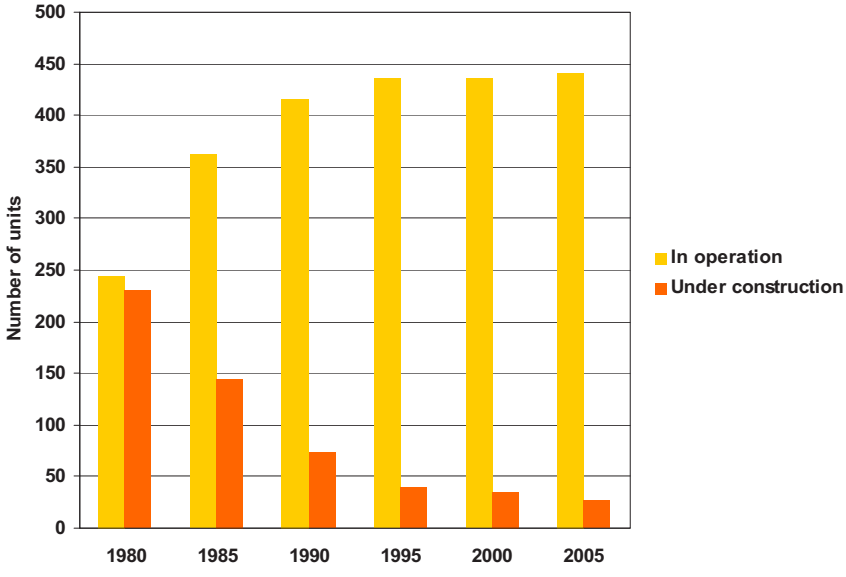

FIG. 23. Nuclear power units in operation and under construction.

4.1. REGIONAL TRENDS IN NUCLEAR POWER UNITS IN OPERATION AND UNDER CONSTRUCTION

Table 27 shows the trends of nuclear power units in operation by region from 1980 to 2005, and Table 28 shows the number of reactors reported as under construction during this period. The following paragraphs discuss these trends for each region.

From 1980 to 2005 the number of nuclear power plants in operation grew by 196 units worldwide (Table 29). Out of these, 64 units were in the Far East. The second largest addition was in North America, 42 units, followed by Eastern Europe and Western Europe, which had additions of 39 and 32 units, respectively. The remaining increase of 19 units was in three regions (Middle East and South Asia, Latin America, and Africa), while Southeast Asia and the Pacific did not embark on a nuclear power programme through this period. The

TABLE 27. NUCLEAR POWER UNITS IN OPERATION BY REGION

	1980	1985	1990	1995	2000	2005
North America	79	106	128	130	117	121
Latin America	1	3	4	5	6	6
Western Europe	103	147	153	149	148	135
Eastern Europe	31	54	65	68	69	70
Africa		2	2	2	2	2
Middle East and South Asia	5	7	8	11	16	17
South East Asia and Pacific	-	-	-	-	-	-
Far East	26	44	56	70	77	90
Total	245	363	416	435	435	441

Note: The data on the Far East include units in Taiwan, China: two units in 1980 and six units in all other years.

TABLE 28. NUCLEAR POWER UNITS UNDER CONSTRUCTION BY REGION

	1980	1985	1990	1995	2000	2005
North America	94	38	5	1		
Latin America	5	6	5	2	1	1
Western Europe	78	41	10	4		1
Eastern Europe	30	41	31	18	14	9
Africa	2					
Middle East and South Asia	5	5	8	6	3	10
South East Asia and Pacific	-	-	-	-	-	-
Far East	16	13	14	8	17	6
Total	230	144	73	39	35	27

Note: The data on the Far East include units under construction in Taiwan, China: four units in 1980 and two units in 2000.

TABLE 29. NUCLEAR POWER UNITS IN OPERATION BY REGION (NET INCREASE)

	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005
North America	27	22	2	- 13	4
Latin America	2	1	1	1	
Western Europe	44	6	- 4	- 1	- 13
Eastern Europe	23	11	3	1	1
Africa	2				
Middle East and South Asia	2	1	3	5	1
Far East	18	12	14	7	13
Total	118	53	19	-	6

regional pattern of nuclear power development was not uniform over the 25 year period.

Until the early 1990s, the number of nuclear power units in operation increased mainly in three regions: Western Europe, Eastern Europe and North America. For example, there was an increase of 44 units in nuclear power units in operation in Western Europe in the five year period from 1980 to 1985 (Table 29), while North America and Eastern Europe witnessed increases of 27 units and 23 units, respectively, compared to an increase of 18 units in the Far East in these five years. From the early 1990s, the increase in nuclear power units in operation was mainly in the Far East, as this region continued to expand its nuclear power capacity, and the number of units in operation increased by 34 units from 1990 to 2005. This was followed by the Middle East and South Asia, which had an increase of nine units in operation over this period.

The pattern of nuclear power development in the various regions was different:

(a) In North America, the number of nuclear power units in operation rose until the mid-1990s, but thereafter this number started declining until early 2000 (Table 27), as 13 units were taken out of operation from 1995 to 2000. This trend changed in the early 2000s, when the number of nuclear power units in operation increased, as four units were reconnected to the grid.
(b) This trend was more or less observed in Western Europe, except that the declining trend continued in this region until 2005, as the number of units in operation declined by 13 units between 2000 and 2005.
(c) Though slowly, the number of nuclear power units in operation continued to increase in Eastern Europe, as the nuclear power plants in operation increased by five units from 1990 to 2005.
(d) There was a continuous increase in nuclear power units in operation in the Far East, with the biggest increase of 18 units in the early 1980s. The

pace slowed in the following years, with the smallest increase of seven units between 1995 and 2000.

(e) In the Middle East and South Asia, the number of units in operation increased slowly, with the largest increase of five units from 1995 to 2000.

Table 28 shows the nuclear power units under construction by region, and that there was a different pattern of nuclear power development in each region:

(1) There was a sharp decline in the number of nuclear power units under construction in North America from 1980 to 1985, which in absolute terms was much greater than the increase of units in operation, indicating that some of the projects were taken off the 'under construction' list. This trend continued in the remaining period, and the units under construction declined to zero by the year 2000, starting from 94 units reported as being under construction in 1980.

(2) In Western Europe, the decline in absolute terms in the number of units under construction from 1980 to 1985 was smaller than the increase in units in operation, indicating that new projects were initiated during this period. However, the number of units under construction kept on declining more rapidly thereafter, to zero in 2000. This trend reversed, and one unit was under construction in 2005.

(3) Eastern Europe went through three phases of expansion: there was a big increase in the units under construction from 1980 to 1985, followed by a severe decline in the early 1990s, and a continuous slow decline until 2005. The number of units under construction in 2005 was nine, which was the second largest number among all the regions.

(4) The number of units under construction in the Far East fluctuated between 8 and 17 over a 20 year period (from 1980 to 2000), and declined to 6 units in 2005.

(5) In the Middle East and South Asia, the number of units under construction ranged from three to eight units from 1980 to 2000, as the units in operation increased and new projects were initiated. The number of reactors under construction was highest in 2005, i.e. ten units, the highest number among all the regions.

In brief, one more region, i.e. the Middle East and South Asia, has joined Eastern Europe and the Far East in increasing the number of nuclear power units in the world in recent years.

4.2. NUCLEAR POWER CAPACITY EXPANSION AND GENERATION

There was an approximately twofold increase in the world's electricity generating capacity over the 25 year period (Table 30), which reached 4117 GW(e) in 2005, growing at a rate of 3.2% per annum. This growth rate was higher than the growth rate of 2.9% per annum in world electricity generation from all sources, indicating a decline in the annual capacity factor of the installed capacity.

Over the 25 year period, nuclear power capacity grew at an average rate of 4.1% per annum, which was higher than the growth in total electricity capacity and resulted in an increase in the share of nuclear power capacity from 7% in 1980 to 9% in 2005. In between, this share increased from 1980 until the mid-1990s, and was about 13% in 1990. Thereafter it started declining, but ended at a level higher than that in 1980.

Compared to the average growth rate of 4.1% in nuclear power capacity, the growth rate of nuclear power generation was much higher, i.e. 5.8% per annum (see Table 2 and Fig. 24). This difference was due to improvements in the average capacity factors of nuclear power units. In the aggregate, the annual capacity factor of nuclear power units increased from 54.1% in 1980 to 81.4% in 2005.

4.3. TRENDS IN NUCLEAR POWER CAPACITY EXPANSION BY REGION

Figure 25 and Table 31 show that the world's nuclear power capacity essentially expanded in only four regions, Western Europe, North America, the Far East and Eastern Europe. To start with, the major share of world nuclear power capacity was in Western Europe and North America. Out of 134 GW(e) of the world's nuclear capacity in 1980, only 31 GW(e) was in the Far East and

TABLE 30. WORLD ELECTRICITY GENERATING CAPACITY (GW(e))

	1980	1985	1990	1995	2000	2005
Nuclear	134	247	319	343	350	368
All sources	1868	2213	2533	2823	3165	4117
Nuclear share (%)	7.2	11.1	12.6	12.1	11.1	8.9

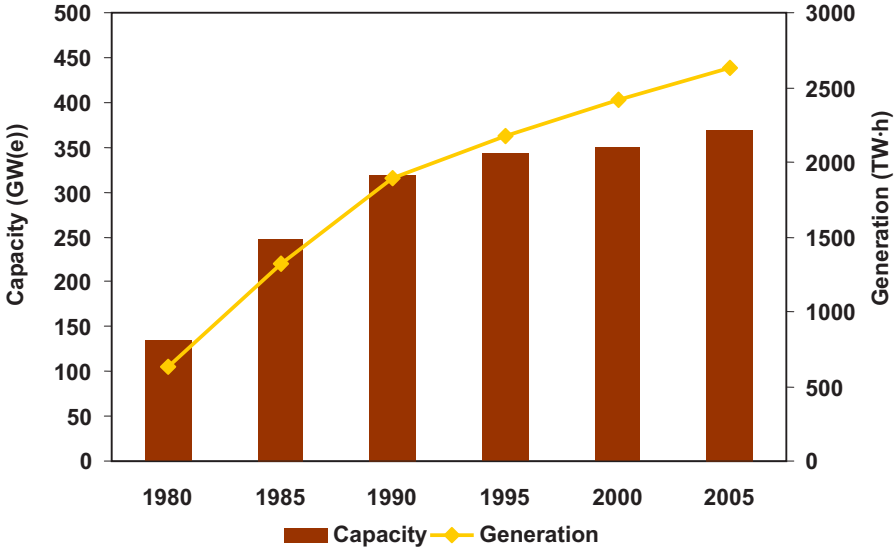

FIG. 24. The world's nuclear power capacity and generation.

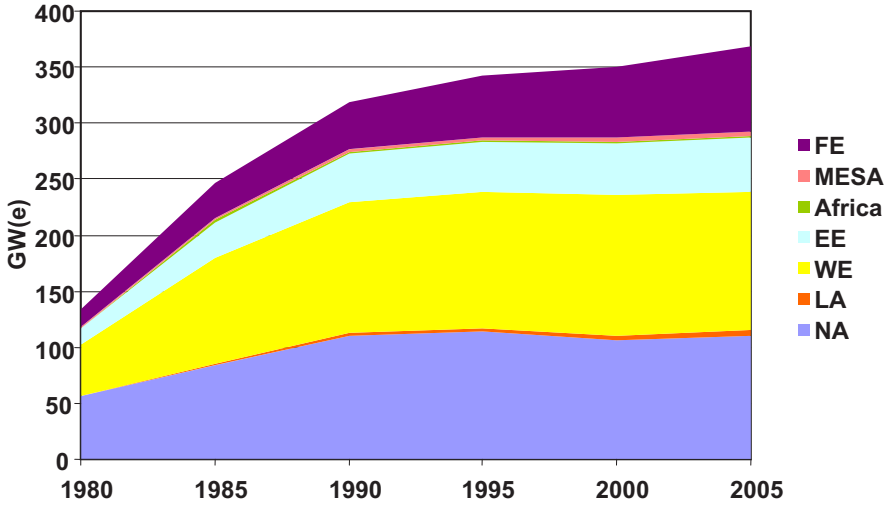

FIG. 25. Nuclear power generating capacity by region.

Eastern Europe together, which was 23% of the world's total. Over the 25 year period, there was a significant expansion in nuclear power capacity in all four regions and an increase in the share of the Far East and Eastern Europe that went up to 34% in 2005.

TABLE 31. NUCLEAR POWER GENERATING CAPACITY BY REGION (GW(e))

	1980	1985	1990	1995	2000	2005	Growth rate (% p.a.) 1980-2005
North America	56	84	110	114	106	111	2.8
Latin America	0	2	2	3	4	4	10.6
Western Europe	46	95	117	122	126	124	4.0
Eastern Europe	14	32	43	45	45	48	5.1
Africa		2	2	2	2	2	-
Middle East and South Asia	1	1	1	2	3	3	5.3
South East Asia and Pacific	-	-	-	-	-	-	-
Far East	17	32	43	56	63	76	6.2
Total	134	247	319	343	350	368	4.1

Among the four regions, the regional pattern of expansion in nuclear power capacity was different from the pattern of increase in nuclear power units in operation, indicating the difference in the size of units added by the regions. The ranking of regions by the increase in the number of units in operation was as follows: Far East, North America, Eastern Europe and Western Europe, with the largest increase in the Far East. This ranking changed for nuclear capacity expansion (Table 31):

(a) The greatest expansion was in the nuclear power capacity of Western Europe, by 78 GW(e), as its capacity increased from 46 GW(e) in 1980 to 124 GW(e) in 2005. The major increase (71 GW(e)) was during the period from 1980 to 1990. Thereafter, the increments were smaller and slipped to a small decline of 2 GW(e) capacity in the last five year period from 2000 to 2005 (Fig. 26).

(b) The Far East was the only region that registered almost a fourfold increase in its nuclear power generating capacity, from 17 GW(e) in 1980 to 76 GW(e) in 2005. This increase of 59 GW(e) over the 25 year period was the second largest increase among all the regions. There was a significant and continuous increase in nuclear capacity of the region until 2005 (Fig. 27), with the greatest expansion during the early 1980s and the least expansion during the late 1990s.

(c) North America expanded its nuclear power capacity by about a factor of two, from 56 GW(e) in 1980 to 111 GW(e) in 2005, and registered the third largest expansion (55 GW(e)) among all the regions. This expansion was a little smaller than the addition made in the nuclear power capacity of the Far East over the 25 year period. There was a rapid expansion in the nuclear power capacity of North America until 1990, followed by a slower expansion in the next year and even a small decline between 1995

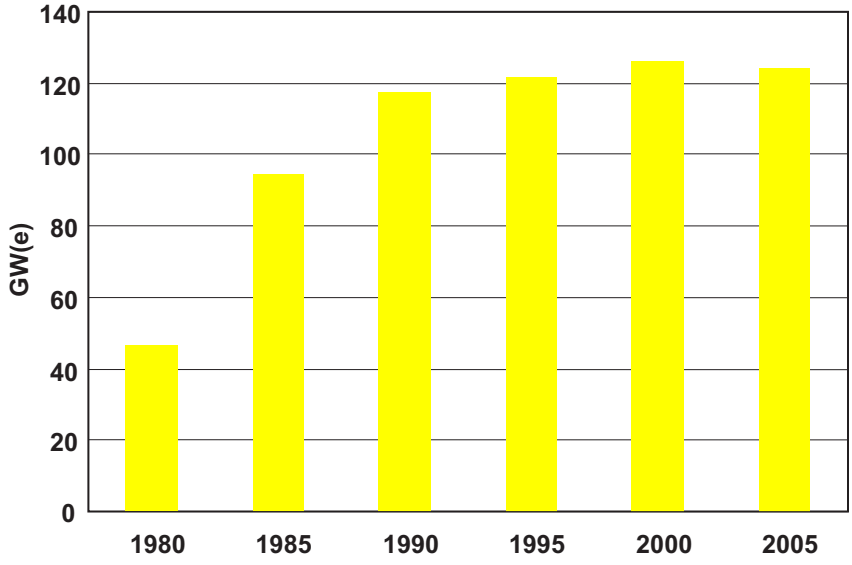

FIG. 26. Nuclear power generating capacity in Western Europe.

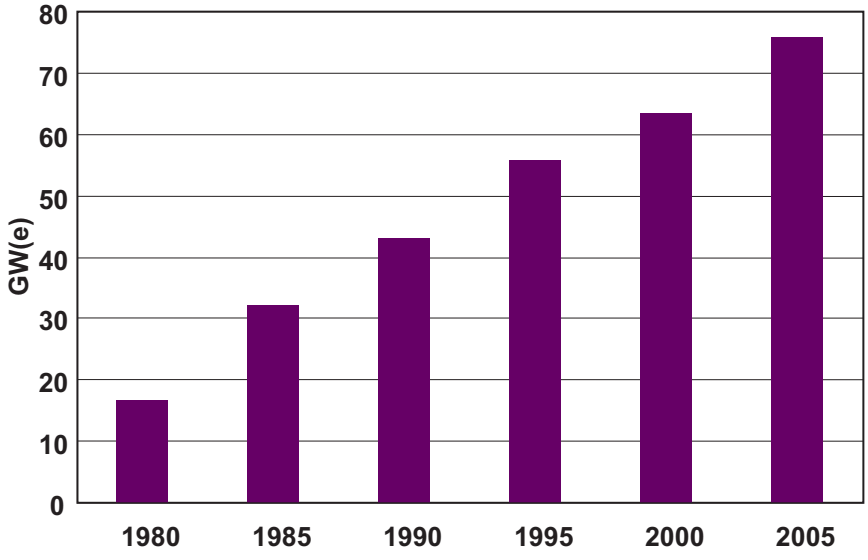

FIG. 27. Nuclear power generating capacity in the Far East.

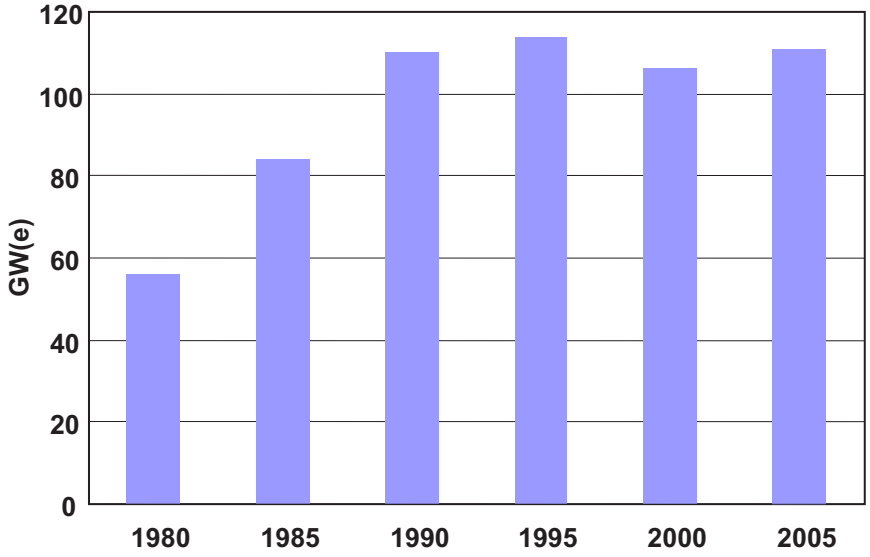

FIG. 28. Nuclear power generating capacity in North America.

and 2000. The nuclear capacity began increasing again with a small increase between 2000 and 2005 (Fig. 28).

(d) The nuclear power generating capacity of Eastern Europe increased from 14 GW(e) in 1980 to 48 GW(e) in 2005, recording the third biggest increase (i.e. 34 GW(e)) over the 25 year period. There was a rapid expansion until the late 1980s, followed by a small increase in the rest of the period.

In the remaining three regions that have nuclear power programmes (Latin America, Africa, and Middle East and South Asia), there was a total increase of 9 GW(e) in nuclear power generating capacity over the 25 year period, while expansion in Africa took place only during the early 1980s.

Table 32 shows that at five year intervals there were changes in the regional shares of the world's nuclear power capacity over the 25 year period:

(1) North America's share was the highest in 1980; however, there was a continuous decline to 30% in 2005, resulting in it having the second biggest share among all regions.

(2) From the mid-1980s, the share of Western Europe in the world's nuclear capacity remained the largest, though slowly declining from 38% in 1985 to 34% in 2005 due to the growing share of the Far East.

TABLE 32. REGIONAL SHARES IN THE WORLD'S NUCLEAR POWER GENERATING CAPACITY (%)

	1980	1985	1990	1995	2000	2005
North America	42	34	35	33	30	30
Latin America	-	1	1	1	1	1
Western Europe	35	38	37	36	36	34
Eastern Europe	10	13	13	13	13	13
Africa	-	1	1	1	1	0
Middle East and South Asia	1	1	0	1	1	1
South East Asia and Pacific	-	-	-	-	-	-
Far East	12	13	13	16	18	21

(3) Until the mid-1990s, the share of the Far East in the world's nuclear capacity was around 13%. From 1995 onwards it increased from 16% in 1995 to 21% in 2005, accounting for the third largest share in the world's nuclear power capacity.
(4) Eastern Europe had the fourth largest share of the world's nuclear capacity, which increased from 10% in 1980 to 13% in 1985, and thereafter the region maintained this share until 2005 (Table 32).

A review of nuclear power development over the 25 year period shows that there was an impressive expansion in the use of this technology, but mainly in the four regions which are most economically developed. The use of this technology remained very limited in the less developed and developing regions. The next section presents the current outlook for expansion in the use of this technology in the next 25 years.

5. OUTLOOK FOR NUCLEAR POWER DEVELOPMENT

The IAEA has been making projections of energy, electricity and nuclear power use for the medium to long term period. These projections are not forecasts[1] but are meant to give a range of plausible development based on

[1] While 'forecasts' are made to look into the future, projections are made to assess the impact of plausible changes in the policies that may alter the current trends in the future.

experts' judgement of the prevailing trends of expansion in the use of energy, electricity and nuclear power, and possible improvement in these trends.

The projections of energy and electricity use are based on analyses of global and regional projections made by other international organizations. The estimates of the nuclear power capacity and generation, however, have been derived using a bottom-up approach and are based on country by country analysis, but presented on a regional basis. These estimates have been established by a group of experts participating each year in the IAEA's meeting on nuclear capacity projections, and have been based on a review of the current nuclear power projects, long term plans and policies in the Member States. To encompass the future uncertainties, two sets of estimates have been made, low and high.

The low estimates are based on the number of nuclear power units under construction or firmly planned in the projection year, the most recent retirement and life extension plans, and the experts' judgement on construction of additional units, as announced by the governments and the power utilities under their long term expansion plans. The high estimates are based on upward revision of the low estimates based on experts' judgement, assuming essentially full implementation of these long term plans.

These two sets of estimates have been made to reflect contrasting but not extreme underlying assumptions about the different driving factors that have an impact on nuclear power deployment. The intention has been neither to predict nor to reflect the complete range of possible futures from the lowest to the highest feasible, but to present experts' opinions on the plausible range of nuclear power capacity expansion in the medium to long term period. The next section reviews the history of the estimates of the world's nuclear power capacity expansion, projected at five year intervals, and compares those with the actual nuclear power capacity in these years.

5.1. PREVIOUS NUCLEAR POWER PROJECTIONS

Figures 29 and 30 show the low and high estimates, respectively, of expansion in the world's nuclear power capacity since 1985. These estimates show that the long term expansion plans of the mid-1980s were aimed at a rapid expansion in nuclear power capacity, and that experts also had high expectations. The estimates made in 1985 projected a two to threefold increase in the low and high estimates, respectively, by 2000. These plans and expectations were in line with the developments from 1970 to 1985. In 1985, nuclear power capacity was projected to be 702 GW(e) in 2000 from the actual capacity of

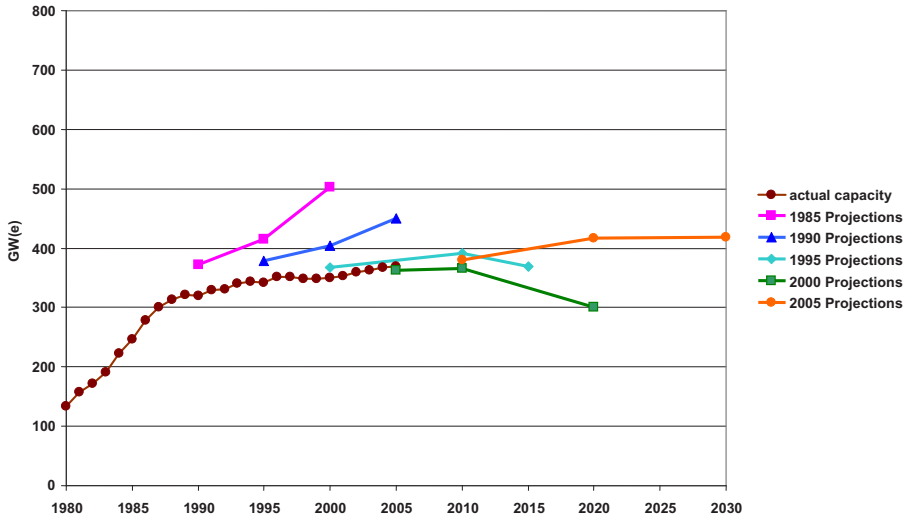

FIG. 29. Projection of the world's nuclear power capacity in the low estimates.

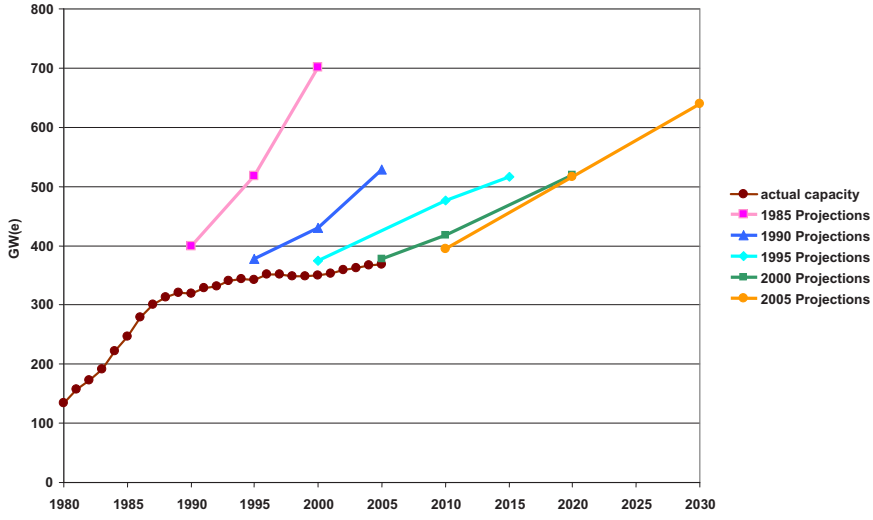

FIG. 30. Projection of the world's nuclear power capacity in the high estimates.

247 GW(e) in 1985, i.e. an expansion of 455 GW(e) in 15 years. Even the low estimates projected nuclear power capacity to expand by 255 GW(e) in this period.

The projections made in the following years, until the year 2000, show a continuous downward revision in the estimates of nuclear power capacity expansion (see Tables 31 and 32). By 2000, the world had revised its expansion plan for nuclear power capacity downwards drastically. Compared to the actual capacity of 350 GW(e) in 2000, the high estimates projected that nuclear power capacity would be 520 GW(e) in 2020, i.e. an addition of only 170 GW(e) in 20 years, and the low estimates even projected a reduction of 50 GW(e) during this period.

The year 2005 brought new plans and new expectations. The low estimates were reversed to project an increase of 50 GW(e) over the next 25 years — from an actual capacity of 368 GW(e) in 2005 to a projected capacity of 418 GW(e) by 2030 — rather than a decline, and the high estimates projected an increase of 272 GW(e) in this period, which was the biggest expansion projected in all previous years after mid-1985.

Tables 33 and 34 also report the actual capacity in operation from 1990 to 2005 at five year intervals and the realization rate of the estimates for these years. The table shows that:

(a) The realization rates for the low estimates were higher than those for the high estimates for all projections. For example, the realization rate was 70% for projections made in 1985 for 2000, compared to the realization rates of 50% in the high estimates for 2000. This indicates that the announced long term plans for nuclear power expansion were too ambitious in the experts' opinion, and were revised downwards significantly.

(b) The downward revisions of the long term plans by the experts improved over the period, as the realization rate for the next 15 year period improved to 82% (realization rate of projections made in 1990 for the year 2005 for the low estimates in Table 33). Similarly, the realization rate also improved for the high estimates, indicating that the nuclear power expansion plans were becoming more realistic.

(c) The realization rates for the medium term projections improved from 86% to 101% for the low estimates (Table 33). The realization rate of 101% indicates that the actual development from 2000 to 2005 was above the experts' projections, and this development was close to the expansions given in the announced plans for this period, i.e. a 97% realization rate for the high estimates.

TABLE 33. PROJECTED NUCLEAR POWER CAPACITY EXPANSION IN THE LOW ESTIMATES (GW(e))

Projection Year	1990	1995	2000	2005	2010	2015	2020	2030
1985	372	415	502					
1990		378	404	450				
1995			367		391	369		
2000				363	366		300	
2005					380		416	418
Actual capacity	319	343	350	368				
Realization with respect to:								
1985 projections	86%	83%	70%					
1990 projections		91%	87%	82%				
1995 projections			95%					
2000 projections				101%				

TABLE 34. PROJECTED NUCLEAR POWER CAPACITY EXPANSION IN THE HIGH ESTIMATES (GW(e))

Projection Year	1990	1995	2000	2005	2010	2015	2020	2030
1985	400	518	702					
1990		378	430	528				
1995			375		476	516		
2000				378	417		520	
2005					395		516	640
Actual capacity	319	343	350	368				
Realization with respect to:								
1985 projections	80%	66%	50%					
1990 projections		91%	81%	70%				
1995 projections			93%					
2000 projections				97%				

The next section discusses how much the nuclear power developments between 2000 and 2005 have changed the vision for nuclear power development for the next 25 years.

5.2. THE IAEA'S 2006 NUCLEAR POWER PROJECTIONS

In recent years, there have been rising expectations for nuclear power development. Many factors have contributed to these expectations, including continued improvements in the performance of nuclear power plants, the lengthening track record of safe operation of the world's nuclear power plants, energy security concerns, new environmental constraints and the persistent increase in global energy demand [6]. Additionally, emphasis on poverty alleviation worldwide [7] and the need for additional energy at an affordable

TABLE 35. NUCLEAR POWER CAPACITY IN THE LOW AND HIGH ESTIMATES: 2006 PROJECTIONS (GW(e))

	2005	2010		2020		2030	
		Low	High	Low	High	Low	High
North America	111	114	116	120	131	126	158
Latin America	4	4	4	6	7	6	18
Western Europe	124	122	124	91	129	48	149
Eastern Europe	48	48	50	68	76	78	107
Africa	2	2	2	2	4	2	10
Middle East and South Asia	3	10	11	17	27	23	46
South East Asia and the Pacific					1	1	5
Far East	76	81	83	119	145	130	187
World Total	368	381	390	423	520	414	679

Note: Nuclear capacity estimates take into account the scheduled retirement of old units at the end of their lifetime.

and stable price have turned many countries towards the consideration of nuclear power. Specific nuclear power expansion plans in countries such as China, India, Japan, the Republic of Korea and the Russian Federation have encouraged a growing number of developing countries to desire nuclear power to meet their energy needs for economic growth.

Against this backdrop, the IAEA in 2006 made projections of nuclear power expansion through 2030 [3]. Table 35 shows the low and high estimates for nuclear capacity expansion made in 2006 according to the definition given at the start of this section. The regional estimates of nuclear power development show that there are great differences in the pace and pattern of development estimated by region.

For example, Western Europe is projected to expand its nuclear power capacity to 149 GW(e) — only a 20% increase — in the next 25 year period, even in the high estimates. In the low estimates this region is expected to retire many of its nuclear power units. As a result, Western Europe's nuclear power capacity is estimated to decrease to 48 GW(e) in 2030, compared to 124 GW(e) in 2005, according to the low estimates (Fig. 31).

In contrast, the Far East is expected to continue expansion of its nuclear power capacity, which is projected to reach about 130 GW(e) in 2030 in the low estimates and some 187 in the high estimates (see Fig. 32). In both the low and high estimates, nuclear power capacity in the Far East is projected to be even greater than the projected capacity of North America in 2030, and consequently the Far East will be the region with the greatest nuclear power capacity in the world in 2030 (Fig. 31).

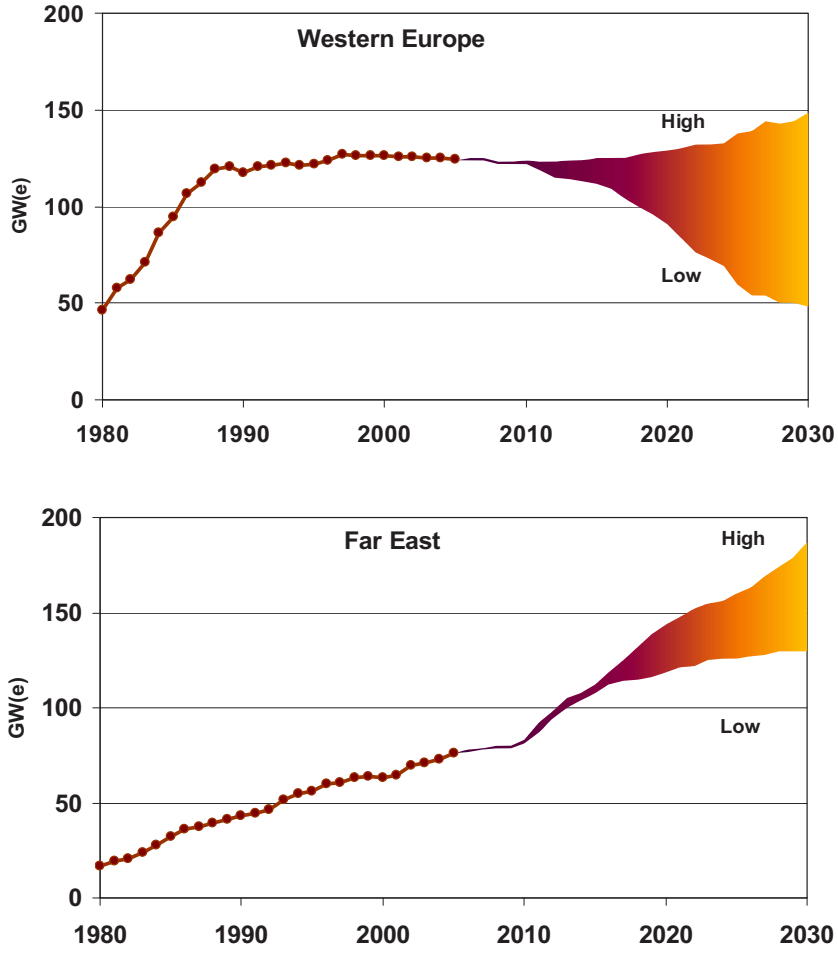

FIG. 31. Estimates of nuclear power capacity expansion in Western Europe and the Far East.

In the other regions, nuclear power capacity is projected to expand in the next 25 year period according to both the low and high estimates, except in Africa, where nuclear power capacity is projected to remain constant in the next 25 years in the low estimates, while Southeast Asia and the Pacific is projected to initiate its nuclear power programme in this period.

The highlights of the pattern of nuclear power development until 2030, as estimated in the IAEA's 2006 projections for the regions other than Western Europe and the Far East, are summarized below:

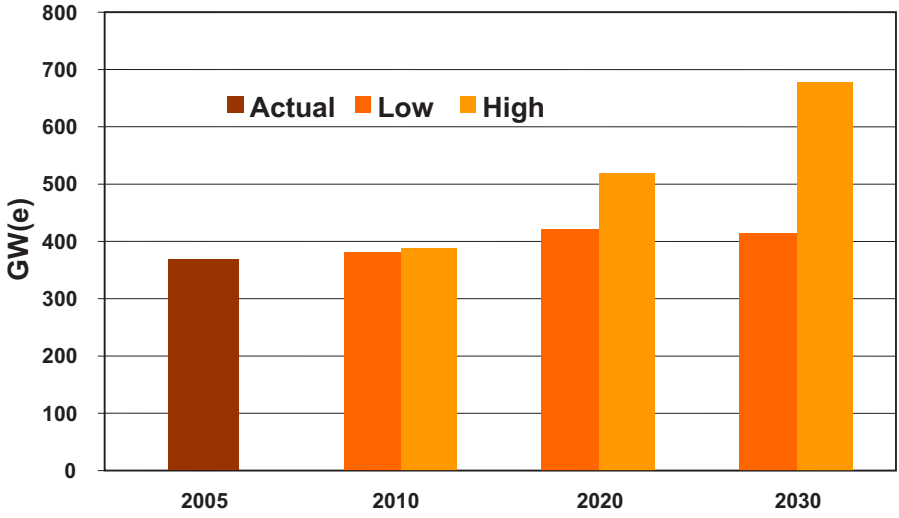

FIG. 32. Projections of world nuclear power capacity until 2030, made in 2006.

(a) It is estimated that Latin America will expand its nuclear power capacity by fourfold in the high estimates, compared to a 50% increase in the low estimates.

(b) The high estimates project a twofold increase in the nuclear capacity of Eastern Europe, while a 62% increase is projected in the low estimates.

(c) The high estimates for Africa project a fivefold increase in its nuclear power capacity, to reach 10 GW(e) by 2030.

(d) The Middle East and South Asia had a very small nuclear power capacity in 2005 (3 GW(e)), and it is projected to add 20 GW(e) by 2030 in the low estimates and 43 GW(e) in the high estimates.

(e) Until 2005, Southeast Asia and the Pacific had been the only region that has no nuclear power plant. The region is projected to have 1 GW(e) of nuclear capacity by the low estimates in 2030. In the high estimates, the region will have 1 GW(e) nuclear power capacity in 2020, which is projected to increase to 5 GW(e) by 2030.

On the aggregate, the world's nuclear power capacity is projected to be (Fig. 32):

(1) 423 GW(e) in 2020, i.e. an expansion of 55 GW(e) in 15 years (2005–2020), followed by a small decline of 9 GW(e) from 2020 to 2030 in the low estimates.

(2) 520 GW(e) in 2020, i.e. an increase of 152 GW(e) in 15 years, followed by a bigger increase of 159 GW(e) between 2020 and 2030 in the high estimates.

Comparison of these projections of 2006 with those made in 2005 shows that:

(i) The low estimates of 2005 are revised upward for 2020 (from 416 GW(e) to 423 GW(e)) and are revised downward for 2030 (from 418 GW(e) to 414 GW(e)).
(ii) The high estimates of 2005 are revised upward for both 2020 (from 516 GW(e) to 520 GW(e)) and 2030 (from 640 GW(e) to 679 GW(e)).

5.2.1. Projections of nuclear power generation made in 2006

Table 36 shows estimates of nuclear power generation in the eight regions until 2030 at ten year intervals. These projections are made on the basis of the projected improvements in the average annual capacity factor in all regions, with wide variations. For example, this factor in North America is projected to increase from 90% in 2005 to 92% by 2030, whereas the Middle East and South Asia region, which had the lowest annual capacity factor in 2005 (60%), is projected to increase to 74% in 2030. The other regions having large nuclear capacities, such as Western Europe and the Far East, are currently generating at annual capacity factors of 81% and 75%, respectively. These regions are projected to increase this factor to 88% and 81%, respectively, by 2030. These improvements in annual capacity factors are assumed to be the same in both the low and high estimates for all regions.

In the aggregate, this implies an increase of 4% in the world's annual capacity factor of nuclear power units, from 81% in 2005 to 85% in 2030. As a result of the improved average annual capacity factor in all regions, the world's nuclear power generation is projected to increase by 17% and 92% (in the low and high estimates, respectively) in the next 25 years, compared to 13% and 85% increases in world nuclear power capacity by 2030 in the low and high estimates, respectively.

By regions, nuclear power generation in 2030 is projected to be in the range of 6–1017 TW·h in the low estimates and in the range of 31–1325 TW·h according to the high estimates.

All these expansions in nuclear power capacity and generation are not much, compared to the projected increase in total electricity and energy use in the world. The following section discusses this comparison.

TABLE 36. ESTIMATES OF NUCLEAR ELECTRICITY GENERATION (TW·h)

	2005	2010		2020		2030	
		Low	High	Low	High	Low	High
North America	870	912	921	971	1 056	1 017	1 273
Latin America	26	31	32	47	54	45	136
Western Europe	879	898	910	683	972	374	1 146
Eastern Europe	314	314	329	461	510	545	748
Africa	12	14	14	17	34	18	85
Middle East and South Asia	18	59	65	103	166	150	299
South East Asia and the Pacific					6	6	31
Far East	507	554	570	820	1 006	919	1 325
World Total	2 626	2 782	2 842	3 102	3 803	3 074	5 043

Note: Nuclear generation estimates take into account the scheduled retirement of the units at the end of their lifetime.

5.3. NUCLEAR POWER DEVELOPMENT IN THE CONTEXT OF ENERGY AND ELECTRICITY NEEDS

The estimates of energy use in the medium to long term are made by international, national and private organizations based on a multiplicity of different assumptions. The basic differences refer to assumptions about some fundamental factors, such as:

(a) Regional prospects of economic development;
(b) Link between energy use and economic growth, demographic changes and technological progress;
(c) Physical, economic and political constraints applying to energy production and use;
(d) Future prices of different fuels.

These factors, and the way they might evolve, vary from country to country and across the regions. The IAEA experts group also prepares the low and high estimates of energy and electricity use and the required electricity capacity. The estimates of total electricity capacity made in 2006 are reported in Table 37 for the next 25 years. The estimates of nuclear power generation are used to compute the shares of nuclear power in these projected values of energy and electricity use, and the estimates of nuclear power capacities are

TABLE 37. ESTIMATES OF TOTAL ELECTRICITY GENERATING CAPACITY AND THE SHARE OF NUCLEAR POWER (2005–2030)

	2005		2010		2020		2030	
	Total Electricity GW(e)	Nuclear share (%)	Total Electricity GW(e)	Nuclear share (%)	Total Electricity GW(e)	Nuclear share (%)	Total Electricity GW(e)	Nuclear share (%)
North America	1 252	8.8	1 289	8.9	1 400	8.6	1 546	8.2
			1 335	8.7	1 478	8.9	1 643	9.6
Latin America	276	1.5	305	1.4	385	1.6	485	1.2
			339	1.3	526	1.4	802	2.2
Western Europe	751	16.5	782	15.6	864	10.5	964	5.0
			818	15.1	953	13.5	1 121	13.3
Eastern Europe	466	10.3	469	10.2	505	13.5	543	14.3
			489	10.2	596	12.7	724	14.7
Africa	104	1.7	111	1.6	138	1.5	175	1.2
			125	1.4	191	2.2	292	3.5
Middle East and South Asia	300	1.2	338	2.9	439	3.8	568	4.1
			365	3.0	547	4.9	800	5.8
South East Asia and the Pacific	146		165		208		258	0.3
			176		258	0.3	374	1.3
Far East	822	9.2	854	9.5	1 003	11.8	1 169	11.1
			987	8.5	1 371	10.6	1 867	10.0
World Total — Low Estimate	4 117	8.9	4 314	8.8	4 943	8.6	5 709	7.3
World Total — High Estimate			4 633	8.4	5 920	8.8	7 622	8.9

Note: Nuclear generation estimates take into account the scheduled retirement of units at the end of their lifetime.

used to compute their shares in total power generation capacities from all sources.

According to the low estimates, nuclear power will not be able to keep pace with the expansion in total electricity capacity, and consequently the share of nuclear power in the total capacity will continuously decline, by a projected 7.3% by 2030, compared to 8.9% in 2005. In the high estimates, this decline in the share of nuclear power is larger in 2010, but thereafter nuclear power starts to catch up and is able to achieve a share of 8.9% in 2030.

The projections of total capacity expansion at the regional level in 2010 show that:

(1) The share of nuclear power in total capacity remains close to the level of 2005 in all regions (in both estimates), except for the Middle East and South Asia, Western Europe and the Far East (Table 37);
(2) The share of nuclear power capacity in the Middle East and South Asia increases from 1.2% to about 3% in total capacity of 2010 in both estimates;
(3) Western Europe and the Far East are projected to have a decline in the nuclear power shares in both estimates, with a relatively greater decline in the high estimates.

In brief, the decline in the share of nuclear power in world electricity capacity in 2010 will take place because of the Middle East and South Asia, Western Europe and the Far East. In these regions, nuclear power development will not be able to keep pace with the growth in total electricity capacity.

The pattern of electricity capacity expansion from 2010 onward is different for different regions. Five trends are observed in the share of nuclear power capacity in total electricity generating capacity:

(i) A continuous decline in the share of nuclear power by 2030 in Western Europe in both the low and high estimates (Table 37). The pace of the decline is faster in the low estimates compared to that in the high estimates.
(ii) A decline in the share of nuclear power in the low estimates and an increase in the nuclear power share in the high estimates in two regions, North America and Africa.
(iii) A persistent increase in the share of nuclear power in two regions (Eastern Europe and the Middle East and South Asia), in both the low and high estimates.

(iv) A persistent increase in the share of nuclear power in Latin America in both the low and high estimates, except for a decline between 2020 and 2030 in the low estimates.
(v) An increase in the share of nuclear power in both the low and high estimates between 2010 and 2020, and a decline in the nuclear power share in both the low and high estimates between 2020 and 2030 in the Far East (Table 37).

In all the regions, except Western Europe, capacity expansion in the high estimates is projected to be greater for nuclear power compared to other sources of generation. However, a slower expansion in nuclear capacity in the two regions, Western Europe and the Far East, results in projection of a constant share of nuclear in the world's electricity generating capacity in 2030.

Table 38 shows estimated projections in total electricity generation by 2030 and the share of nuclear in total electricity generation. In both the low estimates and high estimates of total world electricity generation, the nuclear shares are projected to decline continuously until 2030, except for a small increase from 2005 to 2010 in the low estimates. The nuclear share is projected to decline to 12.3% in the low estimates and 13.3% in the high estimates by 2030, compared to the share of 15.5% in 2005.

The pattern of changes in the projected share of nuclear power in the regions is quite mixed (Fig. 33). The share of nuclear power is projected to:

— Decline continuously and significantly until 2030 in Western Europe in both estimates;
— Decline continuously until 2030 in North America in both estimates, except for an increase in 2010 in the low estimates;
— Decline in 2010 and to increase thereafter until 2030 in Eastern Europe in both estimates;
— Increase continuously until 2030 in the Middle East and South Asia in both estimates;
— Have a mixture of increase and decrease in different periods in the two estimates in the other regions.

The decline in the share of nuclear in total world electricity generation in 2030 even in the high estimates, when the nuclear capacity share remains at the level of 2005, is due to the sharp decline in nuclear power capacity and generation in Western Europe and expansion in nuclear capacity in the regions that have lower annual capacity factors.

TABLE 38. ESTIMATES OF TOTAL ELECTRICITY GENERATION AND THE SHARE OF NUCLEAR POWER (2005–2030)

Country Group		2005		2010 (a)		2020 (a)		2030 (a)	
		Total Electricity TW·h	Nuclear share (%)	Total Electricity TW·h	Nuclear share (%)	Total Electricity TW·h	Nuclear share (%)	Total Electricity TW·h	Nuclear share (%)
North America		4 631	18.8	4 743	19	5 414	18	6 057	17
				4 993	18	6 111	17	7 430	17
Latin America		1 116	2.3	1 187	3	1 613	3	2 206	2
				1 326	2	2 103	3	3 442	4
Western Europe		2 995	29.4	3 177	28	3 464	20	3 756	10
				3 325	27	4 280	23	5 535	21
Eastern Europe		1 723	18.2	1 797	17	2 076	22	2 358	23
				1 917	17	2 629	19	3 789	20
Africa		510	2.4	570	3	740	2	931	2
				607	2	961	3	1 509	6
Middle East and South Asia		1 240	1.5	1 346	4	1 789	6	2 313	6
				1 518	4	2 407	7	3 672	8
South East Asia and the Pacific		630		717		915		1 138	1
				746		1 064	1	1 510	2
Far East		4 087	12.4	4 280	13	5 231	16	6 328	15
				4 958	12	7 578	13	11 303	12
World Total	Low Estimate	16 930	15.5	17 818	16	21 242	15	25 087	12
	High Estimate			19 391	15	27 133	14	38 191	13

Note: Nuclear generation estimates take into account the scheduled retirement of units at the end of their lifetime.

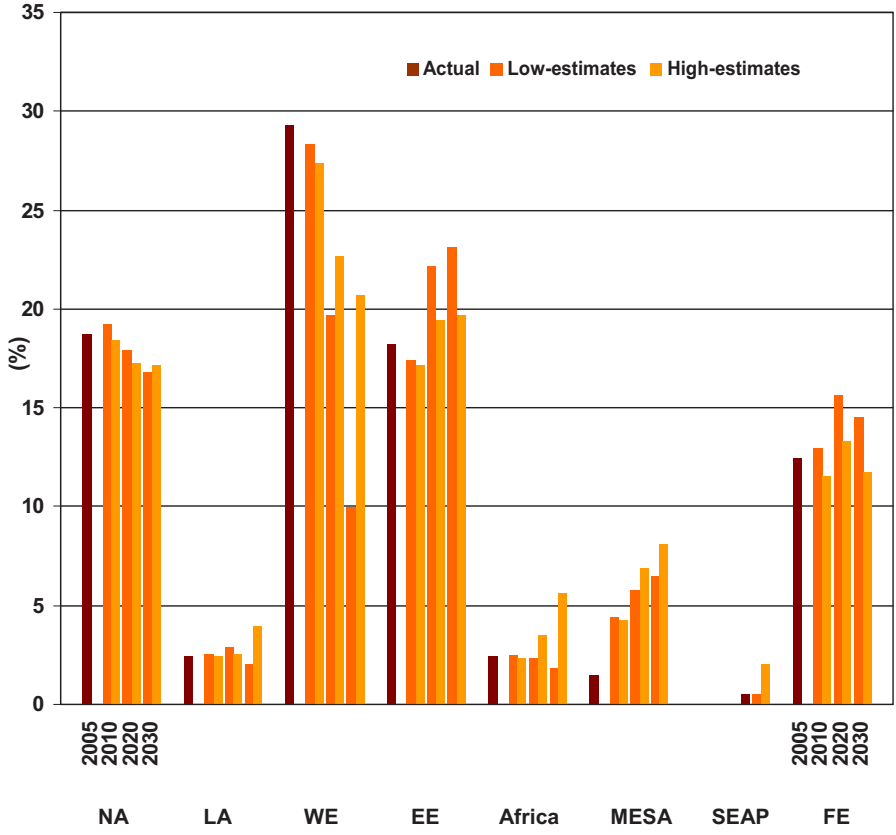

FIG. 33. Actual and estimated nuclear power shares in total electricity generation.

Global energy use is projected to increase by 42% from 2005 to 2030 (Table 39) in the low estimates and by 92% in the high estimates. The share of nuclear power is projected to decline to 4.9% in the low estimates. In the high estimates, the share of nuclear power is projected to remain at the level of 2005 (6.1%) as the share of electricity in total energy use is projected to increase from 33% in 2005 to 38% in 2030; this increase is larger in the Far East (from 36% to 43%) and in Eastern Europe (from 36% to 49%) over this period.

The regional pattern of nuclear power shares in total energy use shows that:

(a) The nuclear share declines in Western Europe in both the low and high estimates, with a greater decline in the low estimate and a small decline in the high estimates.

TABLE 39. ESTIMATES OF ENERGY USE AND THE SHARE OF NUCLEAR POWER IN 2030

	Total energy use (EJ) 2005	Share of nuclear (%)	Total energy use (EJ) 2030		Share of nuclear (%)	
			Low	High	Low	High
North America	113	8	133	159	8	9
Latin America	31	1	55	83	1	2
Western Europe	71	14	82	94	5	13
Eastern Europe	56	6	75	98	8	8
Africa	30	0.4	47	62	0.4	1
Middle East and South Asia	49	0.4	89	121	2	3
South East Asia and the Pacific	23		38	53	0.2	1
Far East	102	5	164	237	6	6
World Total	473	6	683	907	5	6

(b) In North America, nuclear power is expected to maintain its 2005 share in 2030 in the low estimates, and to increase marginally in the high estimates. A similar pattern is projected for Latin America, with a relatively larger increase in the share of nuclear power in the high estimates.

(c) In the Far East, there is a small and equal increase in the share of nuclear power in total energy in 2030 in both estimates.

(d) In all other regions, the nuclear share is projected to increase in 2030 in both estimates, with a larger increase in the high estimates in almost all these regions.

6. CONCLUSIONS

According to the IAEA's 2006 projections, world nuclear power capacity is expected to expand from 368 GW(e) in 2005 to 414 GW(e) in 2030 in the low estimates — an increase of only 13% — and to 679 GW(e) in 2030 in the high estimates — an increase of 85%. A relatively larger increase is projected in nuclear power generation — 17% in the low estimates and 92% in the high estimates — which is projected to reach the level of 3074 TW·h in the low estimates and 5043 TW·h in the high estimates. The nuclear share of total electricity generation is projected to taper off at 13% in 2030, even in the high

estimates, as total electricity generation is expected to increase more rapidly, from 16 930 TW·h in 2005 to 38 191 TW·h — more than a twofold increase.

The World Energy Outlook [2] presents two scenarios of world energy and electricity supply and demand until 2030. It estimates the world's nuclear power generating capacity to be some 416–519 GW(e) in 2030, compared to 368 GW(e) at the end of 2005. The share of nuclear power in world total electricity generation is projected to decline to 10–14%, compared to 15.5% in 2005. The low estimates of nuclear power development are almost equal in the projections of the IAEA and the IEA, while the high estimates of the IAEA are higher than those of the IEA.

Studies with a very long term vision of the world's energy use paint different sets of scenarios. For example, the Special Report on Emission Scenarios (SRES) of the Intergovernmental Panel on Climate Change (IPCC) has carried out energy projections for a 100 year period [1]. Many of the scenarios reported in the SRES study envisage an accelerated expansion of nuclear power until 2050. According to the median value of all 40 scenarios of the SRES study, nuclear power capacity will be doubled by 2030 (819 GW(e)) and quadrupled by 2050 (1607 GW(e)).

All these projections show a range of possible expansions in the world's nuclear power capacity that can be realized under certain assumptions about energy policies and programmes at the national and international levels, as well as energy needs in the distant future. How the future for nuclear power unfolds will depend upon a number of factors, such as intergovernmental efforts to limit carbon emissions from growing energy use, the desire of countries to reduce dependence on imported energy, public perception and support for national policies on nuclear power, technological advances in nuclear technology addressing key issues including safety and proliferation, and the continued good and safe performance of existing nuclear power plants and how far the policies and plans for the energy and power sectors are changed to take into account all these concerns.

Looking at the energy/electricity needs of the future is an ongoing activity of various national and international organizations. All such efforts aim to assess possibilities of exploiting various sources of energy/electricity in meeting these needs and the prospects of growth for various technologies. The IAEA's projections assess nuclear power's contribution to energy/electricity supplies in the medium to long term. The IAEA prepares these projections in collaboration with many international organizations such as WNA, CEA, DOE, OECD/NEA and IEA, who also make use of these projections. Furthermore, the IAEA and other organizations working on issues related to nuclear fuel — starting from demand for initial fuel supply to the level of waste management and disposal — have also been using these projections.

The three part summary of nuclear power — history of development, previous projections and the current projection — will be of some interest to the Member States, energy experts, the media and the general public interested in the history of nuclear power development over the past quarter century and its future in the next quarter century. The regional pattern of 25 years of the past and the future of nuclear power presented in this summary will enlighten them on the changing sources of development of the world's nuclear power use.

REFERENCES

[1] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, Special Report on Emissions Scenarios, Cambridge University Press, Cambridge (2000).

[2] INTERNATIONAL ENERGY AGENCY, World Energy Outlook, OECD/IEA, Paris (2006).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Energy, Electricity and Nuclear Power Estimates for the Period up to 2030, Reference Data Series No. 1, IAEA, Vienna (2006).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Power Reactors in the World, April 2006, Reference Data Series No. 2, IAEA, Vienna (2006).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Power Reactor Information System, http://www.iaea.org/programmes/a2/index.html

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Technology Review 2006, IAEA, Vienna (2006).

[7] UNITED NATIONS, United Nations Millennium Declaration (Fifty-fifth Session), A/RES/55/2), United Nations, New York (2000).

Annex

NOTES AND DEFINITIONS

Throughout this report, energy use refers to the total primary energy production, plus the net energy trade, less changes in international bunkers and domestic stock. The data on electricity produced by nuclear power plants are converted to joules based on the average efficiency of a nuclear power plant, i.e. 33%; data on electricity generated by geothermal heat are converted to joules based on the average efficiency of a geothermal power plant, i.e. 10%. The conversion to joules of electricity generated by hydropower or by the other non-thermal sources such as wind, tide and solar is based on the energy content of the electricity generated (the equivalent of assuming 100% efficiency).

The nuclear data presented on the number of nuclear power units in operation and under construction and data on their capacities in Section 4 are based on actual statistical data collected by the IAEA's Power Reactor Information System (PRIS) [5]. Data on nuclear power generation are also taken from the revised data series on PRIS and are different from the data published in Ref. [4] on nuclear power reactors.

Energy and electricity data for 2005, however, are estimated, since the latest available information from the Department of Economic and Social Affairs of the United Nations is for 2003. Population data originate from the World Population Prospects (2003 Revision), published by the Population Division of the UN Department of Economic and Social Affairs, and the 2005 values are estimates.

The total energy use has been calculated by adding the primary energy production, the net energy trade minus changes in international bunkers and domestic stocks.

Energy units

1 MW(e) = 10^6 watt
1 GW(e) = 1000 MW(e) = 10^9 watts
1 GJ = 1 gigajoule = 10^9 joules
1 EJ = 1 exajoule = 10^{18} joules
1 EJ = 23.9 million tonnes of oil equivalent (MTOE)
1 TW·h = 1 terawatt·hour = 10^9 kW·h = 3.6×10^{-3} EJ

Method used to estimate capacity equivalent of improvement in annual capacity factor of nuclear power plants from 1990 to 2005

Act_cap_2005 ≡ World's actual nuclear power capacity in 2005 = 368 GW(e)
Act_gen_2005 ≡ World's actual nuclear power generation in 2005 = 2626.4 TW·h
ACF_1990 ≡ World's average annual capacity factor of nuclear power plants in 1990 = 67.7%
Est_gen_2005 ≡ Estimated generation in TW·h from world's nuclear power capacity of 2005 if it would have been operating at **ACF_1990**.
Est_add_gen ≡ Estimated additional generation in TW·h due to improvement in annual capacity factor
Est_add_cap ≡ Estimated capacity in GW(e) equivalent to the estimated additional generation

Estimated equivalent nuclear power capacity

Est_gen_2005 = $(368 \times 8760 \times 0.677)/10^6 = 2184.1$ TW·h
Est_add_gen = 2626.4 TW·h – 2184.1 TW·h = 442.3 TW·h
Est_add_cap = 442.3/8.76/0.677 = 74.54 GW(e)

GROUPING OF COUNTRIES AND AREAS INTO EIGHT REGIONS

The countries and geographical areas included in each region are listed below (IAEA Member States are denoted by an asterisk)

1. North America

Canada*
United States of America*

2. Latin America

Anguilla
Antigua and Barbuda
Argentina*
Aruba
Bahamas
Barbados
Belize*
Bermuda
Bolivia*
Brazil*
Cayman Islands
Chile*
Colombia*
Costa Rica*
Cuba*
Dominica
Dominican Republic*
Ecuador*
El Salvador*
Grenada

Guadeloupe
Guatemala*
Guyana
Haiti*
Honduras*
Jamaica*
Martinique
Mexico*
Montserrat
Netherlands Antilles
Nicaragua*
Panama*
Paraguay*
Peru*
Puerto Rico
S. Georgia & South Sandwich Islands
Saint Kitts and Nevis
Saint Lucia
Saint Pierre and Miquelon
Saint Vincent & The Grenadines
Suriname
Trinidad and Tobago
Turks and Caicos Islands
Uruguay*
Venezuela*

3. Western Europe

Andorra
Austria*
Belgium*
Cyprus*
Denmark*
Finland*
France*
Germany*
Gibraltar
Greece*
Greenland
Holy See*
Iceland*
Ireland*
Italy*
Liechtenstein*
Luxembourg*
Malta*
Monaco*
Netherlands*
Norway*
Portugal*
San Marino
Spain*
Svalbard and Jan Mayen Islands
Sweden*
Switzerland*
Turkey*
United Kingdom*

4. Eastern Europe

Albania*
Armenia*
Azerbaijan*
Belarus*
Bosnia and Herzegovina*
Bulgaria*
Croatia*
Czech Republic*
Estonia*
Georgia*
Hungary*
Kazakhstan*
Kyrgyzstan*
Latvia*
Lithuania*
Montenegro*
Poland*
Republic of Moldova*

Romania*
Russian Federation*
Serbia
Slovakia*
Slovenia*
Tajikistan*
The Former Yugoslav Republic of Macedonia*
Turkmenistan
Ukraine*
Uzbekistan*

5. Africa

Algeria*
Angola*
Benin*
Botswana*
Burkina Faso*
Burundi
Cameroon*
Cape Verde
Central African Republic*
Chad*
Comoros
Congo
Côte d'Ivoire*
Democratic Rep. of the Congo*
Djibouti
Egypt*
Equatorial Guinea
Eritrea*
Ethiopia*
Gabon*
Gambia
Ghana*
Guinea
Guinea-Bissau
Kenya*
Lesotho
Liberia*
Libyan Arab Jamahiriya*
Madagascar*
Malawi*
Mali*
Mauritania*
Mauritius*
Mayotte
Morocco*
Mozambique*
Namibia*
Niger*
Nigeria*
Reunion
Rwanda
Saint Helena
São Tome and Principe
Senegal*
Seychelles*
Sierra Leone*
Somalia
South Africa*
Sudan*
Swaziland
Togo*
Tunisia*
Uganda*
United Republic of Tanzania*
Western Sahara
Zambia*
Zimbabwe*

6. Middle East and South Asia

Afghanistan*
Bahrain
Bangladesh*
Bhutan

British Indian Ocean Territory
Cocos (Keeling) Islands
French Southern Territories
Heard Island & McDonald Islands
India*
Iran, Islamic Republic of*
Iraq*
Israel*
Jordan*
Kuwait*
Lebanon*
Nepal
Oman
Pakistan*
Qatar*
Saudi Arabia*
Sri Lanka*
Syrian Arab Republic*
Territories Under the Jurisdiction of the Palestinian Authority
United Arab Emirates*
Yemen*

7. Southeast Asia and the Pacific

Australia*
Brunei Darussalam
Cook Islands
Fiji
Indonesia*
Kiribati
Malaysia*
Maldives
Marshall Islands*
Micronesia (Fed. States of)
Myanmar*
Niue
Norfolk Islands
Northern Mariana Islands
Palau*
Papua New Guinea
Pitcairn Islands
Samoa
Singapore*
Solomon Islands
Thailand*
Tokelau
Tuvalu
US Minor Outlying Islands
New Zealand*
Vanuatu
Wallis and Futuna Islands

8. Far East

Cambodia
China*
Democratic People's Republic of Korea
Hong Kong, China
Japan*
Korea, Republic of*
Lao People's Democratic Republic
Macau
Mongolia*
Philippines*
Taiwan, China
Vietnam*

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Various global energy studies have projected a range of possible futures for nuclear power. Many of these studies point to a need for substantial expansion in nuclear power by 2030 to meet global energy demand. This report presents global and regional trends of energy use, electricity generation and nuclear power development during the past 25 years (1980–2005). The current projections of nuclear power development for the next 25 years (2005–2030) are compared with the previous projections of nuclear power development made by the IAEA. The current projections of nuclear power are also presented in the context of energy use and electricity generation projected until 2030.

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA
ISBN 978–92–0–107407–2