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Directorate-General for Energy and Transport

EUROPEAN ENERGY AND TRANSPORT TRENDS TO 2030

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**Includes a CD-ROM with
detailed results and
supporting documents**

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A great deal of additional information on the European Union is available on the Internet.

It can be accessed through the Europa server (<http://europa.eu.int>).

Any comments and questions on this publication may be sent to: tren-projections@cec.eu.int

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FOREWORD BY MRS DE PALACIO, VICE-PRESIDENT OF THE EUROPEAN COMMISSION (RELATIONS WITH THE EUROPEAN PARLIAMENT, TRANSPORT AND ENERGY)

The European Council held in Copenhagen in December 2002 concluded the accession negotiations with ten candidate countries for their membership of the EU from May 2004. With the largest ever enlargement of the Union now decided, it is important to have an up to date view on long term European energy and transport developments for an enlarged Union.

This publication on European Energy and Transport Trends to 2030 extends the analysis presented in previous editions of the Annual Energy Review. In addition to a statistical analysis of the last ten years, this publication gives detailed projections on energy and transport for the current EU and the enlarged Union of 25. It addresses also the wider European and world developments.

Following the broad debate launched with the Green Paper on the security of energy supplies, the European Union has now developed a new approach to energy policy recognising the clear link between energy supply and management of demand. The projections presented in this outlook to 2030 are built upon an integrated approach encompassing both supply and demand. The projections show how the future may develop in which policy makers will have to act in order to contribute towards sustainable development. In terms of energy policy this implies reconciling energy security with reduced environmental impacts of energy production and use while ensuring simultaneously that our economies remain competitive and growing.

The completion of the internal market is a key element for improving competitiveness. The Commission has therefore proposed to extend the market opening to all

customers in energy and transport, which should lead to significant reductions in consumer prices. The economic reform agenda launched at the Lisbon summit encompasses this market opening with due regard to public service obligations and energy security as confirmed by the Seville European Council of June 2002. The Energy Council of November 2002 has finally reached agreement on a complete market opening.

Energy and transport represent services that are essential for the functioning and growth of our economy. Energy and transport are, however, also sources for environmental concerns. In fact, policies in both areas have a key role to play for sustainable development. Moreover, energy and transport investments have long lead-times, while the infrastructure is operated over several decades. A long-term view is therefore required in particular for dealing with issues such as climate change and the nuclear option.

The projected CO₂ emission growth is driven by developments in the transport and power generation sectors. This publication gives a detailed view on how energy demand and emissions from transport might develop over the next three decades. The White Paper on the Common Transport Policy sets out various policy actions that are also relevant for energy demand and ensuing environmental emissions.

Total CO₂ emissions have been stable over the last decade while emissions from power generation have even decreased. About half of our electricity has been generated on the basis of non-fossil fuels. With the current pace of renewables penetration and the phase-out of nuclear decided by certain Member states the share of zero carbon fuels is projected to decrease to less than 40% by 2030. CO₂ emissions will rise accordingly. These results hold for both the current EU and the enlarged Union, although in terms of carbon free electricity generation the enlarged Union does have a somewhat less favourable position.

Two years after the launching of the Energy Green paper, this forward analysis provides an updated look at key indicators. It turns out that some of the indicators (import dependency, share of zero carbon fuels and CO₂ emissions) are slightly less alarming than previously projected, which reflects among other things the policy

initiatives undertaken since 2000. In the new projections, zero carbon fuels for the current EU are expected to reach a share in total energy demand of 22 % in 2010, of which renewables account for 8 %, while the Green Paper had shares of 21% for zero carbon fuels and of 7% for renewables in 2010. These changes have contributed towards a somewhat lower CO₂ emission growth (+ 4%) for energy related emissions including transport and international aviation (instead of 5% in the Green Paper). On energy security, the prospects are now slightly better with an import dependency projected at 68% in 2030 instead of 71% in the Green Paper. In any case, more policy effort is needed.

The forthcoming enlargement to a Union of 25 Member states will modify the picture without changing significantly the challenges and opportunities. Zero carbon fuels for EU-25 are expected to contribute 21% in 2010 and import dependency would reach 68% in 2030. CO₂ emissions in the enlarged EU would stay about 1% below their 1990 level in 2010 following the deep restructuring that many acceding countries have undergone. However, energy and transport policies will have to further contribute to fulfilling the international obligation of the Kyoto protocol, which includes a minus 8% target for the European Community.

European energy and transport policies are now committed to pursue further the objectives set out in the Green and White papers. A forthcoming publication by the Directorate-General for Energy and Transport on scenario analysis will explore several issues addressed in these two policy documents. This publication serves the purpose of informing the reader in depth about the baseline on which this further analysis is being built.

I would like to repeat my invitation of previous years regarding your comments and suggestions. Our electronic letterbox (tren-projections@cec.eu.int) remains at your service, and our internet site (http://europa.eu.int/comm/dgs/energy_transport/index_en.html) provides you with detailed information on energy and transport policies and market developments. Finally, I hope that the projections set out in this publication give interesting and constructive insights in how the energy future may unfold.

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The attached CD includes in pdf format:

- The present publication in electronic format (Trends to 2030.pdf),
- The two appendixes of the publication (Appendix1.pdf and Appendix2.pdf),
- A background study on global energy developments (World Energy Scenarios.pdf) prepared by IEPE (Institut d'Economie et de Politique de l'Energie/CNRS-UPMF Grenoble),
- A study on the environmental implications of the energy developments of this baseline in a format similar to the statistical publication on Energy – Environment Indicators (Energy and Environment indicators.pdf) prepared by E3M-Lab/NTUA.

Detailed tables on energy, transport and environment developments for all countries and groups of countries can be found under the directory **Detailed Reports**.

Under the **Energy Balances** directory the user can find detailed energy balances by sector and fuel following EUROSTAT nomenclature. The corresponding figures as regards CO₂ emissions can be found in the **CO₂ Emissions Balances** directory.

Finally, under the directory **Model Description** summary descriptions of both the PRIMES and the ACE model can be found.

DEFINITIONS & UNITS

ACC	Acceding Countries
CCN	EU candidate countries + Norway + Switzerland
CEEC	Central and east European countries
CHP	Combined heat and power
CIS	Commonwealth of Independent States
DG	Directorate-General
EU	European Union
GDP	Gross domestic product
GIC	Gross inland consumption
Gpkm	Gigapassenger-kilometre or 10^9 passenger-kilometre
Gtkm	Gigatonne-kilometre or 10^9 tonne-kilometre
GW	Gigawatt, or 10^9 watt
GWh	Gigawatt-hour or 10^9 watt-hour
IEA	International Energy Agency
kgoe	Kilogramme of oil equivalent
km	Kilometre
ktoe	Thousand toe
kWh	Kilowatt-hour
MEuro	Million euro
Mt	Million metric tonnes
Mtoe	Million toe
OECD	Organisation for Economic Cooperation and Development
pkm	Passenger-kilometre (one passenger transported a distance of one kilometre)
pps	Purchasing power standard
Eurostat	Statistical Office of the European Communities
t	Metric tonne, or 1 000 kilogrammes
tkm	Tonne-kilometre (one tonne transported a distance of one kilometre)
toe	Tonne of oil equivalent, or 10^7 kilocalories, or 41.86 GJ (Gigajoule)
TWh	Terawatt-hour, or 10^{12} watt-hour
UN	United Nations

INTRODUCTION AND PURPOSE

This report reviews the key issues arising from an assessment of likely economic, energy, transport and CO₂ trends over the period to 2030 for current EU Member States, and EU candidate and neighbouring countries. The results and conclusions are presented here in the context of the “Long Range Energy Modelling” framework contract. They are based on quantitative analysis, with the use of the PRIMES and ACE mathematical models, and on a process of communication with and feedback from a number of energy experts and organisations.

A major focus of the study is to assess the impacts following the accession negotiations with ten candidate countries for EU membership concluded at the Copenhagen Council in December 2002 on the enlarged EU energy system. These countries are Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

Part I reviews the international context, focusing in particular on the demographic and macro-economic framework; the outlook for primary energy prices; the likely evolution of the world energy system; and the prospects for CO₂ emissions to 2030. Part II examines the EU energy and transport outlook to 2030. Part III addresses these issues for a group of 15 countries comprising the ten acceding states, three other candidate countries for EU membership (Bulgaria, Romania and Turkey), and two close neighbours of the EU (Norway and Switzerland). Finally Part IV provides an analysis of the energy and transport outlook to 2030 for the enlarged EU of 25 Member States embracing the current EU-15 and the ten acceding states.

The report utilises material provided by a number of organisations, including several European Commission Directorates-General, especially EUROSTAT, the UN-HABITAT Global Urban Observatory and Statistics Unit, and modelling work by DRI-WEFA, ESAP SA (EPIC database, benchmarking of results), IEPE-CNRS (the POLES model), IFP (the PRIMES-refinery model) and NTUA (the GEM-E3 models). A thorough benchmarking of technological data used in the PRIMES and ACE models was performed for this study by ERM (technical and economic data both for the demand and supply sides) and ECN (focusing on renewable energy forms and co-generation technical and economic characteristics and potentials).

PART I: THE INTERNATIONAL FRAMEWORK

This provides an overview of the international context and examines likely trends in international energy prices. The POLES model is used and a continuation of existing trends is assumed. The key points for the period to 2030 include:

Assumptions

- World population grows by 1% pa to more than 8 billion people in 2030. Population growth remains particularly high in Africa, Asia and Latin America.
- World GDP grows by nearly 3% pa, significantly faster than population. Economic growth is projected to be faster in Asia, Africa, Latin America and also the former centrally planned economies compared with traditional OECD countries.
- World GDP per capita increases by 1.9% pa.

World energy prices

Assuming the continuation of current world energy market structures and taking a conventional view on fossil fuel reserves, world energy prices develop moderately as no supply constraints are likely to be experienced over the next 30 years under Baseline conditions.

- Oil prices decline from their high 2000 levels over the next few years, but they then gradually increase to reach a level in 2030 no higher than that in 2000 (and 1990). The long-term increase in oil prices results from the increased dependence upon Gulf region output and the higher production costs for unconventional oil supplies.
- Gas prices broadly follow oil prices as these fuels compete for many end uses. Gas prices are influenced by two contrasting trends: the cleanliness and high use efficiency cause gas prices to rise faster than for oil; but factors such as more intense gas-to-gas competition and greater integration of regional gas markets (with more LNG) exert downward pressure on gas prices. Gas import prices in Europe stay well below the oil price.
- Coal prices remain flat and well below those of oil and gas especially in the long run.

World energy consumption

Given sustained economic growth, especially in Asia, energy demand increases substantially (by 1.8% pa) over the projection period, while energy intensity (energy demand/GDP) of the world economy falls by just over 1% pa - a continuation of the long-term trend. The global energy system will become increasingly dominated by fossil fuels. Dependence on fossil fuels is expected to reach 88% by 2030 compared to 81% in 2000.

- Oil remains the most important fuel, its share rising slightly to 37%. Beyond 2010, as world production exceeds additional discoveries, world oil reserves decline slowly.
- Gas is the fastest growing fuel and global demand doubles by 2030. Incremental production is concentrated in the CIS and Middle East.
- Solid fuels use also grows substantially, by some 90% to 2030,

especially in coal rich countries like China and India.

- Nuclear's contribution grows up to 2010 but stabilises thereafter, a break from the rising production trend in recent decades.
- The global share of renewable sources declines in the Baseline case. Hydropower production rises almost two-thirds and production from other renewables doubles by 2030. But traditional renewables use (mainly biomass, often consumed at unsustainable rates) declines and is replaced by commercial fuels. As a result, overall global use of renewables does not increase to 2030. With strong growth of total energy demand, the share of renewables declines.

World CO₂ developments

Given these trends global CO₂ emissions increase substantially in the Baseline case - by 87% from 2000 to 2030. Compared with 1990 (the Kyoto Protocol base year) global CO₂ emissions rise by 41% in 2010, and in 2030 they are over twice those emitted in 1990.

CO₂ emissions grow more slowly than GDP but slightly faster than energy demand. The world energy system departs from the long-established trend of decarbonisation given growing reliance upon fossil fuels, especially coal, and the falling share of carbon-free sources - renewables and nuclear. Global carbon intensity (CO₂/energy demand) thus deteriorates.

The EU in the world context

EU energy demand and CO₂ emissions grow much more slowly than at the world level, and thus the EU's share of world energy consumption and of CO₂ emissions falls further.

These trends also apply for the EU after the imminent enlargement to 25 Member States. The EU-25 share of world energy consumption falls from some 17% in 2000 to about 12% in 2030. By then the EU-25 could account for approximately 10% of global CO₂ emissions, from some 16% in 2000.

PART II: EU-15 ENERGY AND TRANSPORT OUTLOOK TO 2030

This presents a Baseline projection of the EU energy and transport outlook to 2030 on the basis of current market trends and existing policies. In future this Baseline will be used as a reference for additional policy-relevant scenario analyses addressing issues such as renewables, nuclear, energy efficiency, energy import prices, alternative GDP growth, and Kyoto targets. This Baseline case projects EU energy demand and supply on the basis of assumptions of economic activity, world energy prices and of the broad framework conditions for economic actors (e.g. discount rates for investment).

Key Assumptions

- Energy import prices follow the world developments reviewed in Part I.
- Baseline assumptions include continued economic modernisation, substantial technological progress, and completion of the internal market. Existing policies on energy efficiency and renewables continue; the fuel efficiency agreement with the car industry is implemented; and decisions on nuclear phase-out in certain Member States are fully incorporated.
- For analytical purposes the Baseline case does not include any new policies to reduce greenhouse gas emissions. This is to assist in identifying any remaining policy gaps in the energy and transport sectors with respect to the EU's Kyoto commitments.
- The Baseline macro-economic scenario assumes continued GDP growth of 2.3% pa on average over the projection period, similar to that over the past 30 years. The assumed growth rates are modest compared with the ambitions of the Lisbon strategy but also high compared with the current weak state of the EU economy.

Primary energy demand and supply

GDP doubles between 2000 and 2030 (at 2.3% pa), but primary energy demand grows by only 18% (0.6% pa). Energy intensity (energy demand/GDP) improves considerably, by 1.7% pa, mainly due to further structural shifts towards services and less energy-intensive industrial production.

- Renewables, especially wind, are the fastest growing energy source to 2030 (+74%). Even so, under present market and policy conditions, the share of renewables is only 8% in 2010 and 9% in 2030 - compared with 6% in 2000.
- Natural gas grows next fastest (+64%), satisfying the bulk of incremental EU energy demand (some 80% of additional energy needs in 2030). The natural gas share rises to 32% of total energy consumption.
- Oil demand grows by only 3%. But oil remains the largest single fuel with a share of 40% in 2000 and 35% in 2030, just ahead of natural gas.
- Nuclear output declines by 19% between 2000 and 2030, especially given the phase-out decisions in certain Member States.
- Solid fuels use declines to 2015 but it then increases again to slightly exceed the 2000 level in 2030 (+ 5%) mainly as a replacement fuel for nuclear in the power sector.

Final energy demand

Final energy demand rises 0.8% pa, and the energy intensity of final demand improves by 1.4% pa over the next 30 years.

- The tertiary sector is the fastest growing energy demand sector (+1.1% pa) given the increased importance of services in the EU economy.
- Transport was the fastest growing EU energy demand sector in the 1990s. Passenger and freight transport activity continues to grow strongly. Freight transport activity is projected to rise by 2.1% pa and passenger transport by 1.4% pa in 2000-2030. With GDP growing by 2.3% pa this means some decoupling of transport activity from economic growth in particular for passenger transport.
- But overall transport demand is projected to grow by 0.9% pa to 2030, much slower than in the recent past, due to fuel efficiency improvements following the environmental agreement with the car industry. This result is even more impressive given modal shifts towards more air and road transport, i.e. towards less energy efficient modes, exerting upward pressure on both energy demand and emissions.
- Industrial energy demand increases by 0.8% pa in 2000-2030, despite shifts towards less energy intensive industries and faster growth of less energy consuming activities within the main sectors (e.g. high value-added pharmaceuticals grow faster than petrochemicals).
- Household energy demand also increases (+0.6% pa). Given limited population growth this is mainly due to the rising number of households (+ 40 million between 2000 and 2030), resulting from changes in age structure, lifestyles and smaller household size. There are saturation effects in some end-use applications, especially in space heating.

The fuel mix on the demand side undergoes limited but still important changes over the projection period.

- Electricity and steam use continue to grow strongly and their share in final energy demand increases. Natural gas also grows faster than average. Consequently, energy demand is increasingly met by network based fuels (their combined share rising from 48% in 2000 to 55% in 2030). These fuels are clean and convenient for final consumers but they allow little or no flexibility in terms of storage near point of use.
- Biomass/waste use in final demand rises only moderately and the role of new renewables, such as solar, remains marginal despite strong growth in relative terms especially towards the end of the projection period.
- With slower growth of transport demand and fuel switching away from oil in other sectors, oil loses importance in final demand. Solid fuels become marginal in final use and are consumed mainly in heavy industries (e.g. cement, iron and steel).

Power generation

- Over the projection period, natural gas becomes the most important source for power generation; solid fuels, oil and nuclear all lose market shares.
- Renewables become much more important for power generation, almost matching nuclear's share by 2030. But, under Baseline conditions with strong electricity demand growth, the renewables share in power generation falls well short of the indicative 22% target for 2010 - despite rapid growth in wind generation.
- Approximately half of the EU electricity is generated from carbon free energy sources (renewables and nuclear). Given the nuclear phase-out decided in certain Member States, and despite the projected strong penetration of renewables, this share will fall to 38% by 2030.
- The CHP share increases only moderately, despite its key role in the efficient use of fossil fuels.
- Investment requirements in electricity generation are substantial because capacity increases from 580 GW at present to about 950 GW in 2030. Growth in generating capacity exceeds that for electricity production given the rising share of renewables with lower annual capacity utilisation (given fluctuating water availability and intermittent generation).
- Despite these heavy investment requirements and rising fuel input costs, especially for natural gas, electricity prices fall over time reflecting efficiency gains derived from technological progress, fuel switching and completion of the internal market.

Indigenous energy production and imports

Indigenous energy production peaks around 2005. Its decline stems from lower fossil fuel production (especially coal, and North Sea oil and gas) and the progressive nuclear phase-out. This decline is not offset by rapidly expanding production of renewables, despite renewables becoming the second largest indigenous source after nuclear by 2030.

Net imports of fossil fuels consequently rise by about two-thirds in 2000-2030. Natural gas imports account for the bulk of this increase. Oil imports also increase, by nearly a quarter, over this period.

- Given the combination of rising energy demand and falling indigenous energy production, EU energy import dependency reaches 68% in 2030 compared with just under 50% in 2000.
- Dependency on imported oil rises from 75% in 2000 to nearly 90% in 2030. For both natural gas and solid fuels import dependence increases even faster to reach some 80% in 2030, from

about 45% for gas and 50% for solids in 2000.

CO₂ emissions

Energy related CO₂ emissions are projected to exceed the 1990 level by 4% in 2010 and by 19% in 2030 in the absence of additional policies to curb emissions.

This rise in CO₂ emissions stems from several factors: only modest improvements in carbon intensity (CO₂ emissions/energy demand) to 2015 with a deterioration thereafter following the phase-out of nuclear power in certain Member States; and limited fuel switching to renewables under Baseline conditions.

Policy challenges

To meet these challenges concerning energy security and climate change more extensive policy measures will be required, as set out in the Commission's Green Paper on Energy Security and the White Paper on the Common Transport Policy. However, some of the indicators such as import dependency, CO₂ emissions and the share of renewables are slightly less alarming now compared with the analysis two years ago for the Green Paper. Import dependency is now seen to rise to 68% instead of 71% in the Green Paper; CO₂ emissions are projected to exceed the 1990 level in 2010 by 4% rather than 5% in the Green Paper; and the share of renewables in 2010 is expected now to amount to 8% in 2010 (instead of 7%).

PART III: CANDIDATE AND NEIGHBOURING COUNTRIES' ENERGY AND TRANSPORT OUTLOOK TO 2030 WITH A VIEW TO EUROPE-30

This part examines the 13 candidate countries and the EU's direct neighbours, Norway and Switzerland, with which it has close economic relations. It also includes a summary of results for Europe-30, comprising the present EU-15, the 13 candidate countries, and the two neighbours.

Key Assumptions

Energy import prices correspond with those for the current EU. The policy assumptions are also similar to those for the EU given the gradual accession of many of these countries and continuation of close economic and political relations with the others.

The group is rather diverse – comprising rich countries (Norway and Switzerland) and those with much lower per capita incomes, such as Bulgaria, Romania and Turkey. GDP growth in the candidate countries is projected to exceed that in EU-15 to 2030.

Primary energy demand and supply

For the combined group of candidate and neighbouring countries, primary energy demand rises by 50% in 2000-2030. As GDP

increases much faster (by 165%) over this period, energy intensity improves considerably (by 1.9% pa). This projected growth of energy consumption follows a decade of decreasing energy use in the 1990s due to massive restructuring in the former centrally planned economies.

- Natural gas is the fastest growing fuel, soaring almost 160% to 2030; gas meets nearly 60% of total incremental energy consumption and its share rises from 19% to 33% between 2000 and 2030.
- Oil becomes the most important fuel, replacing solids from 2010 onwards. Rapid growth in transport activity (especially cars and road freight) is the main cause of higher oil use.
- Solid fuels, still heavily used in many central and eastern European countries, are steadily replaced with cleaner, more convenient fuels such as natural gas.
- Nuclear power output declines, given closure of unsafe nuclear reactors in some countries and limited investment in new capacity.
- Renewables grow in line with overall energy consumption, so their share remains at 11% to 2030.

Final energy demand

Final energy demand grows at 1.6% pa, while energy intensity at the level of end users improves by 1.6% pa over the projection period.

- Transport was the only final demand sector to grow during the massive economic transitions of the 1990s. Transport energy demand is expected to continue rising at 3.0% pa, only slightly below GDP growth, reflecting the large projected rise in passenger and freight transport and modal shifts to road and air transport.
- Industrial energy demand grows moderately, following the large decline in the 1990s. Exploitation of energy intensity improvement potential allows industry in candidate countries to expand with limited additional energy consumption.
- Tertiary sector energy demand rises rapidly (+1.9% pa), given fast economic growth in the service sector.
- Household energy demand rises 1.5% pa to 2030 reflecting growth in household numbers and higher living standards, stimulating use of electric appliances.

Natural gas is the fastest growing fuel in final use, followed closely by electricity. Heat demand grows less quickly given the historic high use of district heating in the former centrally planned countries. Solid fuels and biomass lose importance in final demand but oil consumption increases because of rising transport demand.

Power generation

The power sector gradually shifts away from heavy use of solid fuels towards natural gas, which, as in EU-15, becomes the major source for electricity generation in 2030. The share of non-fossil fuels in power generation declines from 47% in 2000 to 31% in 2030, causing much higher CO₂ emissions.

Indigenous energy production and imports

Indigenous energy production rises to 2010 given higher Norwegian gas production and further deployment of renewables. Natural gas and renewables production continue to grow to 2030; but production of solid fuels, oil and nuclear falls.

The group of candidate and neighbouring countries remains a net energy exporter until 2010. After then the region becomes a net importer with imports increasing substantially, as indigenous production declines and energy demand rises.

CO₂ emissions

CO₂ emissions fell 17% in the 1990s due to economic restructuring in formerly centrally planned economies. Even in 2010 CO₂ emissions are projected to be well below the 1990 level. With strong economic growth and the gradual exploitation of large parts of the low-cost fuel switching and energy efficiency potential over time, CO₂ emissions rise quickly from about 2015 to be 21% above 1990 levels in 2030. Nevertheless, with large energy intensity improvements, one unit of GDP in 2030 is produced with only 55% of the CO₂ emitted in 2000.

Europe-30: an overview

Given the economic weight of the current EU, energy developments in Europe-30 are dominated by energy trends in EU-15.

- Primary energy demand in Europe-30 grows 0.8% pa to 2030, considerably slower than GDP growth (2.4% pa), so that energy intensity improves by 1.6% pa.
- Natural gas expands its share of the Europe-30 energy system (from 22% in 2000 to 32% in 2030). Oil remains the largest single fuel contributing 35% in 2030, but both solid fuels and nuclear lose shares. The renewables share rises from 7% in 2000 to nearly 8.5% in 2010 and 9.5% in 2030.
- Transport and tertiary use are the fastest growing final demand sectors to 2030. Energy demand growth in industry is limited because of the substantial potential for improved energy intensity. Rising living standards and smaller household size cause household energy demand to increase moderately: the large energy efficiency potential is exploited, but will be offset by higher appliance ownership and use.
- Import dependency in Europe-30 increases from 36% in 2000 to

60% in 2030. Import dependency in Europe-30 is significantly lower than in EU-15, mainly due to Norwegian oil and gas output. But dependency rises as primary energy demand increases throughout the projection period and indigenous production falls from 2005. Import dependency is highest for oil (from 55% in 2000 to 80% in 2030); for natural gas this rises from 39% in 2000 to 68% in 2030; and for solids from 32% to 65% in the same period.

- CO₂ emissions in Europe-30 return to their 1990 level in 2010 after falling in the 1990s. By 2030 CO₂ emissions exceed their 1990 level by 20%.

Thus, in many respects, energy developments in Europe-30 resemble those in EU-15, especially as regards long-term growth in both CO₂ emissions and import dependency.

Part IV: EU-25 ENERGY AND TRANSPORT OUTLOOK TO 2030

This part examines energy, transport and CO₂ emission developments to 2030 under Baseline conditions in the enlarged Union with 25 Member States (EU-25). As in the case of EU-15, it is planned to use the baseline as a reference for scenario work at the EU-25 level.

Key Assumptions

Energy import prices correspond to those for EU-15. Policy assumptions follow closely those for EU-15 given that the *acquis communautaire* will be implemented in the 10 acceding countries.

Economic growth in EU-25 will be somewhat higher than in EU-15 because acceding countries grow faster, from lower levels in the past. EU-25 GDP is projected to grow 2.4% pa, slightly more than doubling to 2030.

Primary energy demand and supply

EU-25 primary energy demand is projected to be 19% higher in 2030 than in 2000 (0.6% pa), with GDP twice that in 2000. Energy intensity develops favourably, falling by 1.7% pa.

- Some 80% of incremental energy consumption to 2030 will be met by natural gas, demand for which grows by two thirds in 2000-2030. In 2030, natural gas is the second largest fuel, with a 32% share of total EU-25 primary demand.
- Oil remains the largest fuel, although consumption grows by only 8% between 2000 and 2030. In 2030, oil meets 35% of primary energy demand (down from 38% in 2000).
- Renewables are the fastest growing energy source, expanding 75% over the next 30 years. But their share in primary energy demand rises from only almost 6% in 2000 to 7.4% in 2010 and

8.6% in 2030 under Baseline conditions.

- The nuclear contribution increases marginally (+3% in total) to 2010 given higher utilisation of existing capacity and some limited capacity additions, which together offset closure of reactors with safety concerns in some acceding countries. However, in 2030, nuclear output is 22% lower than in 2000; and its share drops from 14.4% to 9.4% in 2000-2030. This results from the nuclear phase-out in certain Member States.
- Solid fuels consumption declines steeply in the medium term but regains its 2000 level by 2030, as a replacement for nuclear and given coal's enhanced competitiveness against higher gas prices in the long term.

Final energy demand

The tertiary sector is the fastest growing final energy market in EU-25, followed by transport - both sectors growing more rapidly than overall final energy demand.

Transport energy demand growth derives from rising transport activity to 2030, and by modal shifts towards road and air transport under Baseline conditions.

- Road gains market share but fuel efficiency improvements, especially in private cars following the fuel efficiency agreement with the car industry, constrain energy demand growth.
- The rail share of both passenger and freight transport falls considerably given large substitution away from rail in the transport system of acceding countries, which are now more reliant on rail transport (e.g. 43% share for rail freight in acceding countries compared with 13% in EU-15¹ in 2000). Road gains market shares accordingly, and with increasing per capita incomes there is a strongly increasing demand for air travel.
- Transport demand per capita in the acceding countries rises strongly as disposable incomes grow, and km travelled per person doubles in 2000-2030. Total km travelled per capita in EU-25 increase by nearly 50% over the same period. Yet passenger transport in EU-25 grows more slowly than GDP (1.5% pa compared with 2.4% pa) leading to considerable decoupling of passenger transport from GDP (with intensity gains of 0.9% pa up to 2030).
- Freight transport intensity in the EU-25 decreases to 2030 but by only 0.2% pa, leading to only limited decoupling of freight transport activity from GDP in the Baseline.

The strong energy demand growth in tertiary activities (1.2% pa) arises mainly in services; tertiary sector value added increases much faster than energy demand (by 2.5% pa up to 2030). Agriculture, also included in this sector, grows much more slowly.

Industrial energy demand is projected to grow by 0.7% pa to 2030, having fallen in the 1990s because of the restructuring in the acceding countries and the former GDR.

- Exploitation of the large potential for energy intensity improvements permits industry in acceding countries to expand activity with only limited additional energy consumption, in turn also restraining EU-25 industrial energy demand growth.
- Further structural change away from heavy industries towards less energy-intensive activities leads to significant energy intensity improvements, limiting industrial energy demand growth.

Household energy demand increases by 0.6% pa by 2030 in EU-25, reflecting higher living standards and more widespread use of electric appliances in acceding countries, but also some saturation effects especially in EU-15 space heating. But demand growth derives from rising household numbers due to demographic changes and lifestyles.

Total final energy demand is projected to grow by 0.9% pa to 2030. This is faster than growth of primary energy demand (0.6% pa), and reflects the significant efficiency gains in the energy transformation sector – especially in power generation.

- Electricity is the fastest growing fuel in final use, growing by 1.6% pa to 2030. Heat from CHP and district heating plants comes next, rising 1.4% pa. Gas also grows above average (by 1.1% pa) but oil use increases more slowly. Despite increasing transport demand, the low oil growth reflects fuel switching away from oil in other final demand sectors. Final demand for solid fuels falls by nearly 50% by 2030 as heavy industries lose their importance and households in acceding countries shift to more convenient means of space heating.
- Electricity provides 40% of the incremental final energy demand to 2030, and natural gas and oil each account for approximately 30%. The role of renewables in final demand increases quite slowly over the period by 0.2% pa.

Power generation

Electricity production increases 54% in 2000-2030.

- Gas-based electricity grows particularly quickly - by over 150% in this period - and in 2030 gas is the most important fuel input for electricity (accounting for 36% of power generation, from 16% in 2000).
- The power station sector gradually shifts away from solid fuels and nuclear, which each had a 32% share in 2000: i.e. nearly two thirds of electricity production is presently based on nuclear and solid fuels, both with favourable characteristics as regards security of supply. But, by 2030, the nuclear share falls to 17%,

¹ These shares reflect EUROSTAT energy statistics that treat energy consumption for maritime transport as bunkers, which are not included in inland energy consumption; consequently these shares do not take account of coastal sea shipping.

and that of solid fuels to 27%.

- Electricity from renewables rises nearly 90% by 2030. Under Baseline conditions the renewables share in electricity generation is projected to be 17% in 2030, compared with 14% in 2000.
- The net effect of greater use of renewables, but lower nuclear output, is that the share of carbon free sources for EU-25 electricity generation falls from 46% in 2000 to 34% in 2030. The share of carbon free electricity generation is higher in EU-15 (49% in 2000), but also decreases to 38% in 2030. The lower shares in EU-25 reflect the rather unfavourable position of acceding countries in terms of zero carbon fuels. Given these trends CO₂ emissions from power generation increase in the Baseline case.

Indigenous energy production and imports

Indigenous energy production decreases slowly until 2010 (-4%). After 2010 the decline accelerates and in 2030 production is 27% lower than in 2000.

- Solid fuels production falls some 50% over 2000-2030; the decline is substantial in both EU-15 and the acceding countries. Oil production also falls by nearly 50% but this happens nearly entirely in EU-15, as the acceding countries produce little oil. Natural gas production drops by 40% to 2030, also largely in the current EU. Nuclear output is projected to fall by 22% over the same period, decreasing both in EU-15 and the acceding countries.
- Only the production of renewables rises: by 37% over 2000-2010 and by 74% over the whole projection period. Most of the increase comes from biomass/waste, while wind grows fastest in relative terms: by 2030 wind production is 14 times higher than in 2000. Renewables output expands in both EU-15 and the acceding countries.
- The acceding countries are less dependent on energy imports than the current EU. In 2000, import dependency was 30% in the acceding countries but close to 50% in EU-15. Over time the acceding countries converge with the current EU, with higher growth of energy demand (compared with EU-15) and a bigger decline of indigenous production. In 2030, import dependency in the acceding countries is expected to reach 65%, while that in EU-15 reaches 68%. Overall EU-25 import dependency increases from 47% in 2000 to 67.5% in 2030.
- By fuel the highest import dependency will continue to be for oil, rising from 76% in 2000 to 88% in 2030. For natural gas this dependency grows from 50% in 2000 to 81% in 2030. Import dependency for solid fuels more than doubles, from 30% in 2000 to 66% in 2030.

CO₂ emissions

CO₂ emissions for the enlarged Union are expected to be 1% lower in 2010 than in 1990; but to increase by 4% in the EU-15 over the same period. This more favourable situation concerning CO₂ in EU-25 derives from trends in the central and eastern European acceding countries. CO₂ emissions in acceding countries fall 23% in 2010 compared with 1990 levels.

In the longer term, EU-25 CO₂ emissions rise. In the EU-15 this is due to upward pressure on CO₂ stemming from growing economic activity and the assumed absence of new policies and measures on climate change in the Baseline case. In addition more rapid GDP growth in acceding countries leads to rising CO₂ emissions from 2005. By 2030 CO₂ emissions in EU-25 exceed the 1990 level by 14%. This overall increase stems from the projected 19% rise in these emissions in EU-15 between 1990 and 2030, but a 9% fall in the acceding countries (i.e. CO₂ emissions from the acceding countries are expected to remain well below their 1990 even in 2030).

- The carbon intensity of the EU-25 energy system falls slightly to 2015 given greater use of renewables and especially natural gas. In the Baseline case this intensity trend is reversed after 2015 given the nuclear phase-out in several Member States, insufficient renewables growth to compensate for this lost nuclear output, and thus replacement of much nuclear generation by fossil fuels.
- In 2000 CO₂ emissions per unit of GDP were higher in EU-25 than in the current EU due to the higher carbon intensity of the EU-25 energy system and the latter's much higher energy intensity stemming from energy inefficient practices inherited from the formerly centrally planned economies.
- The CO₂/GDP ratio is expected to decline in EU-25 throughout the projection period so that in 2030 one unit of GDP is produced with 42% less CO₂ emissions. CO₂ emissions per unit of GDP fall even more quickly in the acceding countries (by 58% between 2000 and 2030). Clearly, with additional policies following ratification of the Kyoto Protocol, even greater reductions are possible but such further policy responses are excluded from the Baseline case.

Policy challenges

In conclusion, energy developments in EU-25 are in many respects similar to those in the current EU - especially as regards the key long-term challenges associated with the growth in CO₂ emissions, the penetration of renewables and rising energy import dependency.

The scope of “European Energy and Transport Trends to 2030” is to explore possible energy and transport developments over the next three decades on the basis of an in depth modelling analysis of the European energy system and its driving forces carried out mainly at the E3M-Laboratory of National Technical University of Athens. The study addresses in particular transport developments and their impact on energy demand. Energy and transport demand in Europe depend on a large number of factors ultimately reflecting decisions made at the level of individual consumers. Within a modelling framework these are naturally grouped into analytically meaningful categories.

Looking thirty years ahead we need to recognise that many uncertainties exist in future developments including in the overall geopolitical environment. Nevertheless, on certain issues there is now a large degree of consensus. The trend toward globalisation appears to be well established, the internal market in energy and transport is progressing towards completion, technology is improving quickly, and environmental issues remain at the heart of energy and transport policy – especially as regards climate change. Similarly, energy security as discussed in the “Green Paper on the security of energy supply” remains a major issue.

This volume explores in considerable detail a baseline describing how the future may unfold if current trends and policies are continued into the future. In this sense the baseline can contribute towards identifying challenges and opportunities implicit in the continuation of existing trends. The indicators shown in this study can help policy makers to evaluate existing trends in relation to policy objectives such as security of energy supply, competitiveness and environmental protection. Furthermore it can be used as a starting point for further scenario analysis of policy relevant cases. Work on such policy relevant cases on the basis of this baseline is underway. It is planned to publish the most interesting results of the scenario analyses upon completion later this year in the same series on European Energy and Transport.

The trends shown in this publication are based on the in-depth quantitative analysis of energy developments including their economic, transport and environmental aspects. The modelling results reflect the dynamic development of technologies against the background of the completion of the internal market. In this respect, the study is comparable to the previous publication on “European Union Energy Outlook to 2020” of 1999.

However, in addition to extending the projection horizon from 2020 to 2030, these Trends to 2030 extend the geographical scope of the detailed analysis, beyond the current EU. With the imminent enlargement to 25 Member states and in the perspective of further enlargement, this study deals with the wider Europe of 30

countries. These 30 European countries include, in addition to the current EU of 15 Member states, the ten acceding countries, the three remaining candidate countries and the two direct neighbours Norway and Switzerland.

Trends to 2030 include a global view that puts European developments into the world context. The international framework to 2030, described in part I, deals with global demographic, economic, energy and CO₂ developments. This study addresses the international framework, in which globalisation takes place against the background of increasing population and a moderate expansion of the global economy. This in turn has substantial impacts on global energy and environment developments.

The second part focuses on EU-15. It gives detailed projections of current trends to 2030 with a focus on the present EU given that:

- better modelling facilities exist for the present Member States, developed over many years, that allow a more in depth analysis of the driving forces of energy, transport and environmental developments;
- this allows an up-date of the scenario analysis undertaken in preparation of the Green paper on the security of energy supplies so as to evaluate key issues of policy concern in comparison with the scenario analysis undertaken more than two years ago.

The third part addresses the candidate countries and direct neighbours as a group in some detail and provides a view on Europe-30. This allows a comparison with the analysis on Europe-30 that was undertaken in preparation of the Green paper. In addition part III enables the reader to follow in detail how energy developments outside the current EU would influence the energy picture of the wider Europe of 30 countries.

The final part of the study deals with the EU of 25 Member states following enlargement in 2004, i.e. the framework for future policy making in the EU. The baseline projections in this part give, for the first time, a comprehensive picture of energy developments including transport and environment issues related to energy for EU-25.

The modelling of EU-25 is somewhat less detailed than the modelling for EU-15, which was undertaken with the PRIMES model. The ten acceding countries, as well as the other European countries in this study, were modelled with the ACE model, which is somewhat less sophisticated and detailed than the PRIMES model that has been developed for EU-15 since 1993. Work is underway to base the modelling analysis of the acceding countries also on the PRIMES model. Given that the transition to the PRIMES model will require some more time, it was deemed preferable to show the development of current trends using the modelling facilities

that are available at present. This allows for a view on the EU in its likely shape from 2004 shortly after the accession negotiations have been successfully concluded in Copenhagen in December 2002 and in advance of the signature of the accession treaties scheduled for April 2003 in Athens.

The CD included in this publication gives background material, such as detailed tables on energy, transport and environment developments for all countries and groups of countries, a background study on global energy developments, a short description of the PRIMES and ACE models, and a study on the environmental implications of the energy developments of this baseline in a format similar to the statistical publication on Energy – Environment Indicators.

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