

STRATEGIES AND INSTRUMENTS TO PROMOTE ENERGY EFFICIENCY IN DEVELOPING COUNTRIES

Project working paper 1

Industrial energy demand and CO₂ emissions in
developing countries in global perspective

V.W. BUSKENS
J.C. JANSEN

Framework of the study

The present paper is the first working paper in the framework of the collaborative research project of ECN, ENDA, IEI and TERI entitled: 'Strategies and Instruments to Promote Energy Efficiency in Developing Countries'. It has been partially financed by the Dutch National Research Programme on Global Air Pollution and Climate Change (NOP/MLK). The project makes a preliminary assessment of major implemented and on-going policy initiatives to improve industrial energy efficiency in the developing world. In addition, it sets out to identify possibilities for transfer of appropriate technology from OECD member states to enhance energy efficiency and environmental performance of manufacturing industries in the developing world. This project is registered with ECN under project number 7128.

Abstract

In this working paper projections are presented of global energy trends and related emissions of the greenhouse gas CO₂ up to the year 2020. The purpose of this paper is to provide indications of the importance of the manufacturing sector in developing countries to global issues on the energy-environment interface. Therefore, special attention is paid to prospects for the contribution of the manufacturing sector in developing countries to global energy demand and CO₂ emissions. The projections presented clearly bring out that the developing countries constitute an increasingly important factor underlying global energy demand - total and industrial - and consequential greenhouse gas emissions.

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1. INTRODUCTION

The present paper is the first working paper in the framework of the collaborative research project of ECN, ENDA, IEI and TERI entitled: 'Strategies and Instruments to Promote Energy Efficiency in Developing Countries'¹. This project sets out to make a preliminary assessment of major implemented and ongoing policy initiatives to improve industrial energy efficiency in the developing world. In addition, it sets out to identify possibilities for transfer of appropriate technology from OECD member states to enhance energy efficiency and environmental performance of manufacturing industries in the developing world.

In this working paper projections are presented of global energy trends and related emissions of the greenhouse gas CO₂ up to the year 2020. The purpose of this paper is to provide indications of the importance of the manufacturing sector in developing countries to global issues on the energy-environment interface. Therefore, special attention is paid to prospects for the contribution of the manufacturing sector in developing countries to global energy demand and CO₂ emissions. *The projections presented clearly bring out that the developing countries will constitute an increasingly important factor underlying global energy demand - total and industrial - and consequential greenhouse gas emissions.*

The projection exercise carried out for the preparation of this paper is based on two scenarios of a recent World Energy Council study [20]. The two WEC energy demand cases/scenarios are i) the reference scenario (henceforth in this report referred to as RS) and ii) the ecologically driven scenario (ES).

The RS scenario assumes a world-wide continuation of prevailing energy policies. By contrast, the ES scenario assumes a world-wide shift in policy emphasis in favour of promotion of energy efficiency improvement and renewable energy. In order to focus on the impact of energy policy changes, both scenarios are based on one set of baseline medium projections of population growth and economic growth². RS projections presented in this paper may be interpreted as projections of most likely developments, barring sustained tensions in the world market for fossil fuels. If sustained tensions were to arise this would be reflected by a concomitant marked upward long-term trend in real world market prices for fossil fuels. With a view to actual trends of the ratio between proven world reserves of fossil fuels and world demand, and advances of backstop technologies as well, the RS scenario of the present paper assumes more or less stable real prices for fossil fuels. Also the ecologically driven scenario presumes the absence of sustained tensions in the world market for fossil fuels.

¹ This project is partially financed by the Dutch National Research Programme on Global Air Pollution and Climate Change (NOP/MLK).

² We have adjusted some of the parameter values underlying WEC projections in accordance with our perception of recent developments.

We distinguish the following world regions:

- the *developing countries* (DCs), subdivided into *Africa*, *Asia*³, and *Latin America*⁴;
- the *transition economies* (TEs) of Central and Eastern Europe and the former USSR⁵; and
- the *OECD* member states, subdivided into *North America*, *Europe* and *Pacific*.

Hereafter, Asia refers to present-day developing Asia (including Asian 'NICs' but excluding Japan), while the region referred to as the Pacific includes Japan, Australia and New Zealand only. The country grouping Asia, in turn, has been further broken down into China, India and Other Asia. This because of the sheer size of both China and India.

The development of CO₂ emissions can be broken down into a number of underlying trends. The following identity brings out this decomposition⁶:

$$C = P \times (Y/P) \times (E/Y) \times (F/E) \times (C/F),$$

where: C = level of CO₂ emissions

P = level of population

Y = Gross Domestic Product (GDP)

E = level of primary energy consumption (including transformation and distribution losses)

F = primary energy requirements met by fossil fuels

The underlying trends refer to:

- Population (P),
- Average living standards (Y/P),
- Economy-wide energy intensity (E/Y),
- Penetration of fossil fuels in the domestic energy market (F/E), and
- Average CO₂ emissions per unit of fossil fuel (C/F).

Among other things, the distinct factors that make up the aforementioned identity will be set out successively in the remainder of this paper.

This paper is structured as follows. The baseline projections of population and economic growth are presented in sections 2 and 3 respectively. Global energy demand and its impact on CO₂ emissions are discussed in section 4. Section 5 considers the share of industry in total energy demand. Projected energy demand and related CO₂ emissions in industry are presented in section 6. The conclusions of the paper are presented in section 7.

³ Excluding OECD member state Japan and developing countries in the Asian part of the former USSR.

⁴ Including the Caribbean.

⁵ In fact this country grouping comprises several European and Asian countries classified by the OECD, the UN and the World Bank as developing countries.

⁶ This identity is further discussed, inter alia, in [12, chapter 2].

2. POPULATION GROWTH SCENARIO

We broadly follow the U.N. medium projections [21]. The growth rates shown in table A.1⁷ indicate that over the coming three decades population growth will remain relatively high in the developing countries (with annual average growth rates of 1.9 and 1.4 percent over the periods 1990-2000 and 2000-2020 respectively). By contrast, low population growth is forecast for the transition economies and the OECD countries (0.5 percent per annum during 1990-2000 for both regions and respectively 0.4 and 0.3 percent per annum for the transition economies and the OECD during 2000-2020). Demographers expect population growth in Africa to remain highest by far (with corresponding growth rates of 2.9 and 2.5 percent per annum respectively). For all regions population growth is projected to decrease slowly over the next decades.

World population is projected to grow from 5.28 billion in base year 1990 to 6.18 billion in the year 2000 and 7.84 billion in 2020 (see figure 2.1 and table A.2). In particular Asia and Africa are bound to cope with growing population numbers: Asia from 2.95 billion in 1990 to 4.35 billion in 2020 and Africa from 0.62 billion in 1990 to 1.35 billion in 2020. The population in Latin America is projected to grow from 0.43 billion in 1990 to 0.70 billion in 2020.

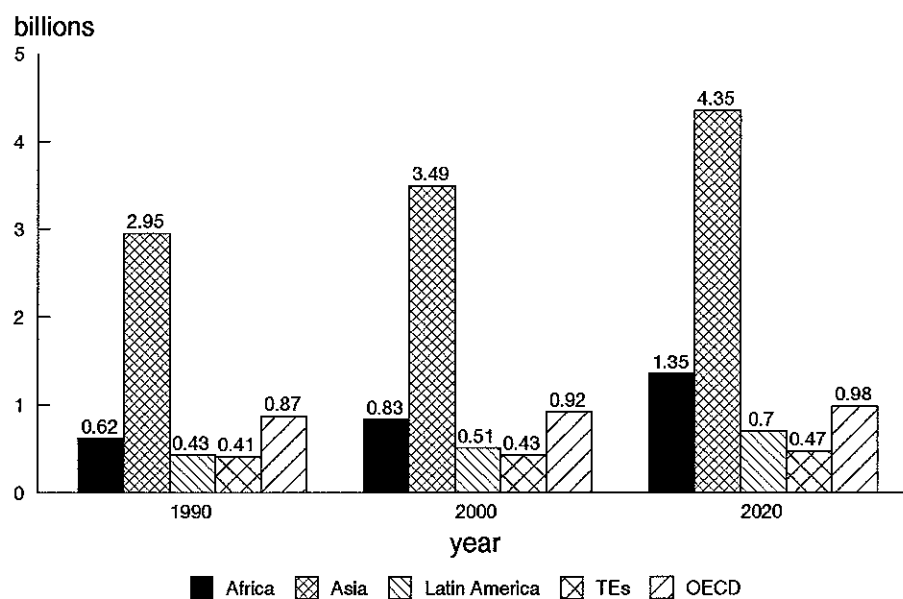


Figure 2.1 Actual and projected population levels, 1990-2020

Remarkable is the substantial increase in the projected proportion of the world population living in developing countries. The share of all current developing countries in world population is projected to increase from 76% in 1990 to 82% in 2020. The share of world population living in Africa is projected to increase sharply from 12% in 1990 to 17% in 2020 (see figure

⁷ Most tables are presented in annex A.

2.2 and table A.3). By contrast, population growth rates of Asia and Latin America are projected be roughly in line with the world at large. This would imply that, up to 2020, the latter two developing regions are to approximately hold on to their 1990 shares in global population, being 55% for Asia and 8% for Latin America.

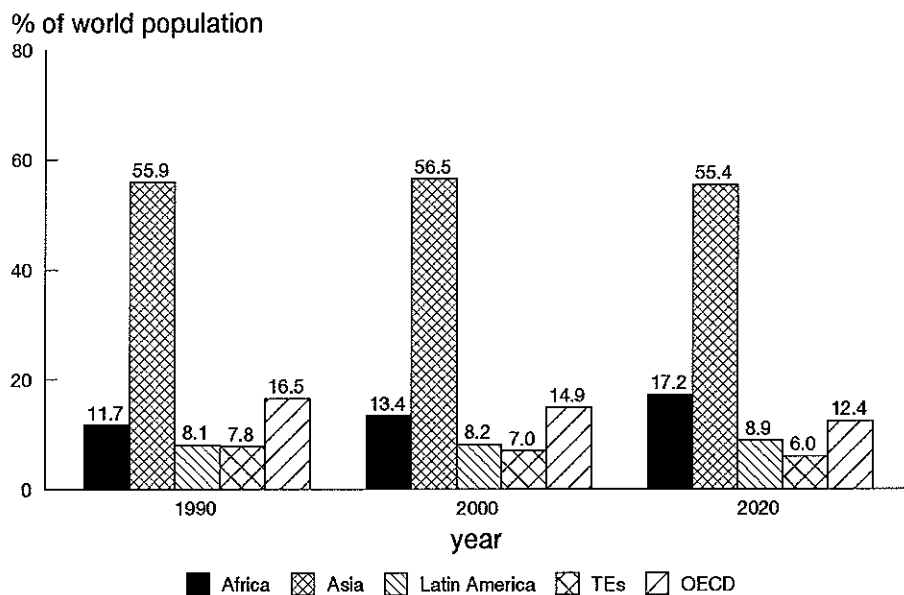


Figure 2.2 Shares of world population, 1990-2020

3. ECONOMIC GROWTH SCENARIO

A convenient first indication of the level of economic activities within the borders of a country or a region is provided by gross domestic product (GDP). GDP on a per capita basis gives a rough indication of average living standards in the geographic entity considered. The rate of increase in GDP of a region over a certain period of time after making allowance for the rise of the general price level over that period, provides an indication of the corresponding rate of economic growth.

A problem is constituted by the conversion from local currencies to a common monetary yardstick, for example US dollars. Using official foreign exchange rates developing country GDPs often tend to be grossly underrated compared to industrial country GDPs. This relates, among various other things, to the relatively large non-monetary sector producing goods and services in developing countries. Another important factor accounting for underestimation of GDP in developing countries relative to industrialised countries using official exchange rates is that prices in developing countries tend to be appreciably lower. In principle, estimates of purchasing-power-parity (PPP) rates would make up for the latter disadvantage. However, at the time of conducting the research work for the present study no comprehensive base year (1990) estimates were available. Therefore, for lack of suitable data it has been decided to use the - admittedly less perfect - GDP indicator without PPP adjustment.

Economic growth is difficult to predict. Any assumptions made, therefore, tend to be inherently contentious. The projections presented in this report, are based on several sources [4,7,11,17,20] combined with own perceptions of recent developments. Our projections of economic growth are shown in tables A.4 through A.8. Tables A.7 and A.8 on projected per capita GDP levels incorporate the population growth scenario discussed in the previous section.

Over the period 1990-2020 economic growth in the developing world at large is projected to amount to nearly 5% per year on average (see table A.4). This compares to a projected average growth rate for the present day industrialised countries of around 2% per annum.

Africa has registered a relatively bad performance during the decade of the 1980s. Economic growth during this decade by 1.8% per annum could not keep up with population growth (3.1% per annum). Hence average living standards in Africa have deteriorated appreciably. This relates, among other things, to external factors such as adverse developments in world primary commodity markets, protective trade practices by industrialised countries especially the EC, but also to internal factors, e.g. political instability, poor performing economic policies and a weak public sector. It is projected that in several African countries political conditions will improve, especially in southern Africa and the Horn of Africa. Furthermore, the positive economic impact of structural adjustment programmes under implementation is poised to become manifest, little by little, before long.

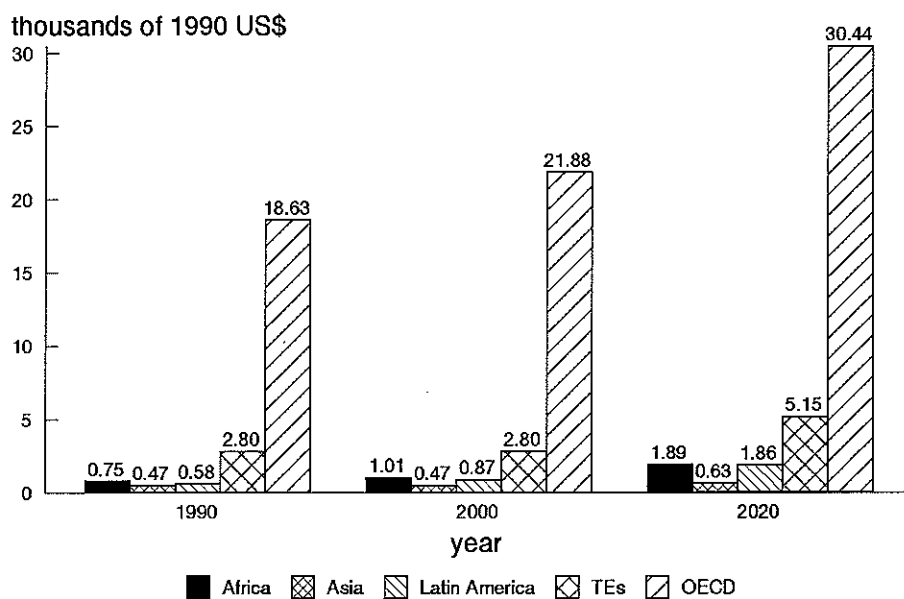


Figure 3.1 Actual and projected levels of per capita GDP, 1990-2020

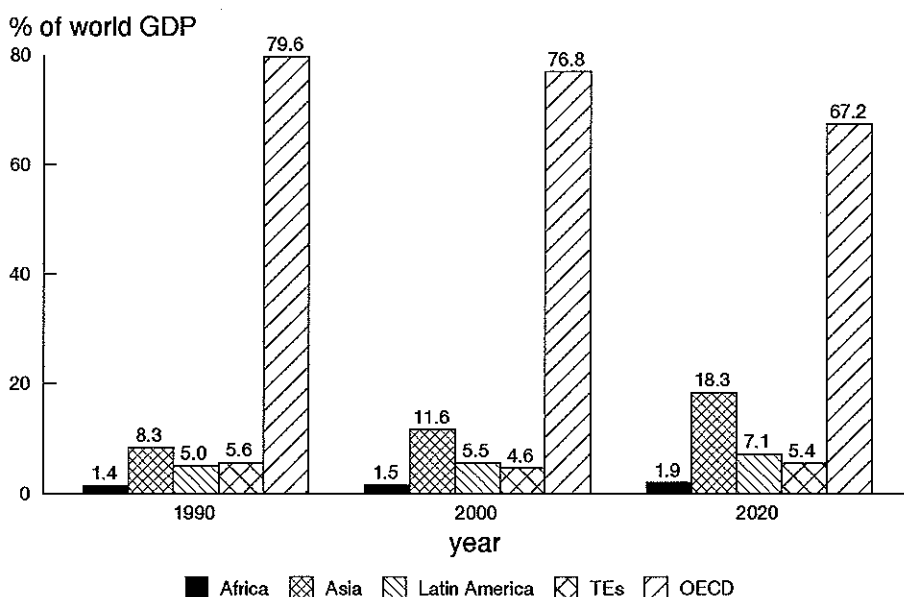


Figure 3.2 Shares of world GDP, 1990-2020

The quite low average living standards are projected to stabilize in the 1990s and to slightly improve during the first two decades of the next millennium. In our baseline scenario, during the periods 1990-2000 and 2000-2020 average economic growth in Africa is projected to stand at 3.0% and 4.0% per annum respectively. Nonetheless, in spite of this perhaps somewhat optimistic scenario the economic divide between Africa and the rest of the world, including other developing regions, is projected to widen appreciably.

Certainly in the near future, GDP growth in Asia is bound to be much higher than in other regions. Especially, growth in China has been quite upbeat hitherto: 9.5% between 1980 and 1990. The Newly Industrialising

Countries, which are included in Other Asia have recorded high growth rates as well. Also India, with an annual growth rate during 1980-1990 of over 5% is doing better than the world at large. Pending a continuation of recent tendencies toward liberalisation of the Indian economy and a fair measure of political stability, a prolonged period of robust economic growth is projected to be in store for India. For the whole of Asia excluding Japan average growth rates of 6% and 5% per annum in the baseline scenario are envisaged for 1990-2000 and 2000-2020 respectively.

Latin America has substantial economic growth potential. Realisation depends much on the choice of economic paradigm (liberalisation versus regulated import substitution), internal political developments and access to major export markets, in particular to the US market. Recent developments on all these counts have by and large improved the prospects for economic growth in Latin America. Economic growth has been set at 3.5% and 4.0% per annum during 1990-2000 and 2000-2020 respectively. These rates would compare favourably to Latin America's growth performance over the 1980s, being on average a mere 1.6% per annum.

Over the period 1990-2020 aggregate GDP in China is projected to grow by a factor six and in India by a factor four (see table A.5). This results in a shift of the distribution of GDP over the world. Although, as mentioned before, GDP of developing countries is underestimated, the discrepancy between distribution of population and GDP is and will remain striking during the next three decades. By way of example, India's share in world population in base year 1990 was 16 percent as against a share of a mere 1.2 percent in world GDP. For the year 2020 our corresponding projections are 16 percent (population) against 2.4 percent (GDP).

As shown in table A.8, an increase of the average per capita world income level by almost one half from US\$ 3860 in 1990 to US\$ 5640 in 2020 is reckoned with. The (low) per capita income level of the group of developing economies as a whole would almost treble. On average, per capita income levels in Africa would virtually stagnate, but grow very rapidly in Asia, while Latin America would perform slightly below developing world average. Graphical representations of projected GDP developments are shown in figures 3.1 and 3.2. These depict the development of regional GDP in per capita terms and the regional distribution of world GDP respectively.

4. TOTAL ENERGY DEMAND AND RELATED CO₂ EMISSIONS

Energy demand and its impact on the environment are determined by:

- population,
- economic development,
- the energy mix,
- the energy intensity of the economy,
- pollution abatement activities.

The economy-wide energy intensity (E/Y) is measured in monetary terms. As for the denominator, reference is made again to the purchasing power parity problems with conversion to a common numéraire. When using official exchange rates, the level of economic activities in many developing countries relative to OECD countries might well be underestimated by a factor three. Apart from this, differences between regions in economy-wide energy intensity are determined by a host of partly interrelated factors, such as:

- economic structure,
- energy mix,
- losses in energy supply and distribution,
- climate,
- total factor productivity (general economic efficiency of the public and private sector),
- penetration of energy-efficient production technology,
- penetration of energy-efficient end-use devices,
- non-technical aspects such as life styles and energy management practices,
- government policies including energy pricing interventions,
- demand-side management policies by energy utilities.

Technology, environmental concerns and government policy affect both energy intensity and the energy mix. Over the next few decades, environmental concerns are expected to increasingly bring to bear political and social pressures to reduce the burning of fossil fuels. This, in turn, will lead to a reduction in overall energy use as well as changes in the fuel mix. Technology development will focus on improvements in energy efficiency.

The reference scenario (RS) used for the present study assumes a fairly modest fall in energy intensity over time. The ecologically driven scenario (ES) incorporates both a sharper fall of intensity and a more pronounced change in the fuel mix, both reducing the level of CO₂ emissions. Projections of energy efficiency improvement⁸ and corresponding development of global primary energy consumption are presented in table A.10 through A.14 on an aggregate basis, and in table A.15 and A.16 on a per capita basis.

⁸ WEC data and assumptions have been adjusted in view of more recent developments and other sources [CEC, 1992; IAEA, 1991; Sathaye 1991].

No sweeping statements can readily be derived from a comparison between regions of economy-wide energy intensities such as the ones in table A.11. In this respect reference has already been made to the purchasing power parity problems and different levels of energy efficiency inherent to a different energy mix (a high proportion of traditional fuels and coal tend to negatively affect the efficiency of energy use) and a different economic structure. Figures in table A.11 would *prima facie* suggest that by world standards energy in developing countries and in formerly centrally planned economies is used utterly inefficient. In projection base year 1990 966 toe and 1,450 toe of energy was spent in developing countries and economies in transition respectively to generate 1 million US\$ worth of GDP. By way of example, this compares to 428 toe/million US\$ for the world at large and to 164 toe/million US\$ for Pacific OECD member states. Although these figures may give a grossly exaggerated impression of the backwardness of the developing countries and economies in transition in terms of energy efficiency, analyses at meso and micro level do corroborate the contention that energy in these countries tends to be used inefficiently (e.g. [11,18]).

Related to this problem is the outcome of the present projection exercise that world wide energy efficiency improvement may well be at variance with developments in the various world regions separately. The latter paradox does appear indeed in both our projection scenarios: energy intensity in the world at large is projected to improve less than in the constituent world regions separately (see table A.10). This relates to the forecasts that the share in world energy use of countries with low economy-wide energy efficiencies (such as China and India) increases. This, in turn, affects negatively world-wide levels of energy efficiency. On the other hand, table A.10 and A.11 present a picture of energy intensities, going down considerably in developing countries during the projection period 1990-2020. This would be brought about, among other things, by fresh investments in new, relatively energy-efficient equipment enabled by relatively high rates of economic growth in the developing world and a shift from traditional and solid fuels to other, inherently more efficient energy carriers.

World energy use is to virtually double under the reference scenario from 8.7 Gtoe⁹ in 1990 to 15.4 Gtoe in 2020. The present-day developing countries will appreciably increase their share in global energy use. They are projected to make up for 55% of global energy demand by 2020 against 33% in 1990 (see figure 4.1 and tables A.13 and A.14). China's share in global energy demand is bound to double from 10.1% in 1990 to 19.7% in 2020, while the corresponding shares of India are 3.2% and 5.5%.

⁹ Gtoe = giga (10⁹) tonnes of oil equivalent

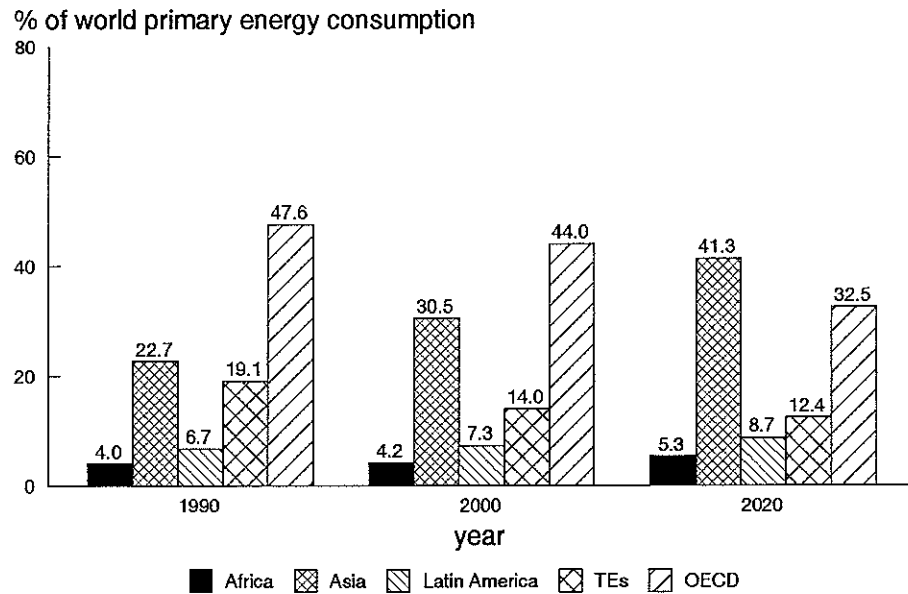


Figure 4.1 Shares of world energy consumption, 1990-2020

The differences in per capita energy use between developing and industrialised regions are illustrated by figure 4.2. Energy use per capita in Africa, Asia and Latin America in base year 1990 is estimated at 0.56, 0.67 and 1.35 toe per capita respectively. The corresponding figure for OECD countries (4.77 toe per capita) indicates that in these countries energy use per head is more than 6.5 times as large on average than in developing countries. Although in relative terms this huge gap is bound to be closing in somewhat, the absolute differences in per capita energy use between the developing countries on the one hand and the industrialised world on the other will remain very substantial during the period up to the year 2020.

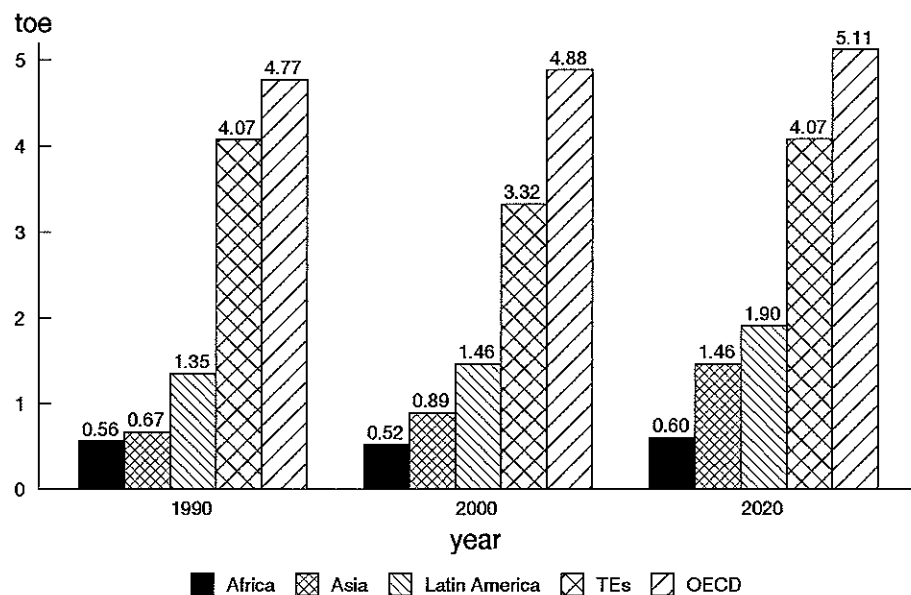


Figure 4.2 Actual and projected energy consumption per capita by region, 1990-2020

The WEC projections of fuel mix shares and IIN data have been used to project the energy mix for the two scenarios. Tables A.17a through A.17f show the projected fuel mix for the whole world, Africa, Asia, Latin America, China and India respectively. Fossil fuels include solids (such as coal and lignite), oil and gas and traditional fuels (mainly fuelwood, charcoal, crop residues, dung) for conventional applications. New renewable refers to renewable energy sources such as solar thermal, solar power, wind power, geothermal, and biomass for new applications.

In both scenarios, the share of oil and coal, (energy carriers with the highest CO₂ emissions) tends to diminish world-wide. Compared to the RS scenario, in the ES scenario these shares are projected to diminish faster and those of renewables to rise considerably faster.

In Africa, a shift from coal towards oil and gas is foreseen. In the RS scenario the share of traditional energy sources is expected to decrease from 44% in 1990 to 31%; in the ES scenario even to 24%. The last scenario shows a shift to new and renewable energy sources including new applications of biomass. In Asia, the share of coal and traditional energy sources is bound to drop whereas in the RS scenario the share of oil, gas and renewables will rise. Conversely, the ES scenario brings out a diminishing share for oil in Asia, while this scenario indicates an astounding growth of gas and renewables. The energy mix of both China and India is heavily oriented towards the use of domestic coal. In China and India the share of solid fuels (coal, lignite) in total primary energy requirements (including traditional fuels) in base year 1990 is 60 and 45 percent respectively. The corresponding shares in commercial energy (excluding traditional and new renewables) are even higher, i.e. 81 and 63 percent. In Latin America the use of coal is already low at present. In the RS scenario, the main shift is from traditional fuels to gas and renewables. The ES scenario indicates for Latin America a major shift from oil and traditional fuels towards new renewable energy sources.

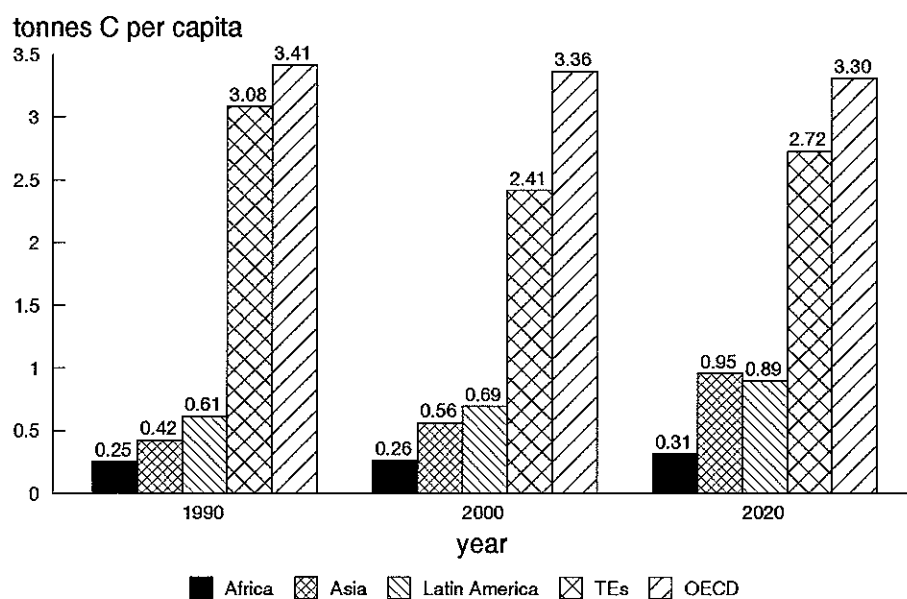


Figure 4.3 Actual and projected levels of CO₂ emissions per capita, 1990-2020

Developments regarding energy demand and fuel mix have major implications for energy-related emissions. Tables A.18 through A.22 present projections of energy-related emission levels under the RS and ES scenario. Especially under the RS scenario world CO₂ emissions are poised to rise sharply in the coming decades. Under this scenario the world would have to cope with energy-related CO₂ emissions going up from 5.88 billion tonnes of carbon in 1990 to 9.67 billion tonnes of carbon in 2020 (see table A.19). This would mainly be occasioned by a shift in the energy mix in the developing world from traditional to fossil fuels and by a persistent rise of energy consumption world-wide, if more so in the developing countries than in the present-day OECD member states and in economies in transition.

On a per capita basis, however, emission of CO₂ in developing countries are not envisaged to catch up with OECD countries to any significant extent (see figure 4.3 and tables A.21 and A.22). In 1990 the developing countries emitted 410 kg of carbon per head (Africa 250 kg/cap; Asia 420 kg/cap; Latin America 610 kg/cap) so as to meet their energy needs as against 3410 kg/cap in OECD countries (5,590 kg/cap in North America!). Under the RS scenario these emissions in the year 2020 would reach a level of 810 kg/cap in the developing countries (310 kg/cap in Africa; 950 kg/cap in Asia; 890 kg/cap in Latin America) compared to 3,300 kg/cap in the present-day OECD area.

By the year 2020 annual CO₂ emissions in the present-day OECD area would be reduced under the ES scenario by about 30% as compared to the RS scenario: 2.25 billion against 3.22 billion tonnes of carbon (see table A.21). The ecologically driven scenario would still allow for an increase in CO₂ emissions in the developing world of 131 percent by 2020 compared to 1990 levels (3.81 billion tonnes of elemental C against 1.65 billion tonnes of elemental C, i.e. a compound annual rate of increase of 2.8 percent). Even under the ES scenario global CO₂ emissions are bound to rise by 20 percent from 1990 to 2020.

By 2020, energy-related CO₂ emissions in the (present-day) developing countries will be substantially larger than in the (present-day) OECD. In both scenarios the share of developing countries in global CO₂ emissions will rise from 28% in 1990 to 54% in 2020 (see table A.20). Even so, the shares of Africa and Latin America will remain relatively modest. The projected global share of energy-related CO₂ emissions by the year 2020 is 4% (RS scenario) to 5% (ES scenario) for Africa and 5% (ES scenario) to 6% (RS scenario) for Latin America.

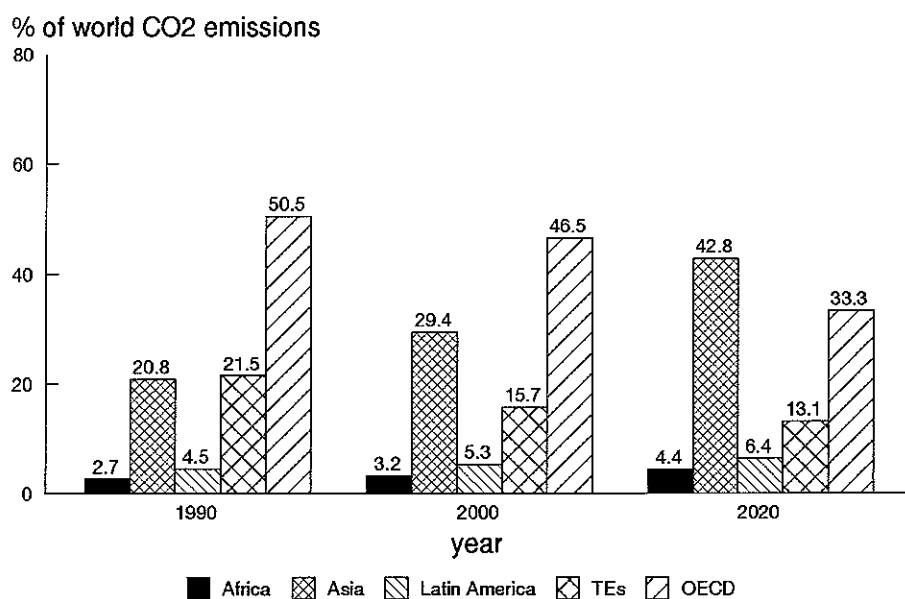


Figure 4.4 Shares of world CO₂ emissions, 1990-2020

The lion's share of the developing country contribution to projected global CO₂ emissions in year 2020 is accounted for by Asia with a global share going up from 21 to 43%. Especially China and, to a much lesser extent, India will assume increasing global importance when it comes to greenhouse effect mitigation. Under the RS scenario China and India would account for 23.3 and 5.6 percent of global CO₂ emissions respectively against 10.9 and 2.9 percent in year 1990 (see figure 4.4 and table A.21). Under the ES scenario China's and India's share would even attain 23.9 and 6.1 percent, respectively.

5. SHARE OF INDUSTRY IN TOTAL ENERGY DEMAND

Starting out from projections of total primary energy use projections are made of energy use in manufacturing industry. Most data on demand for energy brought about by manufacturing activities in developing countries relates to final demand for commercial energy. Data on final use of traditional energy in manufacturing industry - though quite significant in the small-scale sector at less advanced stages of economic development - is scanty. Given the paucity of data on final use of non-commercial energy (wood-fuels, agricultural residues) in manufacturing and its declining relative importance when economic development advances, projections pertain to commercial industrial energy demand. The latter will be derived from projections of total primary energy requirements (discussed in the previous section) and projecting *the share of industrial demand for commercial energy in total primary energy requirements of the economy*. Most available data on industrial energy demand covers manufacturing and mining. Correspondingly, hereafter energy used for mining is included in industrial energy demand.

It stands to reason that the share of industrial energy demand for commercial energy in total energy requirements is related to the role of manufacturing in the economy. Therefore, the literature has been scanned on possible relationships between the nature of structural change of the economy and economic development. Hollis Chenery c.s. have intensively investigated this topic and have found a significant relationship indeed. Among other publications, in [5] convincing evidence is presented that broadly uniform patterns of change in the structure of production can be discerned as income levels rise.

Typically, the share of industry in GDP rises fast at early stages of economic development. This holds especially for large countries, where energy-intensive basic industries also tend to be relatively more important compared to countries with a small domestic market. Hence also scale is an important factor explaining the structure of the economy. At more advanced stages of economic development the rise of the industrial share in GDP tends to taper off and eventually peaks. The economically most advanced, 'post-industrial', societies are dominated by commercial services and the contribution of manufacturing to GDP tends to decline slightly. These broad types of relationships are brought out by both time-series analysis for individual countries and by cross-section analysis among countries.

It has been tried to establish statistical relationships between the share of industrial commercial industry in total energy requirements and per capita income levels. Other explanatory factors investigated are scale and region-specific differences. Statistical analysis was performed on cross-section data for year 1987 of 81 countries. It is noted that this type of analysis does not account for possible differential sectoral developments of energy intensity c.q. energy productivity over time. Nor does it allow for changes in life styles and corresponding consumption patterns. E.g. currently there

is a clear demand shift towards private motorised transportation going on, which cannot be traced by cross-section analysis. These serious flaws can be made up for to some extent once better time-series data become available with respect to the developing countries.

Point of departure has been the hypothesis that primary energy consumption brought about by industry as a proportion of total primary energy consumption will tend to increase in countries which have a low level of economic development. Especially in large countries energy-intensive industries, like cement, steel, etc. are bound to become relatively important at intermediary stages of economic development. Conceivably, at more advanced phases of economic development the thrust will be on more energy-extensive manufacturing activities and services. This would be reflected by a commensurate subsiding of the share of industry in total energy demand. Regression analysis has been performed in order to test these hypotheses.

After various trials, more or less in line with analysis of Chenery et al., the following specifications were retained.

1. $\ln(100 \cdot (\frac{E_i}{E})) = a + b \cdot \ln(\frac{Y}{P})$
2. $\ln(100 \cdot (\frac{E_i}{E})) = a + b \cdot \ln(\frac{Y}{P}) + d \cdot \ln(P)$
3. $\ln(100 \cdot (\frac{E_i}{E})) = a + b \cdot \ln(\frac{Y}{P}) + c \cdot (\ln(\frac{Y}{P}))^2 + d \cdot \ln(P)$

Where: E stands for total primary energy requirements;
E_i stands for industrial end-use demand for commercial energy;

The main results of regression analysis conducted are presented in table 5.1. In this table:

- f denotes the number of the specification retained;
- t indicates the value of the t test;
- F indicates the value of the F test;
- SE stands for standard error;
- n gives the number of observations.

Table 5.1 *Results of regression analysis on the share of industry in total energy demand*

f	a (t)	b (t)	c (t)	d (t)	R ²	Adj. R ²	SE	F	n
1	-0.098 (-0.226)	0.367 (6.525)	-		.35	.34	.74	42.6	81
2	-1.142 (-2.461)	0.412 (7.907)	-	0.243 (4.265)	.47	.46	.67	35.0	81
3	-9.023 (-5.191)	2.538 (5.542)	-0.140 (-4.667)	0.290 (5.611)	.59	.57	.60	36.8	81

If the relations given above are universal among countries and regions and over time, it is possible to project the share of commercial industrial energy demand with data and projections presented in the previous sections 2 to 4. This under the proviso that a reasonable figure can be given for the average country size in a region. Starting out from data and estimates for base year 1990 changes have been projected in the share of commercial industrial energy demand in total energy demand by using the derivative of specification 3. The specification of the derivative is shown below.

$$\left(\frac{E_i}{E}\right)' = \frac{\exp(a + b \cdot \ln\left(\frac{Y}{P}\right) + c \cdot \left(\ln\left(\frac{Y}{P}\right)\right)^2 + d \cdot \ln(P))}{100} \cdot \left(\frac{b}{Y/P} + \frac{2 \cdot c \cdot \ln(Y/P)}{Y/P}\right)$$

Resulting projections of the share under consideration are shown in table 5.2. The figures in table 5.2 may differ considerably from other sources, e.g. OECD/IEA Statistics, because most other sources do not include traditional energy sources in their statistics.

Table 5.2 *Projected shares of commercial industrial energy demand in total energy demand calculated with help of results of regression analysis with specification 3: 1990-2020*

	1990	2000	2020
Africa	0.15	0.17	0.19
Asia	0.33	0.36	0.41
China	0.38	0.41	0.48
India	0.29	0.31	0.35
Other Asia	0.28	0.30	0.34
Latin America	0.21	0.22	0.24
Transition economies	0.37	0.37	0.39
OECD	0.24	0.23	0.21

As for Africa, Latin America, India, Other Asia and the OECD countries the projected shares presented in table 5.2 would seem plausible to us. On the other hand, projections in table 5.2 show a rising trend for China and for the country grouping of economies in transition, whereas *a priori* one would expect a declining share. Major reasons for our expectations are that dirigiste industrial policies in these countries have been stressing energy-intensive basic industries and heavy warfare equipment industries. Changes towards more market-oriented industrial policies which have been gradually introduced in China already since the late 1970s will make for a relative shift toward light consumer industries. Secondly, introduction of appreciably higher energy prices will stimulate factor proportions that economize more on energy resources. In addition, ongoing reforms will stimulate improved management practices which will permit important reductions of outright wastage of energy in the manufacturing industry of these countries.

Keeping the considerations above in mind, it has been decided to make some adjustments to the projected shares of table 5.2 deemed plausible by us. Projections of the share of commercial industrial energy demand used for the present projection exercise are shown in table A.23. The share of industrial energy end-use demand *excluding conversion and distribution losses* in global primary energy use is projected to be rather stable. In between 1990 and 2020 it is projected to stabilise around 28% of global total primary energy use. This would entail that world-wide industrial energy demand increases roughly at the same rate as total primary energy consumption.

In the developing world industrial energy demand as a percentage of total primary energy use is expected to increase over the coming three decades. For Africa this percentage is projected to rise from 17% in 1990 to 19% in 2020 (see table A.23). For Asia the corresponding figures are 33% and 35%, as against 21% and 24% for Latin America. Conversely, for the country grouping of economies in transition and the OECD countries the share of industrial end-use demand in total primary energy use is foreseen to decline.

6. INDUSTRIAL ENERGY DEMAND AND RELATED CO₂ EMISSIONS

Industrial energy demand

Based on projections, discussed in the preceding two sections, of total energy demand and projected shares of manufacturing industry projections have been made of industrial energy demand. Table A.24 shows resulting projections of commercial industrial energy use.

Just like the case of total energy demand, the main prospective increments in industrial energy demand are foreseen in the region of developing Asia. In this region industrial energy demand is bound to quadruple between 1990 and 2020 from 644 Mtoe to 2,196 Mtoe (RS scenario) c.q. to 1,885 Mtoe (ES scenario). In Africa and Latin America industrial energy demand is also expected to increase substantially in relative terms, although especially African industrial energy demand in absolute terms remains rather modest. Industrial energy demand in Africa is projected to go up from 59 Mtoe in 1990 to 153 Mtoe (RS) c.q. to 128 Mtoe (ES) in 2020. For Latin America the corresponding figures are 122 Mtoe in 1990 and 319 Mtoe (RS) c.q. 266 Mtoe (ES) in 2020. A graphical representation of projections under the RS scenario is given in figure 6.1.

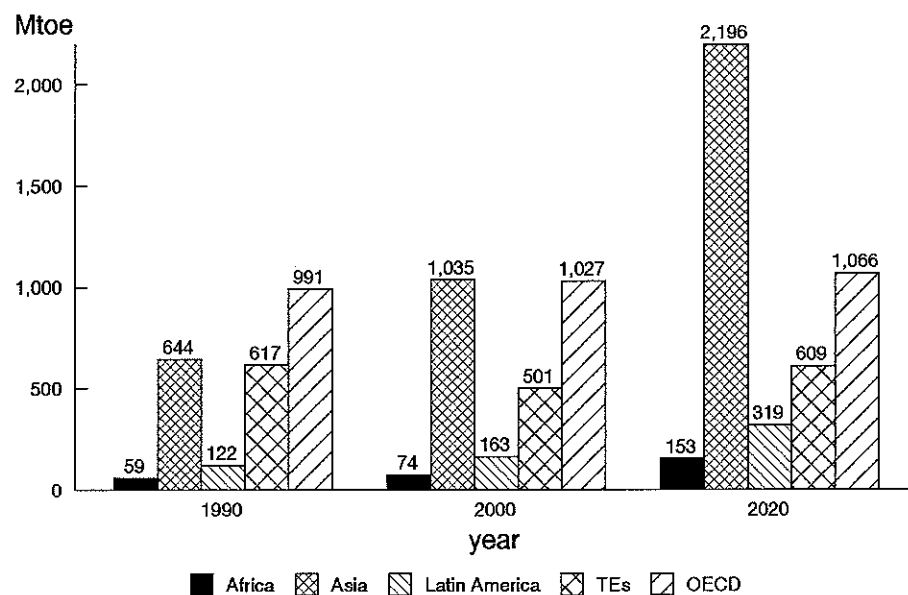


Figure 6.1 *Total industrial energy requirements by region; RS scenario*

Conversely, in the OECD countries and in the group of countries with economies in transition industrial energy demand is projected to more or less stabilize. These trends would point at a fast rising share of the developing world in global industrial energy demand. In 1990 the share of the developing countries was 34%. According to our projections shown in table A.24 this share is to top the 61% mark by 2020 in both the RS and ES scenario.

CO₂ emissions

CO₂ emissions resulting from industrial energy demand hinge primarily on the quantity demanded and the fuel mix. As for the fuel mix used in manufacturing industry in developing countries, data is lacking. In order to calculate CO₂ emissions from industrial commercial energy consumption, the energy mix used directly and indirectly in manufacturing industry is assumed to follow suit the mix for total primary energy consumption.

Traditional energy sources tend to play a modest role in developing country industry relative to its role in energy use of the developing country residential sector. Furthermore, data on industrial use of traditional sources of energy is extremely hard to come by. These two reasons have made us to disregard the use of traditional energy in industry. The result is that the share of CO₂ emissions from industrial energy consumption in total energy-related CO₂ emissions follows the same trend as the share of industrial energy demand in total energy demand, be it that the former share is slightly higher than the latter.

CO₂ emissions as a result of the use of commercial energy in the manufacturing sector of developing countries is expected to rise steeply. Projections of CO₂ emissions resulting from industrial use of commercial energy are shown in table A.25, while figure 6.1 provides a graphical representation of RS scenario projections. Was the emission level as a result of use of commercial energy by developing country industry in 1990 0.68 GtC¹⁰, by 2020 these emissions are projected a level of 1.45 GtC (ES scenario) to 2.02 GtC (RS scenario). This would make for a developing country contribution to global emissions of CO₂ as a result of industrial use of commercial energy rising from 36% in 1990 to more than 64% by the year 2020. Moreover, the contribution of industrial use of commercial energy in the developing world to total global energy-related CO₂ emissions is projected to rise from 11.6% in base year 1990 to 20.9% (RS scenario) in year 2020. If these figures become reality in broad order of magnitude, these would make a strong case in favour of the statement that developing country industry has a quite significant role to play in curbing global greenhouse gas emission levels.

¹⁰ Giga (10⁹) tonnes of elemental C.

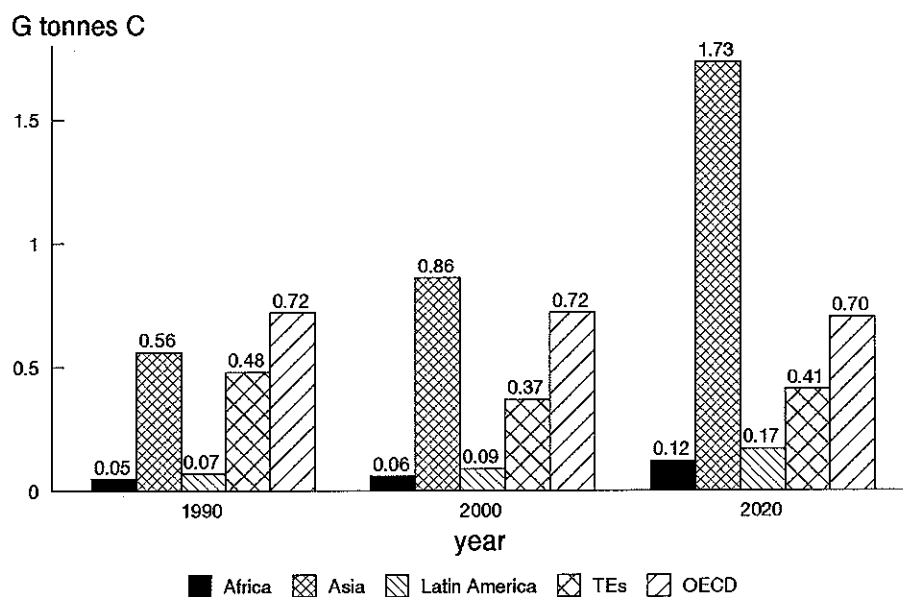


Figure 6.2 World CO₂ emissions from industrial fossil fuel use

Asia, in particular China and India, will assume an increasingly dominant role in developing country emissions of CO₂ as a result of the use of commercial energy in manufacturing. In the RS scenario, by 2020 Asia is projected to contribute no less than 86% of these emissions, of which the two coal-using juggernauts China and India 47% and 12% respectively. The corresponding percentage points for Africa and Latin America are rather modest by comparison, i.e. 6% and 8%.

7. COMPARISON WITH OTHER STUDIES

In this section projection of the present study's RS scenario will be compared with selected corresponding results of two - recent and more prominent - other scenario studies. The 'reference scenarios' of the studies concerned were selected for comparison. In these scenarios 'medium growth trajectories' for population and the level of economic activities are assumed, along with the assumption that no major departures in nature and magnitude from prevailing economic and energy policy interventions by the public sector will occur over the projection period. The studies reviewed for comparison purposes are:

- World Energy Council: [20]¹¹, referred to as 'WEC' in the remainder of this section;
- Commission of the European Communities: [4]¹², henceforth called 'CEC'¹³.

In this section in particular projections will be compared of primary energy requirements for year 2020 by our RS scenario, by WEC and by CEC respectively.

The distinct scenario exercises are not completely similar in several respects. First, some differences exist in time scales and benchmark projection years. The WEC study comes up with medium long term projections up to 2020, just like the present study, but without an interim projection benchmark year. The CEC study scans a relatively nearby prospective period with projection years 1995, 2000 and 2005. All studies have the same projection base, i.e. year 1990. In order to arrive at CEC projections for the year 2020, CEC energy demand projections for 2005 have been extrapolated to the year 2020, using trends of the last projection subperiod of the CEC study, i.e. 2000-2005.

Regional subdivisions do also vary to some extent. The CEC subdivision can be realigned to ours with relative ease. The WEC regional subdivision, however, poses some more problems. For example, the WEC's 'Pacific' region is composed of countries with widely diverging economic structures with countries such as Australia, China, Indonesia, Japan, Pacific Island states and territories and Vietnam. To enable comparisons, in the latter case figures on WEC's region Pacific had to be apportioned to two country groupings adopted in this study, i.e. (developing) Asia and OECD Pacific.

Another major distinctive feature is that energy demand in RS and WEC includes demand for 'traditional' energy, while CEC accounts for 'commercial' energy only. Traditional energy refers mainly to woodfuels and crop residues used for cooking in the household sector and for heat applications in small-scale enterprises in the informal sector.

¹¹ Reference Case B.

¹² Reference Scenario.

¹³ Scenario IS92a of [10] has also been considered for comparative analysis. However, for lack of detailed projection data presented in this study on energy scenarios used we have refrained from doing so.

By contrast, population growth projections, for all three scenarios considered here, are closely in line with each other. All four studies use broadly the same sources for population projections, i.e. recent UN projections and World Bank projections published in [3].

The assumptions on economic growth are broadly similar, if with some notable exceptions. WEC's economic growth assumptions for Africa boil down to an average annual rate over the period 1990-2020 of about 4.5% per annum against 3.5% for RS and CEC. Conversely, WEC projects a growth for Asia approximately 4.5% per annum against about 5.7% per annum for RS and CEC. RS envisages for OECD subregions North America and Europe about 2.0% real economic growth per annum, against 2.4% in the WEC and CEC scenarios respectively. Global economic growth works out at some 2.7% per annum for RS, against about 3.3% for WEC and 2.8% for CEC. It goes without saying that population and, even more so, economic growth projections over a 30 year period have a highly speculative element, whatever scenario is adopted.

RS assumes a rate of energy intensity improvement until 2020 of 0.7% per year world-wide¹⁴. This apparently modest rate relates to our expectations of an increasingly prominent role of the - less energy-efficient - developing world in world energy markets. It is in line with recent global energy efficiency performance. The CEC scenario assumes 0.8% improvement in energy efficiency per year world-wide until 2005. WEC's assumptions on energy efficiency improvement work out appreciably higher at global level, i.e. at 1.9% improvement per annum. This would appear to us to be on the optimistic side. Realisation of the WEC assumption would require:

- a greatly accelerated 'spontaneous', market-led diffusion of energy-efficient energy technology in the developing world along with steeply rising relative prices of energy resources for end-users; and/or
- developing-country energy markets to remain of a relatively modest size as compared to energy markets in the OECD region.

Especially, WEC's assumptions on energy efficiency improvement in developing regions would imply astounding breaks with historical trends. WEC's Reference Case projections indicate 1.7% per annum improvement of energy efficiency for the developing world at large against approximately 1.1% and 1.2% per annum in the RS and CEC scenarios. Also WEC's baseline assumption for the OECD, 1.9% improvement per year, is more optimistic than CEC's and our RS's with 1.2% and 1.4% improvement respectively.

Baseline projections of primary energy requirements for year 2020 are shown in table 7.1. Projections of global energy requirements in year 2020 vary from 13.4 Gtoe (WEC) to 15.8 Gtoe (CEC). Inclusion of traditional energy would have increased the CEC projection by at least 1 Gtoe.

¹⁴ Energy efficiency as indicated by the average quantity of energy needed to generate one US dollar equivalent of constant purchasing power.

Table 7.1 *Projections of world primary energy requirements: 1990-2020*

	Energy requirements [Mtoe]						Compound annual growth [%]		
	1990			2020			1990-2020		
	RS	WEC	CEC	RS	WEC	CEC ¹	RS	WEC	CEC ¹
Developing countries	2,908	2,876	2,459	8,483	6,687	7,138	3.6	2.9	3.6
Africa	349	361	345	808	940	754	2.8	3.2	2.6
Asia	1,977	1,938	1,643	6,344	4,350	5,158	4.0	2.7	3.9
Latin America	582	577	472	1,331	1,397	1,226	2.8	3.0	3.2
Transition economies	1,667	1,739	1,724	1,902	1,848	2,989	0.4	0.2	1.9
OECD	4,152	4,192	4,112	4,988	4,829	5,681	0.6	0.5	1.1
World	8,727	8,807	8,295	15,373	13,364	15,808	1.9	1.4	2.2

¹ CEC projections for 2005 have been extrapolated by the authors of the present paper.

Our RS projection for the world at large, 15.4 Gtoe of energy requirements in 2020, falls within the range of the other two 'reference case' projections. However, our RS projection for the developing countries is comparatively high, whereas our RS projection for the OECD is relatively low. As compared to WEC and CEC, this relates to our, by and large, higher economic growth assumptions for the developing world, especially Asia, and our lower economic growth expectations for the OECD area. The comparatively lesser improvement of energy efficiency projected in our RS scenario for the developing world is an additional undercurrent making for comparatively higher levels of energy demand in the developing world in the latter scenario.

Given the diverging assumptions on the baseline prospects for improvement of energy efficiency it does not come as a surprise that, for energy-related CO₂ emissions, WEC's Reference Case is more optimistic than baseline projections of the other two studies. WEC projects global CO₂ emissions from energy consumption by the year 2020 equal to 8.4 G tonnes of carbon, as against 9.7 GtC (RS) and 10.1 GtC (CEC). Table 7.2 provides some details.

Table 7.2 *Projections of global energy-related CO₂ emissions: 1990-2020*

	CO ₂ emissions [GtC]						Compound annual growth [%]		
	1990			2020			1990-2020		
	RS	WEC	CEC	RS	WEC	CEC ¹	RS	WEC	CEC ¹
Developing countries	1.65	1.66	1.61	5.18	4.09	4.66	3.9	3.1	3.6
Africa	0.16	0.16	0.19	0.42	0.47	0.46	3.3	3.7	3.1
Asia	1.23	1.24	1.20	4.14	2.94	3.50	4.1	2.9	3.6
Latin America	0.26	0.26	0.23	0.62	0.68	0.69	2.9	3.3	3.8
Transition economies	1.26	1.33	1.21	1.27	1.26	2.00	0.0	-0.2	1.7
OECD	2.97	2.97	2.70	3.22	3.02	3.45	0.3	0.1	0.8
World	5.88	5.96	5.51	9.67	8.37	10.11	1.7	1.1	2.0

¹ CEC projections for 2005 have been extrapolated by the authors of the present paper.

As far as energy use is concerned, none of the three scenarios reviewed in this section project a stabilization of global CO₂ emissions over the coming three decades. The comparatively most optimistic WEC scenario indicates a rise by 1.1% annually, against 1.7% for RS and 2.0% for CEC. The most conspicuous discrepancies concern the projected emissions for Asia.

8. CONCLUSIONS

Some major conclusions of this present project working paper are presented below.

- Over the next three decades (1990-2020), world population is forecast to grow from 5.28 to 7.84 billion. At present no less than 76% of the world population resides in developing countries. This share bound to increase to approximately 82% in 2020. A major increase in the share of Africa in world population is foreseen, i.e. from 12% in 1990 to 17% in 2020.
- In 1990, the contribution of developing countries to world GDP stood at least at, a still modest, 15%. This share is projected to increase to at least 27% by the year 2020. Asia's GDP contributes most of the developing country share and is forecast to grow - even on a per capita basis - considerably faster than world GDP. Aggregated GDP in the other developing areas is envisaged to grow - albeit not so precipitously as in Asia - markedly faster than in the world at large.
- The conclusions under the preceding two points imply *a fast growing contribution of the developing world to global primary energy requirements*. The share of present-day developing countries in world energy demand will rise dramatically while the corresponding shares of OECD countries and economies in transition are bound to drop substantially. If the reference scenario holds energy consumption in the developing world together as a percentage of world primary energy consumption will increase from 33% in 1990 to 55% in 2020.
- Asia is projected to contribute the main part of energy demand in the developing world. Especially China and, if to a lesser extent, India will importantly gaining significance in world energy markets. China and India are projected to contribute 20% and 5% respectively to world primary energy demand as against 10% and 3% in 1990.
- *The impact of developing countries on energy-related CO₂ emissions is poised to be even more pronounced*. In part, this stems from the prominent role of coal in energy supply systems of some large developing countries, particularly those of China and India. Table 8.1 brings out the increasingly dominant role of the developing world on several scores.
- *As far as energy-related CO₂ emissions are concerned, the global stabilisation objective of the Framework Convention on Climate Change will be extremely hard to attain*. Even in this paper's ecologically driven scenario world CO₂ emissions in 2020 are projected to be 20% higher than corresponding 1990 levels. Compared to 1990 levels, by 2020 energy-related CO₂ emissions in the developing countries are poised to surge - even under the ecologically driven scenario - by a whopping 151%.

Table 8.1 *Projected regional contributions to global increments in selected variables over the period 1990-2020 (RS scenario)*

Variable	Global increment over 1990-2020 [%]	Regional contributions to global increment [%]				
		OECD	TEs	Africa	Asia	Latin America
Population	48	4	2	29	55	10
GDP	116	57	5	2	27	9
Energy demand	76	13	3	7	66	11
CO ₂ emissions	64	7	0	7	77	9

- In our reference scenario, by the year 2020 the manufacturing sector is envisaged to contribute 2.0 GtC (billion tonnes of elemental C) of the developing world's projected 5.2 GtC equivalent of CO₂ emissions. Hence, *manufacturing remains an important target sector for CO₂ reduction policies in the developing world.*
- *In the developing world, particularly in Asia, there is a huge potential to curb world CO₂ emission levels. This potential can only be realised by way of a low-polluting and low energy-intensity trajectory of economic development.*
- *The bottom line is that developing countries will have to play an increasingly important role in making our world more sustainable. Issues of technology transfer from OECD member states and indigenisation of state-of-the-art energy technology constitute a factor of primordial importance to enable developing countries to assume this role.*

REFERENCES

- [1] J.H.A. van den Akker: *Climate change in North-South perspective: greenhouse gas emissions, climate change impacts and response options*. ECN-I--91-059, Petten, September 1991.
- [2] Asian Energy Institute: *Global Warming: Mitigation Strategies and Perspectives from Asia and Brazil*. Tata McGraw-Hill Publishing Institute, New Delhi, 1991.
- [3] Bos E., M.T. Vu, A. Levin, R.A. Bulatoa: *World Population Projections 1992-93 Edition: Estimates and Projections with Related Demographic Statistics*. Published for the World Bank, The John Hopkins University Press, Baltimore/London, 1992.
- [4] CEC: *Energy in Europe (special issue): a view to the future*. Commission of the European Communities, September 1992.
- [5] H. Chenery, L. Taylor, 'Development Patterns: Among Countries and over time', *The review of Economics and Statistics*, Vol. 50, No. 4, pp. 391-416, 1968.
- [6] H. Chenery, M. Syrquin: *Patterns of development, 1950-1970*. World Bank, Oxford University Press, Oxford, 1975.
- [7] CPB: *Scanning the Future: a long-term scenario study of world economy 1990-2015*. Sdu Publishers, The Hague, 1992.
- [8] J. Goldemberg, T.B. Johansson, A.K.N. Reddy, R.H. Williams: *Energy for a Sustainable World*. New Delhi, 1988.
- [9] IAEA: *Electricity and the Environment: Background papers to a Senior Expert Symposium held in Helsinki, 13-17 May 1991*. IAEA-TECDOC-624, Vienna, September 1991.
- [10] IPCC: *Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment*. Cambridge University Press, 1992.
- [11] A.T. Keesman, W.K. Foell, P.R. Hills, T. Nagao, T.A. Siddiqi, S.J. Török, 'Energy Scenarios and CO₂ Emissions in Developing Countries of Asia and the Pacific', *Milieu*, Vol. 6, No. 6, November 1991.
- [12] T. Kram: *National Energy Options for Reducing CO₂ Emissions, Volume 1: The International Connection*. ETSAP, Annex IV (1990-1993), IEA, ECN-C--93-046, Petten, September 1993.
- [13] OECD: *World Energy Statistics and Balances, 1971-1987*. Paris, 1989.
- [14] OECD: *Energy Balances of OECD Countries, 1980-1989*. Paris, 1991.
- [15] OECD: *Energy Balances of OECD Countries, 1989-1990*. Paris, 1992 (a).

- [16] OECD: *Energy Statistics and Balances of non-OECD Countries, 1989-1990*. Paris, 1992 (b).
- [17] Sathaye Jayant, Andrea Ketoff, 'CO₂ Emissions from Major Developing Countries: Better Understanding the Role of Energy in the Long Term', *The Energy Journal*, Vol. 12, No. 1, pp.161-196, January 1991.
- [18] Tata Energy Research Institute and Tsinghua University: *Energy Developments in China and India*. New Delhi/Beijing, 1990
- [19] United Nations: *Energy Statistics Yearbook 1990*. New York 1992.
- [20] WEC: *Energy for Tomorrow's World*. World Energy Council, Kogan Page Ltd, London, 1993.
- [21] World Bank: *World Development Report 1992: Development and the environment*. Oxford University Press, New York, May 1992 (a).
- [22] World Bank: *World Tables 1992*. The John Hopkins University Press, London, July 1992 (b).

ANNEX A. ACCOMPANYING TABLES

Table A.1 *Actual and projected annual population growth rates, by region, 1980-2020 [% per annum]*

	1980-1990	1990-2000	2000-2020
Developing countries	2.1	1.9	1.4
Africa	3.1	2.9	2.5
Asia	1.9	1.7	1.1
China	(1.4)	(1.3)	(0.8)
India	(2.1)	(1.7)	(1.2)
Other Asia	(2.3)	(2.1)	(1.3)
Latin America	2.1	1.7	1.6
Transition economies	0.5	0.5	0.4
OECD	0.7	0.5	0.3
North America	0.9	0.8	0.5
Europe	0.5	0.4	0.2
Pacific	0.7	0.5	0.2
World	1.7	1.6	1.2

Source: [3]

Table A.2 *Actual and projected population by region, 1980-2020 [billions]*

	1980	1990	2000	2020
Developing countries	3.25	4.00	4.83	6.40
Africa	0.46	0.62	0.83	1.35
Asia	2.44	2.95	3.49	4.35
China	(0.98)	(1.13)	(1.29)	(1.51)
India	(0.69)	(0.85)	(1.01)	(1.28)
Other Asia	(0.77)	(0.97)	(1.20)	(1.56)
Latin America	0.35	0.43	0.51	0.70
Transition economies	0.39	0.41	0.43	0.47
OECD	0.81	0.87	0.92	0.98
North America	0.26	0.28	0.30	0.34
Europe	0.43	0.45	0.47	0.49
Pacific	0.13	0.14	0.15	0.15
World	4.45	5.28	6.18	7.84

Source: See table A.1.

Table A.3 *Actual and projected shares of world population by region, 1980-2020 [%]*

	1980	1990	2000	2020
Developing countries	73	76	78	82
Africa	10	12	13	17
Asia	55	56	57	55
China	(22)	(21)	(21)	(19)
India	(16)	(16)	(16)	(16)
Other Asia	(17)	(18)	(19)	(20)
Latin America	8	8	8	9
Transition economies	9	8	7	6
OECD	18	16	15	12
North America	6	5	5	4
Europe	10	8	8	6
Pacific	3	3	2	2
World	100	100	100	100
World [billions]	4.45	5.28	6.18	7.84

Source: See table A.1.

 Table A.4 *Actual and projected growth rates of GDP by region, 1980-2020 [% per annum]*

	1980-1990	1990-2000	2000-2020
Developing countries	3.7	4.9	4.6
Africa	1.8	3.0	4.0
Asia	5.6	6.0	5.0
China	(9.5)	(7.0)	(6.0)
India	(5.3)	(5.5)	(4.5)
Other Asia	(4.6)	(5.8)	(4.7)
Latin America	1.6	3.5	4.0
Transition economies	2.1	0.5	3.5
OECD	3.1	2.2	2.0
North America	3.4	2.2	1.8
Europe	2.5	2.0	2.0
Pacific	4.0	2.5	2.2
World	3.0	2.4	2.7

Source: [21]¹⁵

¹⁵ Projections by authors.

Table A.5 *Actual and projected GDP by region, 1980-2020*
[trillion US\$ 1990]

	1980	1990	2000	2020
Developing countries	2.10	3.01	4.87	12.08
Africa	0.24	0.29	0.39	0.85
Asia	0.99	1.70	3.04	8.08
China	(0.15)	(0.36)	(0.72)	(2.30)
India	(0.15)	(0.25)	(0.43)	(1.05)
Other Asia	(0.69)	(1.08)	(1.89)	(4.73)
Latin America	0.87	1.02	1.44	3.15
Transition economies	0.93	1.15	1.21	2.41
OECD	11.93	16.21	20.10	29.70
North America	4.27	5.96	7.41	10.59
Europe	5.44	6.97	8.50	12.63
Pacific	2.22	3.28	4.20	6.49
World	14.96	20.37	26.19	44.19

Source: See table A.4.

Table A.6 *Actual and projected shares of world GDP by region, 1980-2020*
[%]

	1980	1990	2000	2020
Developing countries	14.0	14.8	18.6	27.3
Africa	1.6	1.4	1.5	1.9
Asia	6.6	8.3	11.6	18.3
China	(1.0)	(1.8)	(2.7)	(5.2)
India	(1.0)	(1.2)	(1.7)	(2.4)
Other Asia	(4.6)	(5.3)	(7.2)	(10.7)
Latin America	5.8	5.0	5.5	7.1
Transition economies	6.2	5.6	4.6	5.4
OECD	79.7	79.6	76.8	67.2
North America	28.5	29.3	28.3	24.0
Europe	36.4	34.2	32.4	28.6
Pacific	14.8	16.1	16.0	14.7
World	100	100	100	100
World [trillion US\$ 1990]	14.96	20.37	26.19	44.19

Source: See table A.4.

Table A.7 *Actual and projected GDP per capita growth rates by region, 1980-2020 [% per annum per capita]*

	1980-1990	1990-2000	2000-2020
Developing countries	1.5	3.0	3.2
Africa	-1.3	0.1	1.5
Asia	3.6	4.2	3.9
China	(8.0)	(5.6)	(5.2)
India	(3.1)	(3.7)	(3.3)
Other Asia	(2.2)	(3.5)	(3.3)
Latin America	-0.5	1.8	2.4
Transition economies	1.6	0.0	3.1
OECD	2.4	1.6	1.7
North America	2.5	1.4	1.3
Europe	2.0	1.6	1.8
Pacific	3.3	2.0	2.0
World	1.4	0.9	1.4

Source: See table A.4.

Table A.8 *Actual and projected levels of regional GDP per capita 1980-2020 [thousands 1990 US\$ per capita]*

	1980	1990	2000	2020
Developing countries	0.65	0.75	1.01	1.89
Africa	0.53	0.47	0.47	0.63
Asia	0.40	0.58	0.87	1.86
China	(0.15)	(0.32)	(0.56)	(1.53)
India	(0.22)	(0.30)	(0.43)	(0.82)
Other Asia	(0.89)	(1.11)	(1.58)	(3.03)
Latin America	2.49	2.37	2.83	4.51
Transition economies	2.40	2.80	2.80	5.15
OECD	14.64	18.63	21.88	30.44
North America	16.66	21.29	24.43	31.60
Europe	12.72	15.49	18.14	25.90
Pacific	16.97	23.43	28.53	42.36
World	3.36	3.86	4.24	5.64

Source: See table A.4.

Table A.9 *Actual and projected GDP per capita by region related to world GDP per capita, 1980-2020 [% of world average]*

	1980	1990	2000	2020
Developing countries	19	20	24	34
Africa	16	12	11	11
Asia	12	15	21	33
China	(5)	(8)	(13)	(27)
India	(7)	(8)	(10)	(15)
Other Asia	(27)	(29)	(37)	(54)
Latin America	74	62	67	80
Transition economies	71	73	66	91
OECD	436	483	516	540
North America	496	552	576	561
Europe	388	402	428	460
Pacific	505	607	673	752
World	100	100	100	100
World [thousand US\$ 1990]	3.36	3.86	4.24	5.64

Source: See table A.4.

Table A.10 *Actual and projected energy intensity improvement by region, 1980-2020 [% per annum]*

	1980-1990	1990-2020 RS	1990-2020 ES
Developing countries	-0.64	1.1	1.6
Africa	-1.24	0.8	1.4
Asia	0.56	1.3	1.8
China	(4.84)	(2.0)	(2.5)
India	(-0.42)	(1.0)	(1.5)
Other Asia	(-1.01)	(1.2)	(1.7)
Latin America	-1.43	1.0	1.6
Transition economies	0.48	2.0	2.6
OECD	1.95	1.4	1.9
North America	2.44	1.5	2.0
Europe	1.47	1.2	1.7
Pacific	1.53	1.3	1.7
World	0.94	0.7	1.2

Source: [20,21]¹⁶¹⁶ Projections by authors.

Table A.11 *Actual and projected levels of energy intensity by region, 1980-2020 [toe/million US\$ 1990]*

	1980	1990	2000 RS	2020 RS	2000 ES	2020 ES
Developing countries	906	966	879	702	833	598
Africa	1063	1203	1111	946	1045	788
Asia	1230	1163	1020	785	970	674
China	(3966)	(2414)	(1973)	(1874)	(1317)	(1130)
India	(1047)	(1092)	(988)	(939)	(808)	(694)
Other Asia	(684)	(757)	(666)	(521)	(521)	(448)
Latin America	495	571	516	319	486	352
Transition economies	1521	1450	1184	791	1114	658
OECD	312	256	223	168	212	145
North America	467	364	313	232	298	199
Europe	240	207	183	144	174	124
Pacific	191	164	144	111	138	98
World	471	428	389	348	369	297

Source: See table A.10.

Table A.12 *Actual and projected primary energy consumption growth rates by region, 1980-2020 [% per annum]*

	1980-1990	1990-2000 RS	2000-2020 RS	1990-2000 ES	2000-2020 ES
Developing countries	4.3	3.9	3.5	3.4	2.9
Africa	3.1	2.2	3.2	1.6	2.5
Asia	5.0	4.6	3.6	4.1	3.1
China	(4.2)	(4.9)	(3.9)	(4.3)	(3.4)
India	(5.7)	(4.4)	(3.5)	(3.9)	(2.9)
Other Asia	(5.7)	(4.4)	(3.4)	(3.9)	(2.9)
Latin America	3.0	2.5	3.0	1.8	2.3
Transition economies	1.6	-1.5	1.4	-2.1	0.8
OECD	1.1	0.8	0.5	0.3	0.0
North America	0.9	0.7	0.3	0.2	-0.2
Europe	1.0	0.8	0.8	0.3	0.3
Pacific	2.4	1.2	0.9	0.8	0.5
World	2.2	1.6	2.1	1.0	1.5

Source: See table A.10.

Table A.13 *Actual and projected levels of primary energy consumption, 1980-2020 [Mtoe]*

	1980	1990	2000 RS	2020 RS	2000 ES	2020 ES
Developing countries	1902	2908	4282	8482	4058	7230
Africa	258	349	433	808	407	673
Asia	1213	1977	3106	6344	2952	5447
China	(584)	(881)	(1416)	(3032)	(1345)	(2601)
India	(159)	(278)	(429)	(847)	(408)	(728)
Other Asia	(470)	(818)	(1261)	(2465)	(1199)	(2119)
Latin America	431	582	742	1331	699	1109
Transition economies	1421	1667	1432	1902	1346	1582
OECD	3721	4152	4483	4988	4267	4302
North America	1991	2172	2321	2451	2206	2104
Europe	1306	1442	1558	1818	1481	1562
Pacific	424	538	604	719	580	636
World	7044	8727	10197	15373	9672	13114

Source: See table A.10.

Table A.14 *Actual and projected shares of primary energy consumption, 1980-2020 [%]*

	1980	1990	2000 RS	2020 RS	2000 ES	2020 ES
Developing countries	27	33	42	55	42	55
Africa	4	4	4	5	4	5
Asia	17	23	31	41	31	41
China	(8)	(10)	(14)	(20)	(14)	(20)
India	(2)	(3)	(4)	(5)	(4)	(5)
Other Asia	(7)	(9)	(12)	(16)	(12)	(16)
Latin America	6	7	7	9	7	9
Transition economies	20	19	14	12	14	12
OECD	53	48	44	33	44	33
North America	28	25	23	16	23	16
Europe	19	17	15	12	15	12
Pacific	6	6	6	5	6	5
World	100	100	100	100	100	100
World [Mtoe]	7044	8727	10197	15373	9672	13114

Source: See table A.10.

Table A.15 *Actual and projected levels of per capita energy consumption by region, 1980-2020 [toe per capita]*

	1980	1990	2000 RS	2020 RS	2000 ES	2020 ES
Developing countries	0.59	0.73	0.89	1.33	0.84	1.13
Africa	0.56	0.56	0.52	0.60	0.49	0.50
Asia	0.50	0.67	0.89	1.46	0.85	1.25
China	(0.59)	(0.78)	(1.10)	(2.01)	(1.05)	(1.72)
India	(0.23)	(0.33)	(0.43)	(0.66)	(0.41)	(0.57)
Other Asia	(0.61)	(0.84)	(1.05)	(1.58)	(1.00)	(1.36)
Latin America	1.23	1.35	1.46	1.90	1.37	1.59
Transition economies	3.64	4.07	3.32	4.07	3.12	3.39
OECD	4.57	4.77	4.88	5.11	4.64	4.41
North America	7.78	7.76	7.66	7.32	7.28	6.28
Europe	3.05	3.20	3.73	3.73	3.16	3.20
Pacific	3.25	3.84	4.11	4.69	3.94	4.15
World	1.58	1.65	1.65	1.96	1.57	1.67

Source: See table A.10.

Table A.16 *Actual and projected energy consumption per capita by region related to world energy consumption per capita, 1980-2020 [% of world average]*

	1980	1990	2000 RS	2020 RS	2000 ES	2020 ES
Developing countries	37	44	54	68	54	68
Africa	36	34	32	31	32	30
Asia	31	40	54	74	54	75
China	(38)	(47)	(67)	(103)	(67)	(103)
India	(15)	(20)	(26)	(34)	(26)	(34)
Other Asia	(39)	(51)	(64)	(81)	(64)	(81)
Latin America	78	82	88	97	88	95
Transition economies	230	246	201	208	200	203
OECD	289	289	296	261	297	264
North America	492	469	464	373	465	376
Europe	193	194	202	190	202	192
Pacific	205	233	249	239	252	248
World	100	100	100	100	100	100
World [toe/capita]	1.58	1.65	1.65	1.96	1.57	1.67

Source: See table A.10.

Table A.17a *Actual and projected world fuel mix, 1990-2020*

	1990		2000	2020	2000	2020
	Mtoe	%	RS %	RS %	ES %	ES %
Solids	2288	26.2	25	25	24	20
Oil	2758	31.6	30	28	28	23
Gas	1689	19.4	20	20	20	21
Nuclear	432	5.0	5	6	6	6
Hydro	484	5.5	6	7	6	8
Traditional	930	10.7	11	10	10	9
New renewable	146	1.7	3	4	6	13

 Source: [21]¹⁷

 Table A.17b *Actual and projected fuel mix for Africa, 1990-2020*

	1990		2000	2020	2000	2020
	Mtoe	%	RS %	RS %	ES %	ES %
Solids	71	20.3	18	14	17	14
Oil	70	20.1	26	32	28	30
Gas	35	10.0	12	15	14	16
Nuclear	1	0.3	1	1	1	1
Hydro	11	3.2	4	4	4	4
Traditional	154	44.1	36	31	31	24
New renewable	7	2.0	3	3	5	11

Source: See table A.17a.

 Table A.17c *Actual and projected fuel mix for Asia, 1990-2020*

	1990		2000	2020	2000	2020
	Mtoe	%	RS %	RS %	ES %	ES %
Solids	763	38.6	37	36	37	32
Oil	393	19.9	21	23	18	17
Gas	138	7.0	10	12	9	14
Nuclear	9	0.5	2	3	2	3
Hydro	86	4.4	5	6	5	7
Traditional	555	28.1	23	17	23	15
New renewable	33	1.7	2	3	6	13

Source: See table A.17a.

¹⁷ Projections by authors.

Table A.17d *Actual and projected fuel mix for Latin America, 1990-2020*

	1990		2000	2020	2000	2020
	Mtoe	%	RS %	RS %	ES %	ES %
Solids	23	4.0	4	4	3	1
Oil	214	36.8	36	34	33	25
Gas	82	14.1	18	20	14	13
Nuclear	2	0.3	1	2	1	2
Hydro	87	14.9	18	21	18	21
Traditional	125	21.5	15	12	15	11
New renewable	49	8.4	8	7	16	27

Source: See table A.17a.

Table A.17e *Actual and projected fuel mix for China, 1990-2020*

	1990		2000	2020	2000	2020
	Mtoe	%	RS %	RS %	ES %	ES %
Solids	531	60.3	58	56	56	50
Oil	90	10.2	11	13	9	8
Gas	14	1.6	4	7	4	9
Nuclear	0	0.0	0	0	0	0
Hydro	25	2.8	4	5	4	6
Traditional	221	25.1	22	17	21	14
New renewable	0	0.0	1	2	6	13

Source: [19,20]¹⁸Table A.17f *Actual and projected fuel mix for India 1990-2020*

	1990		2000	2020	2000	2020
	Mtoe	%	RS %	RS %	ES %	ES %
Solids	124	44.6	43	41	42	38
Oil	46	16.5	18	19	15	14
Gas	9	3.2	5	7	6	11
Nuclear	1	0.4	1	2	1	2
Hydro	15	5.4	6	7	6	7
Traditional	80	28.8	26	21	24	15
New renewable	3	1.1	1	3	6	13

Source: See table A.17e.

¹⁸ Projections by authors.

Table A.18 *Actual and projected CO₂ emission growth rates by region, 1990-2020 [% per annum]*

	1990-2000	2000-2020	1990-2000	2000-2020
	RS	RS	ES	ES
Developing countries	4.3	3.7	3.2	2.7
Africa	3.1	3.5	2.8	2.5
Asia	4.8	3.8	3.7	2.9
China	(4.8)	(4.0)	(3.8)	(3.1)
India	(4.6)	(3.5)	(3.5)	(2.8)
Other Asia	(4.8)	(3.7)	(3.7)	(2.7)
Latin America	2.9	2.9	0.8	1.0
Transition economies	-1.9	1.0	-2.7	0.1
OECD	0.4	0.2	-0.7	-1.0
North America	0.4	-0.1	-0.9	-1.4
Europe	0.3	0.5	-0.7	-0.7
Pacific	0.9	0.7	-0.0	-0.3
World	1.2	1.9	0.2	0.8

Source: See table A.10.

Table A.19 *Actual and projected levels of energy-related CO₂ emissions by region, 1990-2020 [G tonnes elemental C]¹*

	1990	2000	2020	2000	2020
		RS	RS	ES	ES
Developing countries	1.65	2.52	5.18	2.26	3.81
Africa	0.16	0.21	0.42	0.21	0.34
Asia	1.23	1.95	4.14	1.76	3.12
China	(0.64)	(1.03)	(2.25)	(0.92)	(1.69)
India	(0.17)	(0.27)	(0.54)	(0.25)	(0.43)
Other Asia	(0.41)	(0.65)	(1.35)	(0.59)	(1.01)
Latin America	0.26	0.35	0.62	0.29	0.35
Transition economies	1.26	1.04	1.27	0.96	0.99
OECD	2.97	3.09	3.22	2.76	2.25
North America	1.56	1.62	1.59	1.43	1.07
Europe	1.00	1.02	1.12	0.93	0.80
Pacific	0.41	0.45	0.51	0.41	0.38
World	5.88	6.65	9.67	5.98	7.06

¹ CO₂ emissions coefficients used are: 1.04 tonne carbon per toe solid; 0.87 tonne carbon per toe oil; 0.65 tonne carbon per toe gas.

Source: See table A.10.

Table A.20 *Actual and projected shares of world energy-related CO₂ emissions by region, 1990-2020 [%]*

	1990	2000 RS	2020 RS	2000 ES	2020 ES
Developing countries	28	38	54	38	54
Africa	3	3	4	3	5
Asia	21	29	43	30	44
China	(11)	(15)	(23)	(15)	(24)
India	(3)	(4)	(6)	(4)	(6)
Other Asia	(7)	(10)	(13)	(10)	(14)
Latin America	4	5	6	5	5
Transition economies	21	16	13	16	14
OECD	51	46	33	46	32
North America	27	24	17	24	15
Europe	17	15	12	15	11
Pacific	7	7	5	7	6
World	100	100	100	100	100
World [G tonnes C]	5.88	6.65	9.67	5.98	7.06

Source: See table A.10.

Table A.21 *Actual and projected levels of CO₂ emissions per capita, 1990-2020 [tonnes elemental C per capita]*

	1990	2000 RS	2020 RS	2000 ES	2020 ES
Developing countries	0.41	0.52	0.81	0.47	0.60
Africa	0.25	0.26	0.31	0.25	0.25
Asia	0.42	0.56	0.95	0.50	0.72
China	(0.57)	(0.80)	(1.49)	(0.72)	(1.12)
India	(0.21)	(0.27)	(0.42)	(0.25)	(0.34)
Other Asia	(0.42)	(0.54)	(0.86)	(0.49)	(0.65)
Latin America	0.61	0.69	0.89	0.56	0.50
Transition economies	3.08	2.41	2.72	2.24	2.12
OECD	3.41	3.36	3.30	3.01	2.31
North America	5.59	5.34	4.75	4.71	3.19
Europe	2.21	2.18	2.30	1.98	1.65
Pacific	2.92	3.03	3.32	2.77	2.49
World	1.11	1.08	1.23	0.97	0.90

Source: See table A.10.

Table A.22 *Actual and projected CO₂ emissions per capita related to world CO₂ emissions per capita, 1990-2020 [% of world average]*

	1990	2000 RS	2020 RS	2000 ES	2020 ES
Developing countries	37	49	66	48	66
Africa	23	24	25	26	28
Asia	37	52	77	52	80
China	(51)	(74)	(121)	(74)	(124)
India	(19)	(25)	(34)	(25)	(37)
Other Asia	(38)	(51)	(70)	(51)	(72)
Latin America	55	64	72	58	55
Transition economies	277	224	220	231	236
OECD	307	313	268	310	257
North America	502	497	385	486	354
Europe	199	203	186	204	183
Pacific	262	282	269	286	277
World	100	100	100	100	100
World [tonnes C/cap.]	1.11	1.08	1.23	0.97	0.90

Source: See table A.10.

Table A.23 *Actual and projected shares of commercial industrial energy use as part of total primary energy consumption, 1980-2020 [%]*

	1980	1990	2000	2020
Developing countries	28	28	30	31
Africa	19	17	17	19
Asia	33	33	33	35
China	(39)	(38)	(37)	(35)
India	(28)	(29)	(31)	(35)
Other Asia	(27)	(28)	(30)	(34)
Latin America	21	21	22	24
Transition economies	39	37	35	32
OECD	27	24	23	21
North America	25	22	21	20
Europe	28	24	23	21
Pacific	35	31	30	27
World	30	28	27	28

Source: [13,15,16]¹⁹¹⁹ Projections by authors.

Table A.24 *Actual and projected commercial industrial energy consumption, 1980-2020 [Mtoe]*

	1980	1990	2000 RS	2020 RS	2000 ES	2020 ES
Developing countries	539	826	1272	2669	1207	2279
Africa	49	59	74	153	69	128
Asia	399	644	1035	2196	984	1885
China	(228)	(335)	(524)	(1061)	(498)	(910)
India	(45)	(81)	(133)	(296)	(127)	(255)
Other Asia	(127)	(229)	(378)	(838)	(360)	(721)
Latin America	91	122	163	319	154	266
Transition economies	554	617	501	609	471	506
OECD	1012	991	1027	1066	978	921
North America	498	478	487	490	463	421
Europe	366	346	358	382	341	328
Pacific	148	167	181	194	485	172
World	2105	2433	2800	4343	2656	3706

Source: See table A.23.

Table A.25 *Actual and projected levels of energy-related CO₂ emissions from industry by region, 1990-2020 [G tonnes elemental C]*

	1990	2000 RS	2020 RS	2000 ES	2020 ES
Developing countries	0.68	1.00	2.02	0.90	1.45
Africa	0.05	0.06	0.12	0.05	0.09
Asia	0.56	0.86	1.73	0.77	1.27
China	(0.32)	(0.49)	(0.95)	(0.43)	(0.69)
India	(0.07)	(0.11)	(0.24)	(0.10)	(0.18)
Other Asia	(0.17)	(0.25)	(0.55)	(0.24)	(0.40)
Latin America	0.07	0.09	0.17	0.07	0.09
Transition economies	0.48	0.37	0.41	0.34	0.32
OECD	0.72	0.72	0.70	0.64	0.49
North America	0.35	0.35	0.32	0.31	0.22
Europe	0.24	0.24	0.24	0.22	0.17
Pacific	0.13	0.14	0.14	0.12	0.10
World	1.88	2.09	3.13	1.88	2.26

Source: See table A.23.

Table A.26 *Actual and projected shares of energy-related CO₂ emissions from industry as part of emissions from total primary energy consumption by region, 1990-2020 [%]*

	1990	2000 RS	2020 RS	2000 ES	2020 ES
Developing countries	41	40	39	40	38
Africa	30	27	28	25	25
Asia	46	44	42	42	38
China	(51)	(47)	(42)	(47)	(41)
India	(41)	(42)	(44)	(41)	(41)
Other Asia	(41)	(39)	(40)	(40)	(40)
Latin America	27	26	27	26	27
Transition economies	38	36	33	35	32
OECD	24	23	22	23	22
North America	22	21	20	21	20
Europe	24	23	21	23	21
Pacific	31	30	27	30	27
World	32	32	32	31	32

Source: See table A.23.

General notes to the accompanying tables

Countries

- North America includes Canada and U.S.
- Pacific includes: Japan, Australia and New Zealand; Europe contains all other OECD countries
- Transition Economies include all East and Central European countries and all republics from the former USSR
- Latin America contains all non-OECD countries in the Americas
- Africa contains the whole African continent
- Asia includes all non-OECD countries of Asia and Oceania.

In all tables the figures for OECD and Developing Countries are implied figures derived from the figures of the separate regions. The figures from Other Asia are derived from of the figures for Asia, China and India.

Table A.1

Figures used from the World Development Report 1992. The projections given in this report until 2025 are interpolated for 2020 using the same growth rate over the 25 years from 2000 to 2025. The figures have been checked with the World Population projections 1992-93 edition and no major differences were found.

Table A.2

Figures used for 1980 and 1990 are the ones presented in the World Development Report 1992. Projections are made with the help of the growth rates of table A.1. The Indian population is bound to top 1 billion around the year 2000.

Table A.3

Figures derived from table A.2. By the year 2010 80% of the world population is projected to live in developing countries.

Table A.4

Figures used for 1980-1990 are the ones presented in the World Development Report 1992. Extrapolations are made with help of different sources and own insights [4,7,17,20]. For the projected development of GDP in China reference is made to another article [11] (1986-2000 GNP increase of 6.5%; 200-2010 GNP increase of 4.5%).

Table A.5

Figures for 1990 correspond with the figures of the World Development Report 1992 and the other figures are calculated with the help of figures of table A.4.

Table A.6

Figures have been derived from table A.5.

Table A.7

Figures have been derived from table A.2 and table A.5.

Table A.8

Figures have been derived from table A.7.

Table A.9

Figures have been derived from table A.8.

Table A.10

The figures for the period 1980-1990 have been derived from table A.5 and table A.13. Projections have been made by the authors based on several sources [9,17,21].

Table A.11

Figures have been derived from table A.5 and table A.13.

Table A.12

Figures have been derived from table A.13.

Table A.13

Data on 1980 and 1990 energy consumption have been taken from several sources: [11,19,21]. The proportion of traditional fuels used in India as a percentage of total energy consumption is estimated at about 30% for 1980 and 1990. This is comparable to the situation in the rest of Asia.

Table A.14

Figures have been derived from table A.13.

Table A.15

Figures have been derived from table A.2 and table A.13.

Table A.16

Figures have been derived from table A.15.

Table A.17

Data about fuel mixes in 1990 have been derived from [21] for the regions and from [19] for China and India. Projections on fuel mixes have been derived from [21] for 2020 for the regions and sub-regions. For 2000 the figures of 1990 [19,21] and 2020 have been obtained by interpolation. For each of the sub-regions of Asia a trend in fuel mix shifts similar to the regional trend has been used. The final fuel mix of Asia has been calculated as a result of the fuel mix of the three sub-regions. The fuel mix is composed as follows. Solids, oil and gas refer to the three types of fossil fuels. Traditional fuel are mainly charcoal and fuel wood. Hydro refers to the already for some time existing renewable energy sources mainly hydro-electric energy. New renewables refer to solar energy and new forms of renewables including new biomass energy sources like ethanol.

Table A.18

Figures have been derived from table A.19.

Table A.19

Figures have been derived with help of the regional fuel mixes and table A.13.

Table A.20

Figures have been derived from table A.19.

Table A.21

Figures have been derived from table A.2 and table A.19.

Table A.22

Figures have been derived from table A.21.

Table A.23

Projections are based on the assumptions that the share of the industrial sector in the GDP of OECD countries will decrease and related to that the industrial energy share will decrease. In developing countries industry experiences a considerable growth. Although also the transport sector is growing fast it is expected that the share of industrial energy use will increase in these countries the next three centuries. In the Transition Economies there will be a shift from energy intensive to more energy extensive industries, which will decrease the share of industrial energy consumption.

Table A.24

Figures have been derived from table A.13 and table A.23.

Table A.25

Figures have been derived from table A.24 and emission factors (see table A.21) and the calculated fuel mix. In table A.24 commercial energy only is incorporated. Therefore, the same fuel mix is used as for total primary energy consumption, excluding traditional energy sources.

Table A.26

Figures have been derived from table A.19 and table A.25.