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EWI/Prognos – Study The Trend of Energy Markets up to the Year 2030

Reference Forecast for the Energy Sector
Energy Report IV – Summary

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Economics and Labour, Berlin**

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Main Results

Nature of the Reference Forecast

Action by economic policymakers is based on ideas articulated with regard to specific tasks (problems, opportunities, and possibilities for responding). The following Reference Forecast offers an analytical outlook on the trend in Germany's energy sector up to the year 2030. For this purpose, it links together long-term development trends in the population, economy, technology, and environment. Account is taken of basic policy decisions with an established or likely impact on the energy sector during the forecast period.

International and National Framework Conditions

Resource Availability: No energy resource bottlenecks are expected up to the year 2030. Energy supplies will become more dependent on politically and economically unstable producer and transit countries. Supply risks will increase.

Energy Consumption by World Regions: According to available international status-quo forecasts, world energy consumption will increase some 60 % by 2030. Developing countries will account for two-thirds of the increase. Counter-measures could reduce the rising trend.

Determinants of World Energy Consumption: Global population will expand from six to eight billion persons. Per capita income will continue to rise. The decline in the amount of energy required to generate a unit of economic output will slow the growth of energy consumption.

Meeting the Demands of Global Energy Consumption: Fossil energy sources will account for more than four-fifths of global energy consumption in 2030. Oil will continue to be the most important primary energy source in 2030, accounting for 35 % of consumption.

Global CO₂ Emissions: According to current international energy projections, energy-related emissions will rise worldwide by more than 60 % up to the year 2030 if no counter-measures are taken. Developing

countries will account for two-thirds of the increase. China and India will become large-scale emission sources.

Expanded Natural Gas Markets: The largest part of world reserves of natural gas is located in reach of Europe. The growing LNG trade will give Europe access to new gas sources. Competition by Asian and American gas consumers will continue to increase.

Prices of Energy Commodities: Oil and natural gas will become significantly more expensive. In 2030, real import prices for oil and natural gas will be roughly twice as high as in the nineties. The oil price will rise in real terms to 37 US-\$(2000) a barrel in 2030. The price of hard coal will increase only slightly, while the price of lignite will remain constant in real terms.

Consumer Prices for Fuel Oil and Natural Gas: Owing to the base effect of energy taxes and processing and transport costs, domestic consumer prices for oil products and natural gas will rise less sharply than import prices.

Electricity Prices: Electricity prices reached a record low in 2000. The wholesale price of electricity will double by 2010 relative to the 2000 level and subsequently continue to rise slightly. Grid prices will decline in real terms throughout the forecast period. After 2010 prices for individual consumer groups will show differing trends. Industrial electricity prices will rise slightly, and household electricity prices will decline slightly.

Structural Changes in the Electricity Sector: The internal market for electricity will impose increasing market pressure on electricity producers. At the same time, investment and operational decisions will be extremely subject to the influence of political factors. Germany is phasing out the use of nuclear energy, expanding the use of renewable energies, and launching CO₂ emissions trading. It will become more difficult to reconcile the goals of cost effectiveness, supply security, and the environmental compatibility of electricity production.

Technical Progress in the Electricity Sector: In the case of fossil-fuel-driven power stations and nuclear power stations, there is considerable potential for boosting operating efficiencies, lowering costs, reducing the emission of pollutants, and increasing security. Some techniques for electricity production from renewable energies will come close to the threshold of cost-effective operations toward the end of the forecast period.

International Framework: The trade in greenhouse gas emission rights was officially launched in the EU's 15 countries on 1 January 2005. A major impact is not expected during the initial allocation period.

Reference Forecast

International Framework: The world economy will expand by an annual average 3% between 2002 and 2030. Risks will increase as the result of the increasing worldwide interdependencies.

Economic and Population Trends in Germany: Germany's economy will experience an annual average 1.4% growth. The population will decline and age rapidly.

Technological Trends in Energy Usage: Technical innovation will continue to influence the form and scope of energy use. The new technologies will only gradually find their way into everyday application as the result of long investment cycles.

Total Final Energy Consumption: Final energy consumption will decline in all demand sectors by 2030. Electricity and natural gas will increase their respective shares.

Final Energy Consumption in Households: Households will consume some 14% less energy in 2030 than in 2002. Owing to the increasing use of electrical devices, electricity consumption will not decline until after 2020.

Final Energy Consumption in Agriculture, Commercial, Services and Other Consumption Areas:

Energy demand will decline by 23% in the sector agriculture, commercial, services and other consumption areas by the year 2030. The energy mix will change considerably. Consumption of all energy sources will fall except for renewable energies.

Final Energy Consumption in Industry: Final energy consumption in industry will decline by a total of 7% by 2030. The demand for electricity will increase.

Final Energy Consumption in Transport: Final energy consumption in the transport sector will decline by just under 4% by 2030 owing to increasingly efficient vehicles. Conventional diesel fuel and bio fuels will take on considerably more importance.

Electricity Production: Electricity will increasingly be produced in Germany from natural gas. Domestic lignite will move up to second place. The renewables will account for 38% of power station capacities and cover 26% of gross electricity production at the end of the forecast period.

District Heating: District heating will decline. Responsible for the drop will be savings in the heating sector. The share of final energy consumption accounted for by district heating will remain unchanged at some 3%. Hard coal, lignite, and fuel oil will be nearly entirely displaced in district heating by waste, biomass, and natural gas.

The Use of Renewable Energies in Germany: Renewable energies' share of primary energy consumption will rise from 3.4% in 2002 to 11.5% in 2030. More than half of the increase will be accounted for by electricity production, a good one-fourth of which will rely on renewable energies in 2030. Renewable fuels will cover 8% of fuel needs in 2030.

Primary Energy Consumption: Primary energy consumption in Germany will fall in the long term. This represents a new trend and a break from the past. Per capita energy consumption will be 12% lower.

Structure of Primary Energy Consumption: The structure of primary energy consumption will change considerably in the forecast period. The share of gas and renewable energies will expand while coal will lose significance.

Energy-Related Emissions: Energy-related greenhouse gas emissions will decline by 18.6 % between 2002 and 2030. At the end of the forecast period they will be 32 % lower than 1990 levels. The Kyoto commitments will be met.

Appendices

Methodology of Energy Forecasts: The methodology used for energy forecasts and the future trends of energy technologies were discussed in two interdisciplinary expert workshops.

Comparison of Current Studies on the Trend in the Energy Sector in Germany: The results vary greatly. Depending on the objectives, methods, and time frames, the studies inevitably yield differing results.

Determination of the Costs of Energy Supplies (value balance of energy): For the first time, the attempt is being made to draft a value balance of energy. This serves to integrate the economy's outlays on energy into the Reference Forecast. Real expenditure on primary energy will double by 2030 at declining primary energy consumption. Energy spending by consumers (without taxes and other charges) will rise by a real one-third.

External Costs of Energy Supplies: Market prices for energy cover only part of the costs associated with energy supplies. More recent approaches attempt to take comprehensive account of the external costs of energy supplies. Methodological and statistical problems have still not been satisfactorily solved.

Main Assumptions

Global Developments

The **global population** will expand by one third from six to eight billion persons. The countries of Asia will take on increasing economic and political importance.

World energy consumption will rise by more than half. Fossil energy sources will account for more than four-fifths of global energy consumption in 2030.

Oil prices will increase to 37 US-\$(2000) a barrel in 2030.

Developments in Germany

There will be no fundamental changes in the **framework conditions** determining the trend in the energy sector up to the year 2030. Democracy and the market economy will remain the underlying principles of society. Energy usage will not be subject to any revolutionary changes. For the majority of consumers, energy does not capture the focus of attention.

Demographic changes are determining social development. The number of persons living in Germany will decline by 2030, and the population will age significantly.

The **economy** will expand at an annual average 1.4%. Additional jobs will be created in the service sector. The industrial base will be sustained.

Technological advances will boost energy efficiency. Energy policy measures will reinforce the rational use of energy. Technical innovation will mainly be implemented as part of normal investment cycles. Revolutionary innovations should not be anticipated.

Energy prices for final users will be determined by international energy prices, domestic processing and transportation costs, and taxes and other levies. Transport and distribution costs will decline in real terms. Energy tax rates will remain constant in real terms.

In line with the decision to phase-out the use of **nuclear energy**, cumulative electricity production from nuclear power has been restricted to 2,623 TWh (since 1 January 2000).

The promotion of **renewable energies** will be continued during the entire forecast period.

Emission trading will be expanded far beyond the borders of the EU. To ensure the participation of many countries, reduction commitments and thus certificate prices will remain moderate.

Main Numerical Assumptions and Results

Reference Forecast 2005	Unit	absolute values				average annual growth (%)			
		2000	2010	2020	2030	2000-2010	2010-2020	2020-2030	2000-2030
World									
population	million	6,068	6,822	7,528	8,117	1.2	1.0	0.8	1.0
GDP real 9	billion US-\$ (1995)	34,510	46,268	62,398	81,175	3.0	3.0	2.7	2.9
oil price, real 2000	US-\$ (2000) / b	28	28	32	37	0.0	1.3	1.5	0.9
Germany									
population	million	82.3	82.4	81.3	79.3	0.0	-0.1	-0.2	-0.1
households	million	38.2	39.7	40.0	39.7	0.4	0.1	-0.1	0.1
GDP real 95	billion Euro (1995)	1,970	2,238	2,611	2,960	1.3	1.6	1.3	1.4
industry production, real 95	billion Euro (1995)	403	453	527	597	1.2	1.5	1.3	1.3
passenger cars	million	42.8	46.9	47.9	47.2	0.9	0.2	-0.1	0.3
carriage [passenger*km]	billion [p*km]	1,051	1,110	1,089	1,060	0.5	-0.2	-0.3	0.0
carriage [tons*km]	billion [t*km]	491	598	715	785	2.0	1.8	0.9	1.6
Prices households (incl. VAT), real 2000									
fuel oil, light	€-cent(2000) / l	40.8	38.6	45.2	51.7	-0.6	1.6	1.4	0.8
gas	€-cent(2000) / kWh	3.7	4.1	4.7	5.4	1.0	1.4	1.4	1.3
electricity	€-cent(2000) / kWh	14.9	16.4	16.0	16.1	0.9	-0.2	0.1	0.3
gasoline unleaded	€-cent(2000) / l	100	108	115	121	0.8	0.6	0.5	0.6
Prices wholesale (w/o. VAT), real 2000									
fuel oil, light (industry)	Euro (2000) / t	381.5	363.7	423.7	485.2	-0.5	1.5	1.4	0.8
natural gas (industry)	€-cent (2000) / kWh	1.71	1.86	2.11	2.34	0.8	1.3	1.0	1.1
electricity (middle voltage)	€-cent(2000) / kWh	n.a.	8.0	8.1	8.5	n.a.	0.1	0.5	n.a.
electricity (high voltage)	€-cent(2000) / kWh	4.4	5.4	5.7	6.2	2.1	0.5	0.8	1.1
Total Primary energy supply	PJ	14,356	14,220	13,019	12,129	-0.1	-0.9	-0.7	-0.6
oil	%	38.3	37.7	38.1	38.0	-0.3	-0.8	-0.7	-0.6
natural gas	%	21.1	25.2	28.7	31.5	1.7	0.4	0.2	0.8
hard coal	%	14.0	11.3	10.8	6.7	-2.2	-1.4	-5.2	-3.0
lignite	%	10.8	10.7	11.6	12.3	-0.2	-0.1	-0.1	-0.1
nuclear energy	%	12.9	10.0	2.7	0.0	-2.6	-13.1		
renewable energy	%	2.9	5.8	8.3	11.5	7.4	2.7	2.6	4.1
Final energy consumption	PJ	9,241	9,275	8,847	8,427	0.0	-0.5	-0.5	-0.3
households	%	28.2	30.2	29.8	29.3	0.7	-0.6	-0.7	-0.2
services	%	16.0	16.0	15.3	14.3	0.0	-0.9	-1.2	-0.7
industry	%	26.1	24.9	25.2	25.8	-0.4	-0.4	-0.2	-0.3
transportation	%	29.8	29.0	29.6	30.6	-0.2	-0.2	-0.2	-0.2
oil products	%	45.1	43.3	41.0	39.6	-0.4	-1.0	-0.8	-0.7
natural gas	%	24.9	26.0	26.3	26.3	0.5	-0.4	-0.5	-0.1
hard coal	%	5.3	4.3	3.9	3.9	-2.1	-1.4	-0.5	-1.3
electricity	%	18.8	20.0	21.2	22.0	0.7	0.1	-0.1	0.2
district heating	%	3.5	3.4	3.3	3.1	-0.3	-0.8	-1.2	-0.7
renewables	%	2.3	3.0	4.2	5.1	2.8	3.0	1.4	2.4
Gross electricity generation	TWh	575	617	594	584	0.7	-0.4	-0.2	0.1
hydro	%	5.1	4.4	4.9	5.0	-1.4	1.0	0.2	-0.1
nuclear energy	%	29.5	20.7	5.2	0.0	-3.5	-12.8		
hard coal	%	24.9	19.5	18.3	8.5	-2.4	-0.6	-7.4	-3.5
lignite	%	25.8	25.8	28.4	29.3	0.0	1.0	0.3	0.4
gas	%	8.6	16.1	24.4	32.7	6.5	4.2	3.0	4.6
wind	%	1.7	7.0	11.1	15.8	15.5	4.7	3.6	7.8
other	%	6.7	6.5	7.6	8.7	-0.3	1.6	1.4	0.9
Efficiency indicators									
TPES per capita	GJ / capita	175	173	160	153	-0.1	-0.7	-0.5	-0.4
GDP / TPES	Euro / GJ	137	157	201	244	1.4	2.5	2.0	1.9
industry production / FEC	Euro / GJ	167	196	236	275	1.6	1.9	1.5	1.7
carriage [passenger*km] / FEC	Pkm / kJ	539	588	631	632	0.9	0.7	0.0	0.5
carriage [tons*km] / FEC	tkm / kJ	645	734	835	917	1.3	1.3	0.9	1.2
CO₂-indicators									
		absolute values				1990-	1990-	2010-	1990-
		1990	2000	2010	2030	2000	2010	2030	2030
CO ₂ -emissions	million t	1,000	853	837	717	-1.6	-0.9	-0.8	-0.8
CO ₂ / GDP	g / Euro	614	381	321	242	-4.7	-3.2	-1.4	-2.3
CO ₂ / population	t / capita	15.9	10.3	10.3	9.0	-4.2	-2.1	-0.6	-1.4

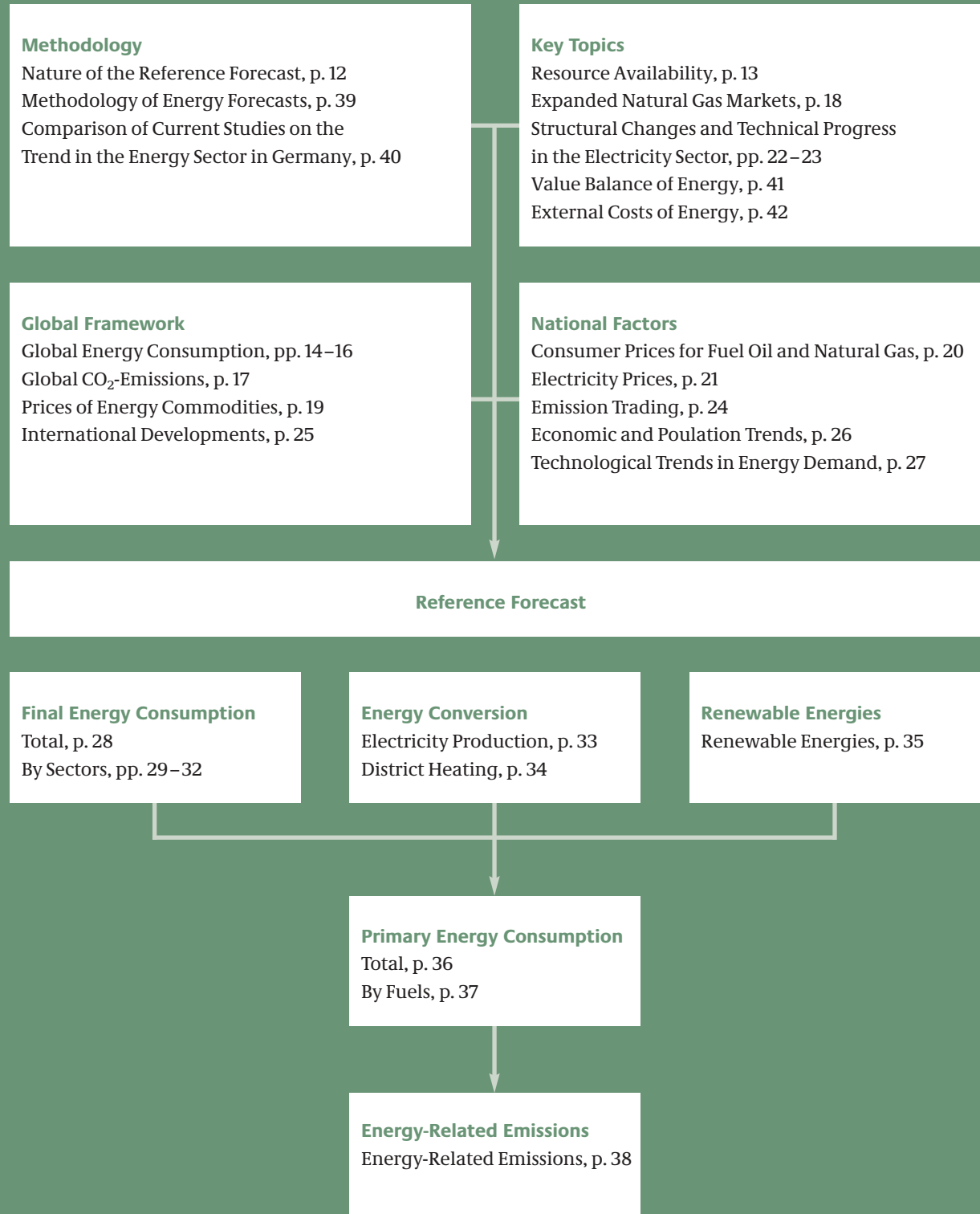
FEC – final energy consumption, n.a. not available, TPES – total primary energy supply

Source: EWI/prognos

Absolute values

Summary

Outline of the study



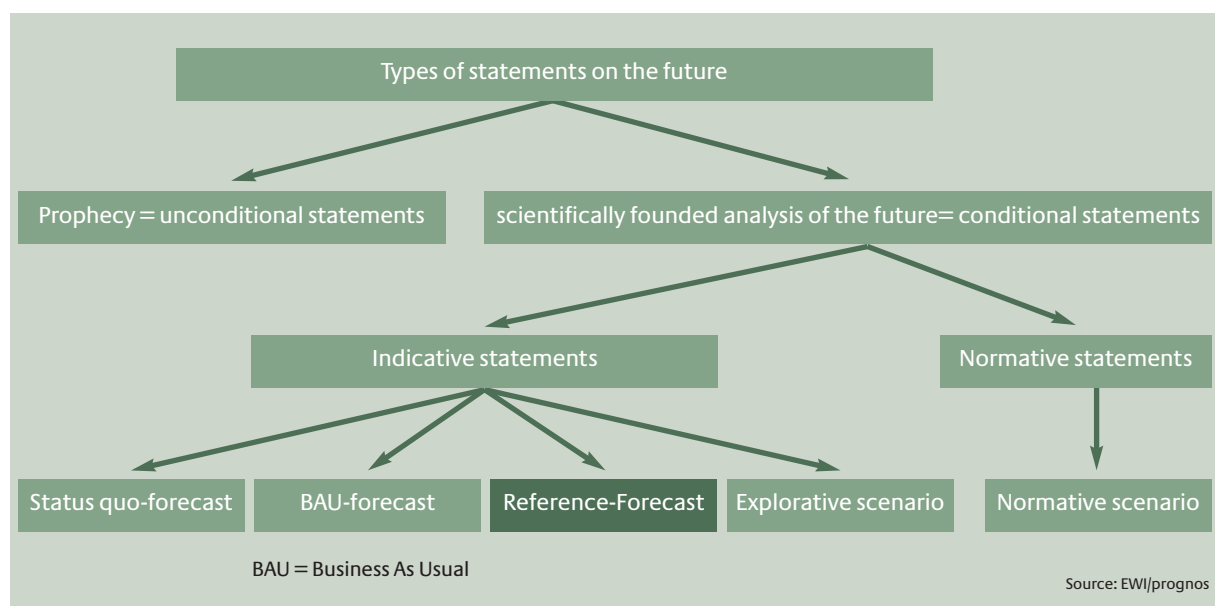
Nature of the Reference Forecast

Action by economic policymakers is based on ideas articulated with regard to specific tasks (problems, opportunities, and possibilities for responding). The following Reference Forecast offers an analytical outlook on the trend in Germany's energy sector up to the year 2030. For this purpose, it links together long-term development trends in the population, economy, technology, and environment. Account is taken of basic policy decisions with an established or likely impact on the energy sector during the forecast period. Examples: phasing-out the use of nuclear energy, climate protection policy, tax policy in the energy sector, and the promotion of renewable energies.

The empirical starting point for the Reference Forecast is the manner in which the overall socio-economic system functions and its transformation as the result of private and political preferences. The likely trend is derived from this basis. The Reference Forecast differs in methodology and purpose from status-quo forecasts and from prescriptive or explorative target scenarios.

It goes beyond a status-quo forecast in that it does not freeze policy decisions to the status quo; rather, it integrates probable reactions by policymakers into the new challenges and opportunities it sketches. In doing so, it also takes account of inertia in the social, economic, and technological systems.

It puts together a picture of the likely trend, while target scenarios and explorative scenarios prescribe and investigate specific and individual goals (example: CO₂ reduction) and the conditions and means for achieving them.



Resource Availability

No energy resource bottlenecks are expected up to the year 2030. Energy supplies will become more dependent on politically and economically unstable producer and transit countries. Supply risks will increase.

World energy supplies will not reach resource availability limits during the period extending to 2030. As in the past, technological progress will offset the trend toward a worsening quality of deposits of extractable energy resources, expand the possibility of commercial use for renewable energies, and permit better utilization of nuclear fuels.

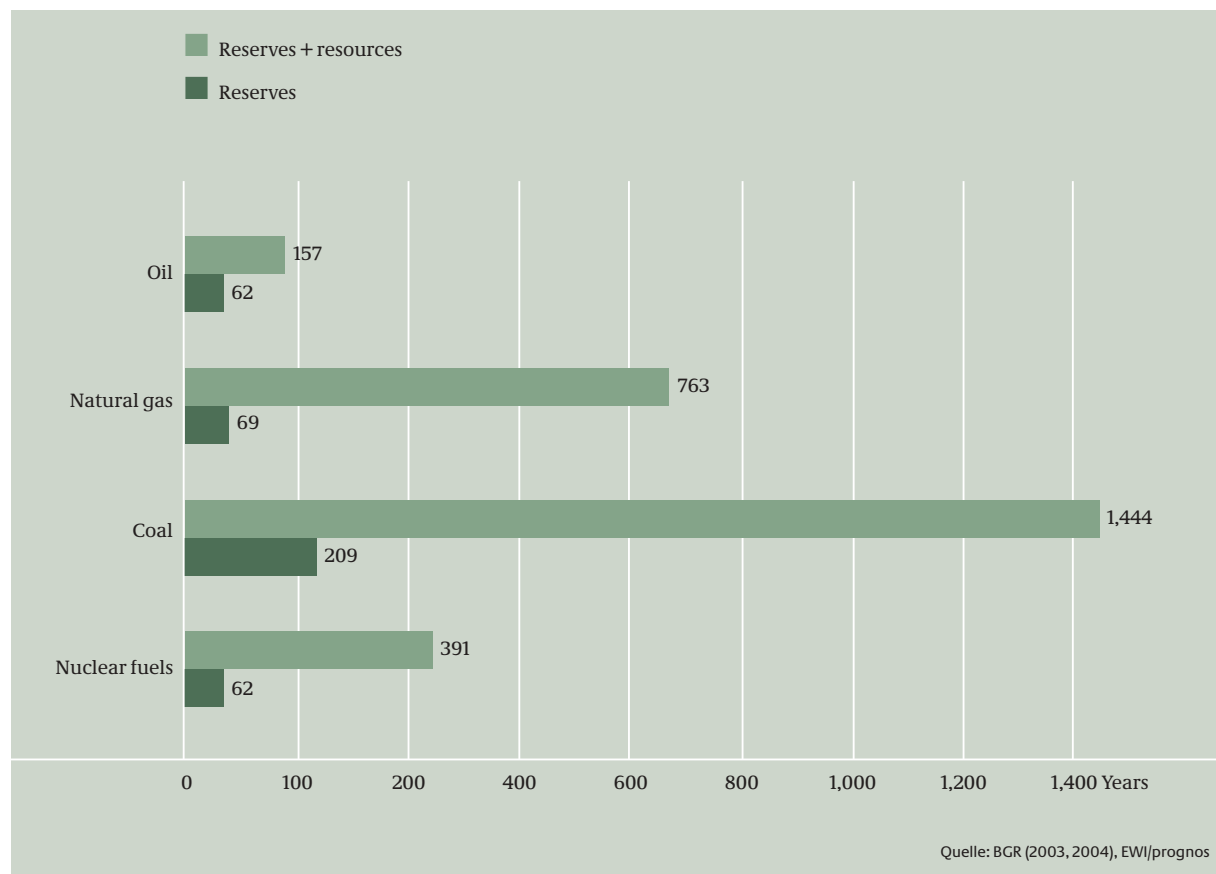
Potentials offered by the renewable energies are enormous. But the amounts that will be commercially exploitable by 2030 remain modest.

By far the largest fossil energy potentials are available in the form of coal. The static reach of coal reserves (based on today's annual production; R/P ratio) exceeds 200 years; that of total resources more than 1,400 years.

The static reach of natural gas resources is also very long. Included are large amounts of non-conventional natural gas.

Oil features the most unfavourable ratio of overall resources to world consumption. Calculation models by the International Energy Agency show that peak production levels of conventional oil could be reached between 2015 and 2035. At that point, non-conventional petroleum will increasingly be used.

Static Reach of Non-Renewable Energy Reserves and Resources



Energy Consumption by World Regions

According to available international status-quo forecasts, world energy consumption will increase some 60 % by 2030. Developing countries will account for two-thirds of the increase. Counter-measures could reduce the rising trend.

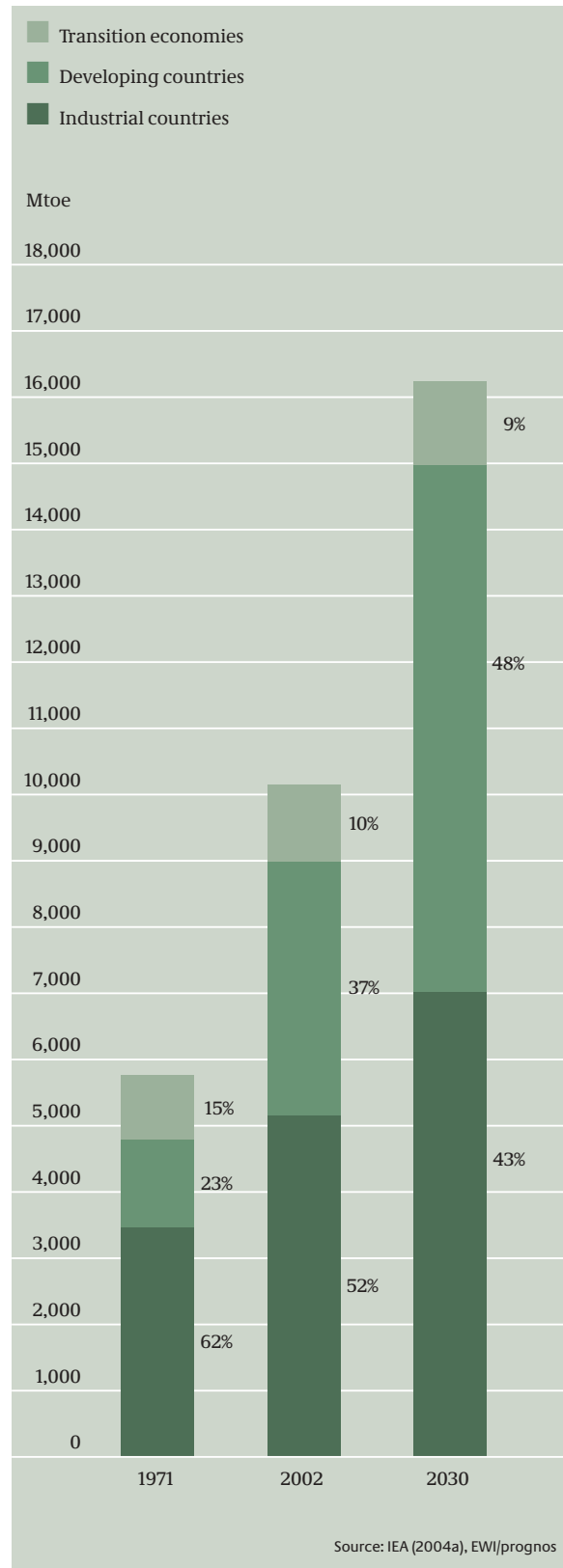
In 2000, industrial countries accounted for more than half of world energy consumption, the developing countries a good third, and the transition economies one tenth. In 2030, the developing countries will be consuming more energy than the industrialized countries.

In 2030, the developing countries will account for 48 % of world energy consumption, while their share the world population will be 82 %.

At 1.2 toe per capita in 2030, per capita energy consumption in the developing countries will be one-fifth of the level reached in the industrial countries (6.4 toe per capita).

Global energy consumption will increase at a somewhat slower pace than during the past 30 years. But owing to the higher starting level, absolute aggregate global energy consumption in the 2000 – 2030 period will be roughly 70 % higher than in the 1970 – 2000 period.

Energy Consumption by World Regions 1971 – 2030



Determinants of World Energy Consumption

Global population will expand from six to eight billion persons. Per capita income will continue to rise. The decline in the amount of energy required to generate a unit of economic output will slow the growth of energy consumption.

In 2030, two billion more people (+33%) will be consuming energy.

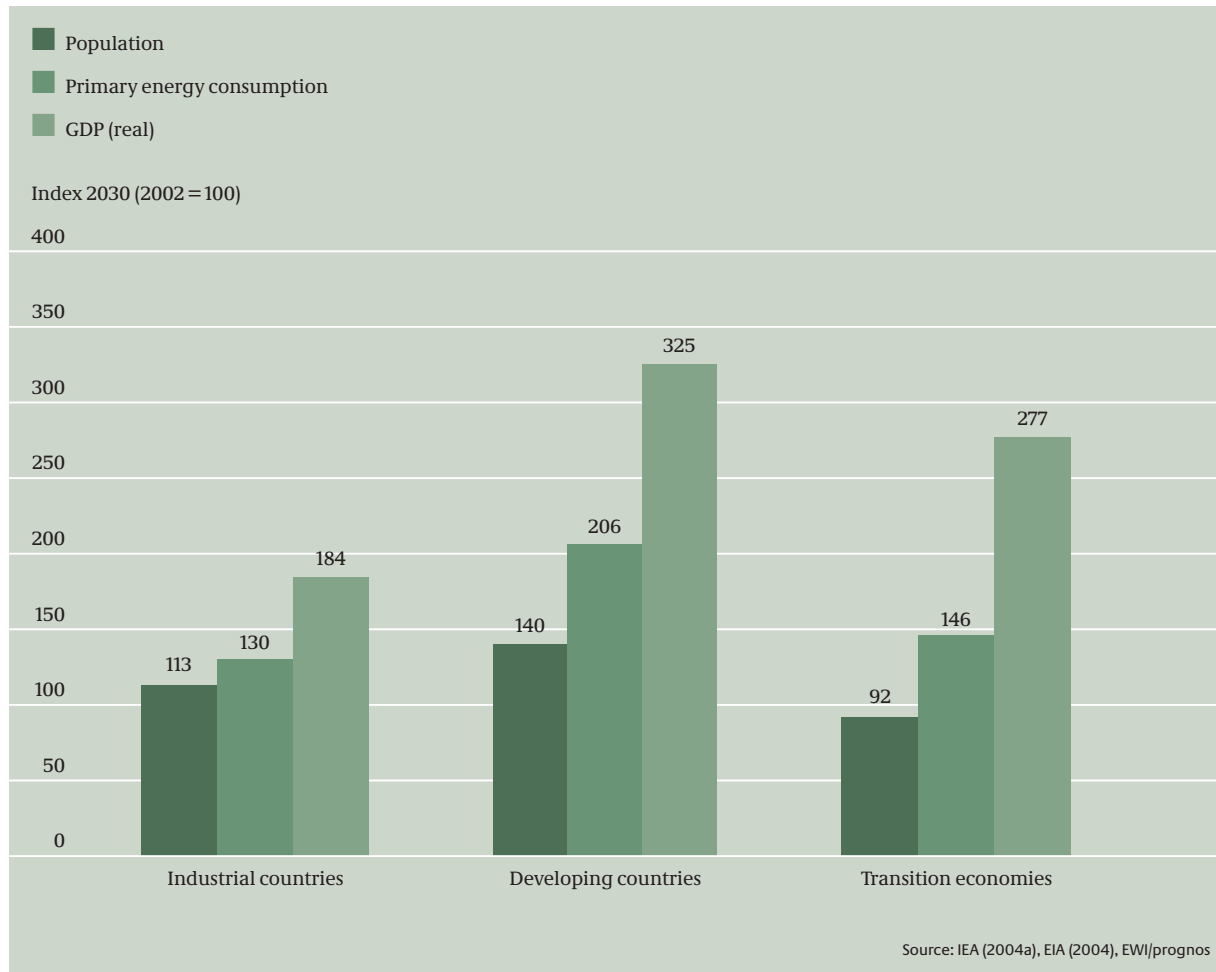
An end of the worldwide increase in energy demand is not in sight. By 2030, world primary energy consumption will rise from an annual 10 to 16 billion toe.

Per capita economic output will be a good 60% higher in the industrialized countries, in the developing countries it will more than double, and in the transition economies it will increase threefold.

Primary energy consumption per unit of economic output (primary energy intensity) will decline in the industrialized countries by just under 30%, in the developing countries by just less than 40%, and in the transition economies by almost 50%.

But the decline in primary energy intensity will not be enough to offset the rise in per capita income. Per capita energy consumption will continue to expand in all of the regions of the world.

Population, Energy Consumption, and GDP by World Regions 2002 – 2030



Meeting the Demands of Global Energy Consumption

Fossil energy sources will account for more than four-fifths of global energy consumption in 2030. Oil will continue to be the most important primary energy source in 2030, accounting for 35% of consumption.

The structural changes observed in world energy consumption over the past three decades will continue over the next three decades.

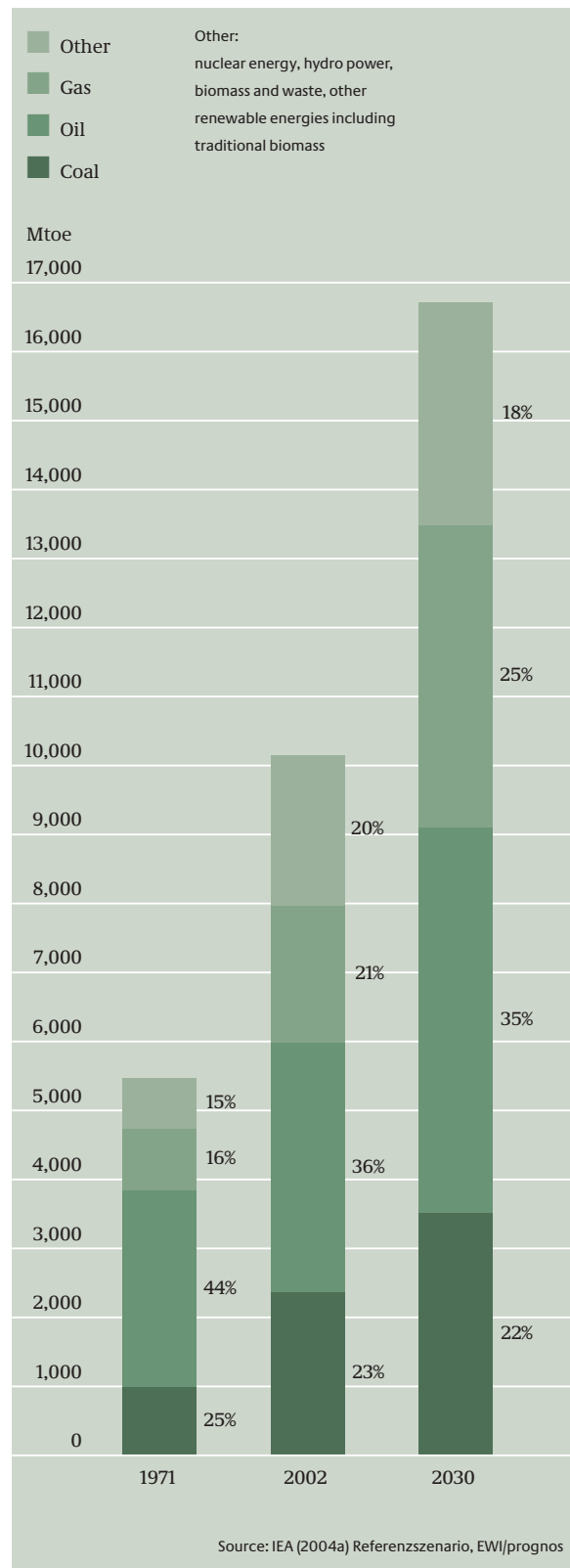
The share accounted for by coal will decline further.

The reduction of oil's share will continue at a barely visible pace. Oil will still be the most important energy source in 2030.

Gas will further increase its share of global energy consumption and become the second most important energy source.

Non-fossil energy sources (hydro power, nuclear energy, other renewable energies including traditional biomass) increased at a faster pace in the past than fossil energy sources; they will continue to expand but their share in global energy consumption will decline slightly.

Global Energy Consumption by Energy Sources 1971 – 2030



Global CO₂ Emissions

According to current international energy projections, energy-related emissions will rise worldwide by more than 60 % up to the year 2030 if no counter-measures are taken. Developing countries will account for two-thirds of the increase. China and India will become large-scale emission sources.

If no countermeasures are taken, the world's energy-related CO₂ emissions will continue to increase up to 2030.

In the IEA's reference scenario, CO₂ emissions will rise just as fast as world energy consumption (1.7 % annually) and increase 60 % by 2030.

Developing countries will account for two-thirds of the CO₂ emission increase. In 2030, developing countries' CO₂ emissions will be higher than those of the industrialized countries.

China and India will become large-scale emission sources. In the IEA's reference scenario (2004), China will be the largest source of CO₂ emissions in 2030 after OECD-North America (US, Canada, Mexico). India and China together will emit more CO₂ than OECD-North America.

The Largest CO₂ Emission Sources 1971 – 2030



Expanded Natural Gas Markets

The largest part of world reserves of natural gas is located in reach of Europe. The growing LNG trade will give Europe access to new gas sources. Competition by Asian and American gas consumers will continue to increase.

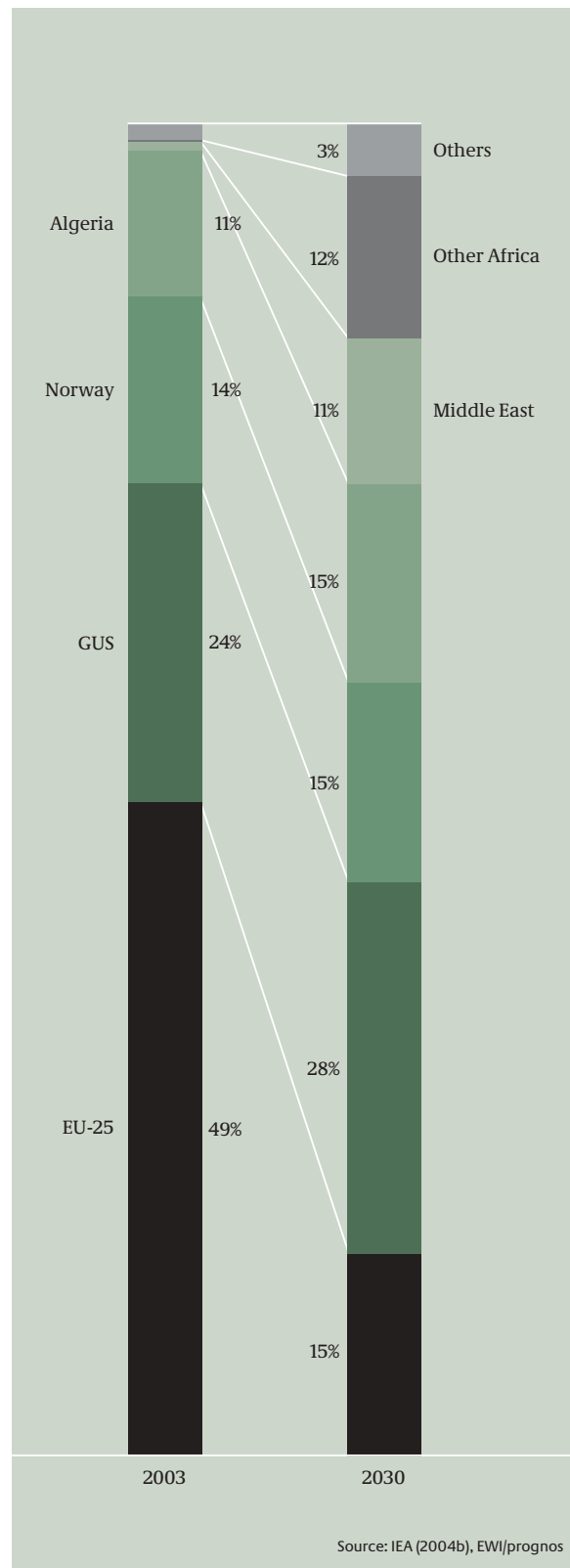
Natural gas consumption by the EU 25 will rise by roughly 50 % by 2030, while natural gas production within Europe will decline sharply. The share of domestic production will fall from 49 % to 15 %.

The lowering of transport costs and expansion of the LNG trade will open up new gas supply possibilities for Europe, but they will also strengthen demand by competitors. Asian consumers will compete with Europe for supplies from the large area comprising West Siberia/Caspian/Middle East (strategic ellipse). An LNG competition with the United States (albeit quantitatively limited) is also expected.

New demand on the gas market is developing with the GTL (Gas to Liquids) technology: the production of oil products from natural gas. The amounts of gas diverted to the oil market will be considerable, but this will hardly have an impact on European gas markets.

Despite the market expansion, the number of large natural gas exporters to Europe will remain limited. The United Kingdom and the Netherlands will disappear as net exporters. Production by Algeria and Norway will peak in the coming decades or will refrain for political reasons from exceeding certain production levels.

Gas Consumption in the EU-25 by Supply Regions 2003 – 2030



Prices of Energy Commodities

Oil and natural gas will become significantly more expensive. In 2030, real import prices for oil and natural gas will be roughly twice as high as in the nineties. The oil price will rise in real terms to 37 US-(2000) a barrel in 2030. The price of hard coal will increase only slightly, while the price of lignite will remain constant in real terms.

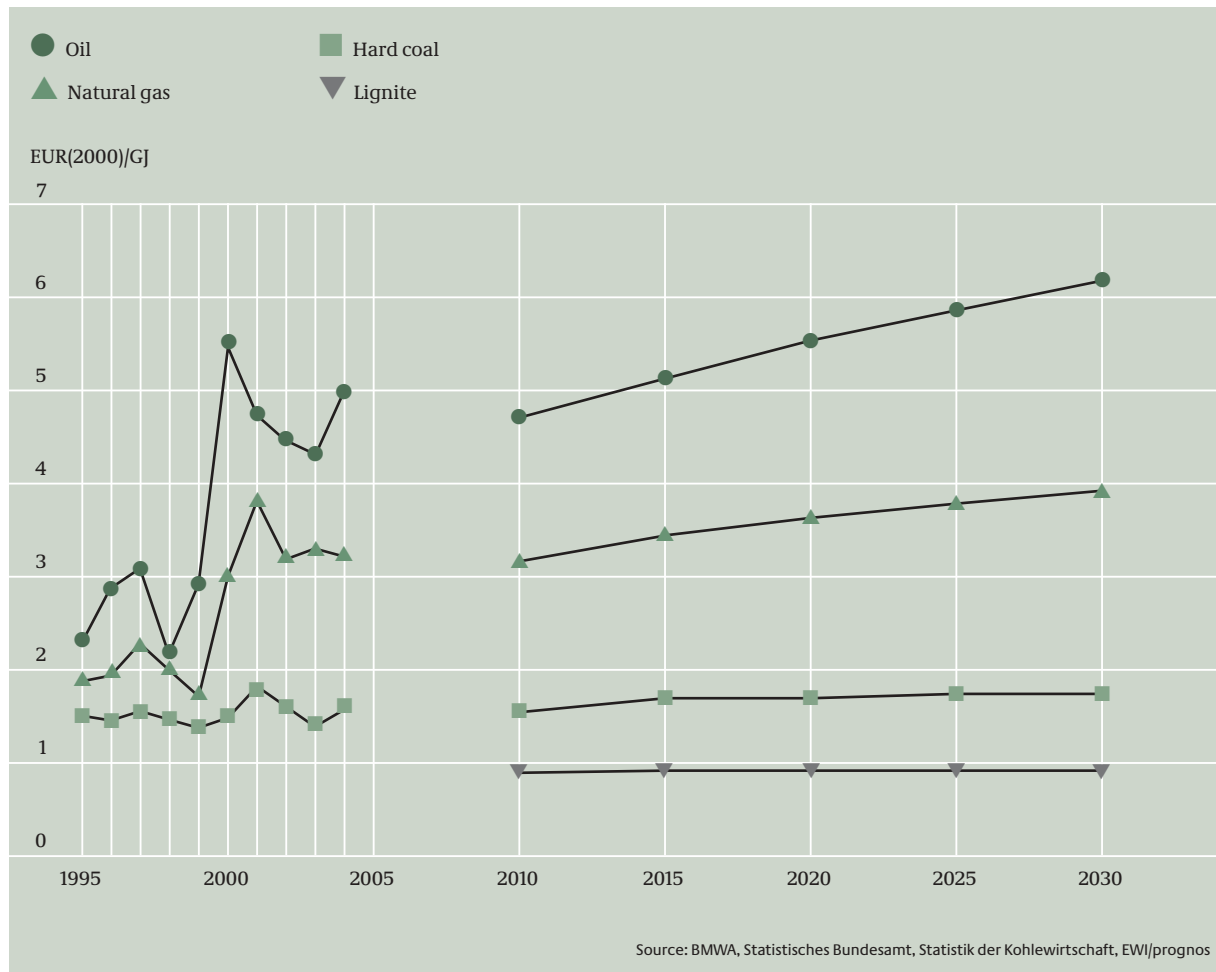
Oil and natural gas will cover two-thirds of world energy consumption in 2030 and import prices for petroleum and natural gas will be roughly twice that of the nineties. Real oil prices will be at 37 US-(2000)

a barrel in 2030. This assessment is in the upper range of price forecasts in the most recent long-term scenarios sketched by the EIA, IEA, and the EU Commission.

The price risks in connection with oil and gas will increase since the dependence of supplies on politically and economically unstable production and transit regions will increase.

By contrast, the import prices for hard coal and the price of lignite will continue to move at a low level.

Real Prices of Oil, Natural Gas, Coal, Lignite 1995 – 2030



Consumer Prices for Fuel Oil and Natural Gas

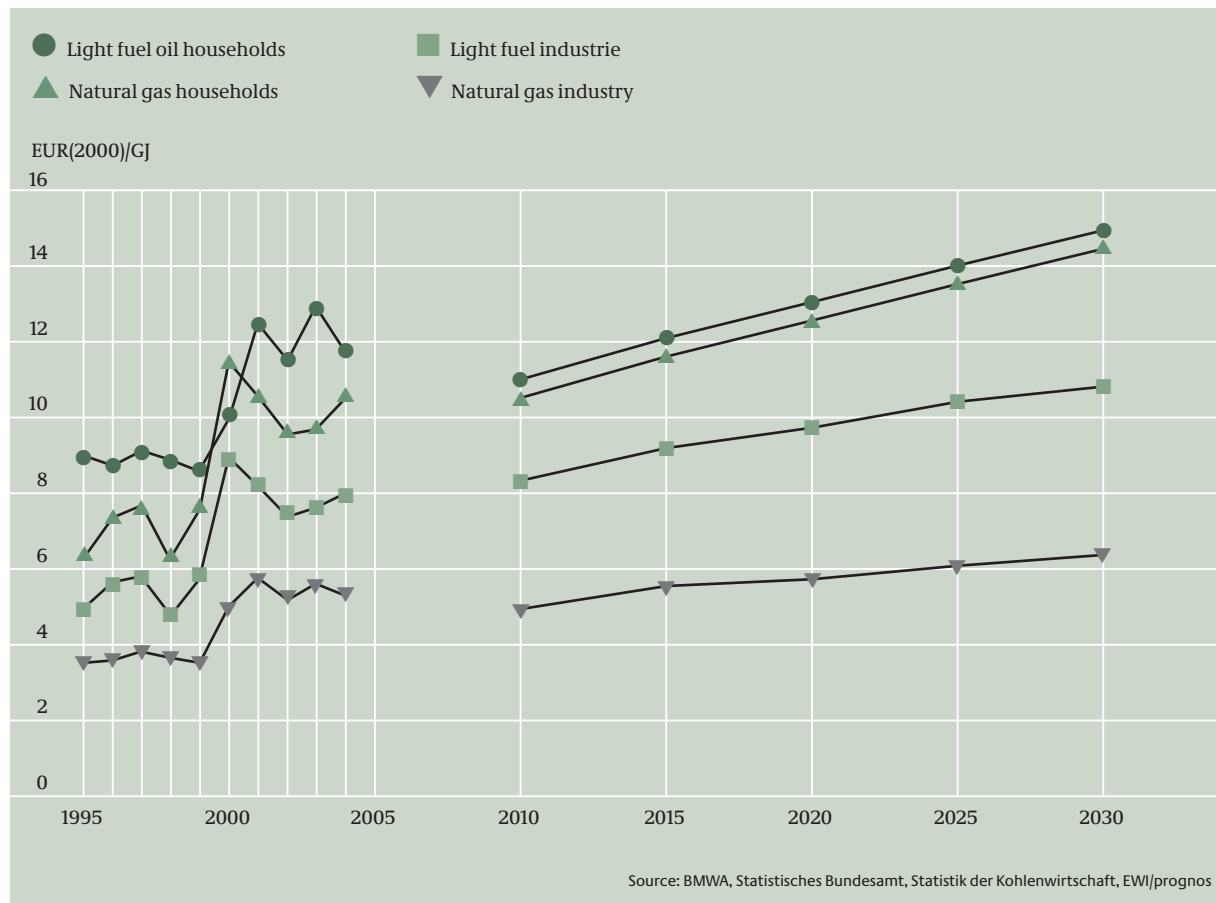
Owing to the base effect of energy taxes and processing and transport costs, domestic consumer prices for oil products and natural gas will rise less sharply than import prices.

Domestic consumer prices will be determined by: the import price trend, the trend of domestic processing and transport costs, energy taxes, and the CO₂ levy.

The Reference Forecast presupposes that energy tax rates (at the 2003 level) will remain constant in real terms and that consumer prices will include a CO₂ surcharge in keeping with the carbon content of the energy source.

Based on this assumption, consumer prices for petroleum products and natural gas will rise more slowly than import prices. In the case of petroleum products, the main reason is the base effect of the tax; in the case of natural gas the reason is grid prices that will decline in real terms.

Real Consumer Prices for Fuel Oil and Natural Gas 1995 – 2030



Electricity Prices

Electricity prices reached a record low in 2000. The wholesale price of electricity will double by 2010 relative to the 2000 level and subsequently continue to rise slightly. Grid prices will decline in real terms throughout the forecast period. After 2010 prices for individual consumer groups will show differing trends. Industrial electricity prices will rise slightly, and household electricity prices will decline slightly.

Electricity prices for end users are determined by producer prices (wholesale prices), grid prices, and taxes and other charges.

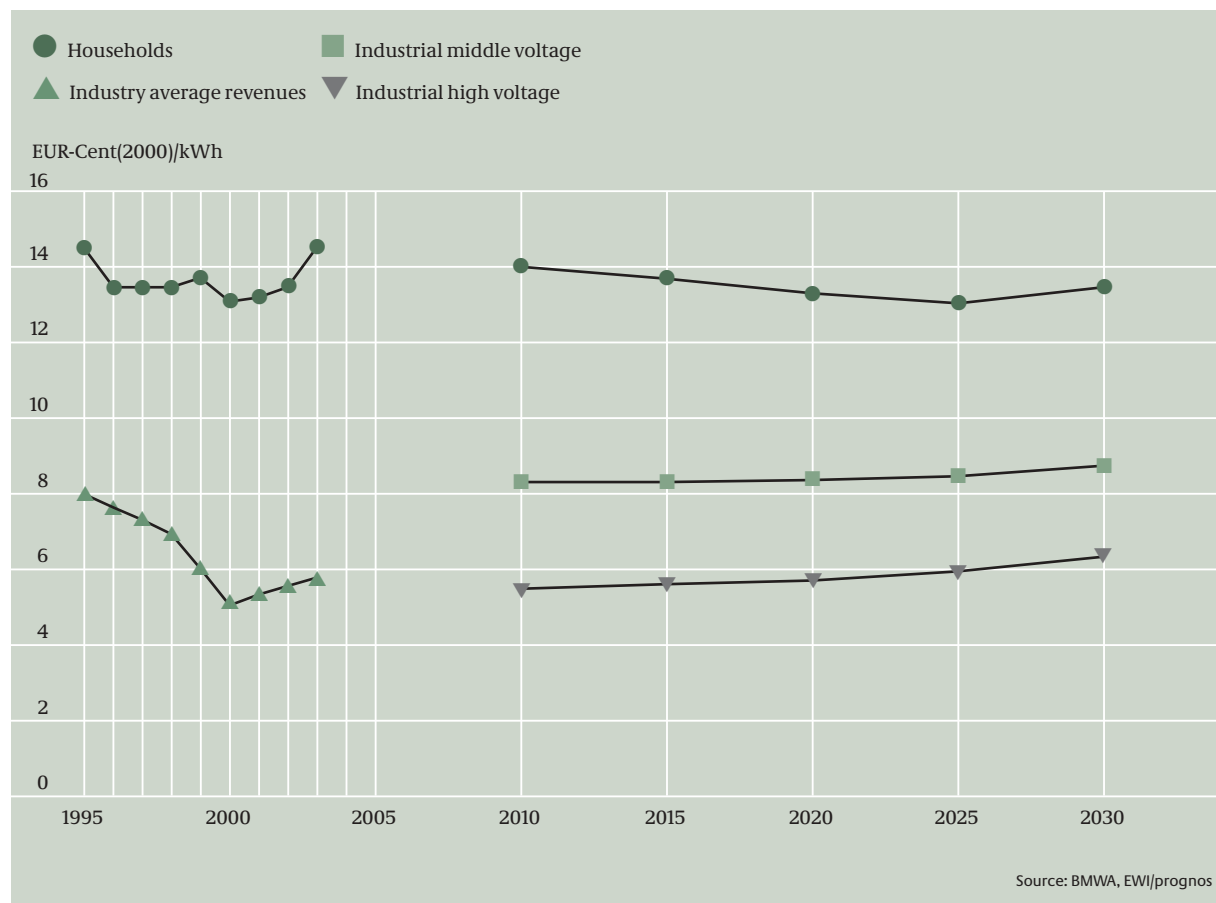
In 2000 the wholesale price for electricity fell to the level of short-run marginal costs. The return to the full cost level in 2010 will mean a real doubling of the 2000 level. The wholesale price will thereafter

again increase slightly as the result of rising fuel prices. By contrast, throughout the entire forecast period grid prices will decline in real terms relative to the 2000 level.

The Reference Forecast presupposes that the electricity tax rates will not rise above the 2003 level. The charges resulting from the promotion of renewable energies and cogeneration processes will rise sharply in the medium term and later decline slightly.

After 2010, industrial and household prices will feature differing trends. Industrial electricity prices will rise in real terms as the result of the higher wholesale prices. Household prices will decline slightly owing to the stronger influence of grid prices.

Real Electricity Prices 1995 – 2030



Structural Changes in the Electricity Sector

The internal market for electricity will impose increasing market pressure on electricity producers. At the same time, investment and operational decisions will be extremely subject to the influence of political factors. Germany is phasing out the use of nuclear energy, expanding the use of renewable energies, and launching CO₂ emissions trading. It will become more difficult to reconcile the goals of cost effectiveness, supply security, and the environmental compatibility of electricity production.

Liberalization of electricity markets and their integration in Europe will continue. Electricity producers will be exposed to increasing market pressure. At the same time, the electricity industry's investment and operational decisions will to a growing extent be influenced by political factors such as the phase-out of nuclear energy, expansion of renewable energies, and launching of CO₂ emissions trading.

The phase-out of the use of nuclear energy means that just less than a fifth of power station capacities, which in 2000 supplied nearly 30 % of electricity production, will be de-commissioned before the end of their commercially viable lifetimes.

An increasing portion of electricity production – from renewable energies and decentralized, heat-directed cogeneration plants – will not be dispatched in accord with the electricity price. This will require greater flexibility on the part of the other, conventionally fuelled power stations. Such power stations will have to provide more balancing and reserve energy.

The steering of production and loads by electricity storage and load management is taking on ever more importance and being applied where profitable.

The integration of increasing amounts of wind energy requires an expansion of the German and European transmission grid and may have a substantial impact on the international exchange of electricity.

CO₂ trading is worsening hard coal and lignite's competitive position in electricity production.

Electricity Exchange in Europe and the Planned Expansion of Inter-Connector Capacities



Technical Progress in the Electricity Sector

In the case of fossil-fuel-driven power stations and nuclear power stations, there is considerable potential for boosting operating efficiencies, lowering costs, reducing the emission of pollutants, and increasing security. Some techniques for electricity production from renewable energies will come close to the threshold of cost-effective operations toward the end of the forecast period.

For fossil-fired power stations, a further substantial improvement of conversion efficiencies is anticipated. In coal-fired plants, conversion efficiencies of more than 60 % are attainable and in gas-fired plants more than 70 %. Further improvements are expected with flexible load-following techniques, pollution prevention, and security aspects.

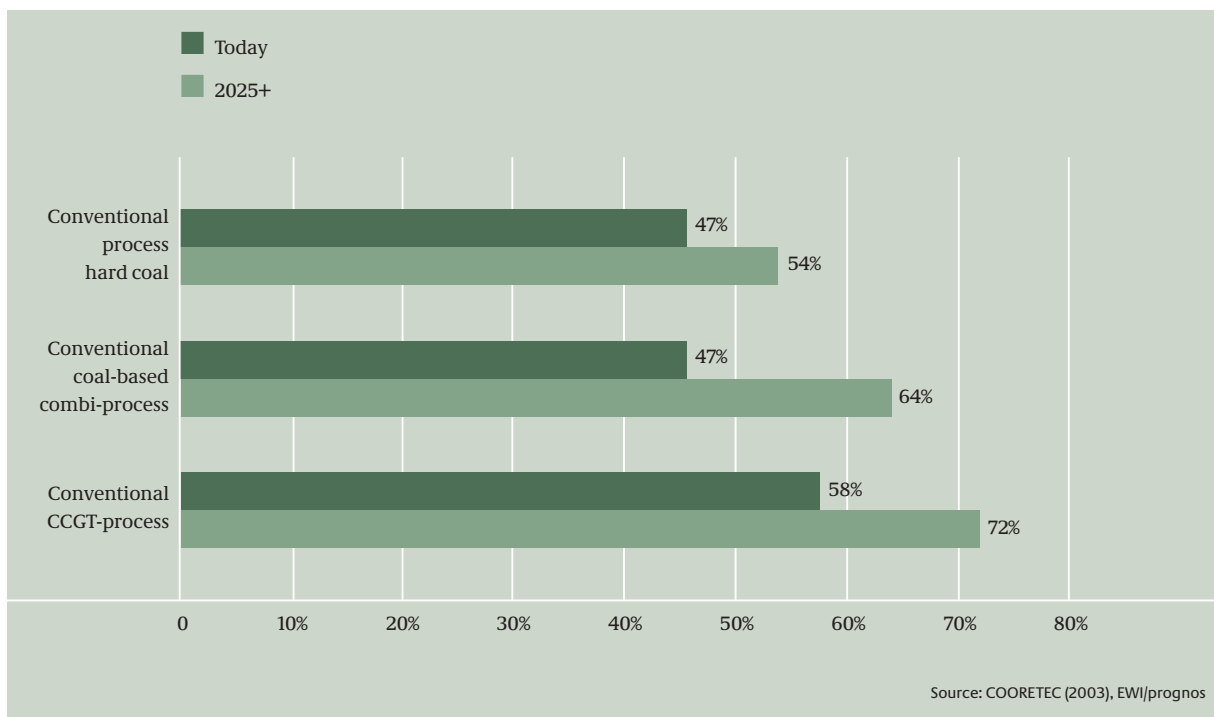
Third generation nuclear power plants are being developed: EPR, SWR 1000, AP 600, AP 1000, and ABWR. Prototype fourth-generation reactors are expected in 2030.

In the case of the new technologies for electricity production from renewable energies, considerable advances are generally anticipated. Some of these technologies will approach commercial break-even in Germany toward the end of the forecast period.

Innovations such as fuel cells and CO₂ sequestration/storage will take on growing but limited importance in the forecast period.

Hydrogen will not play a role as the fuel of the future until after 2030.

Electric Conversion Efficiencies of Selected Power Station Technologies Today and 2025+



Emission Trading in Germany

The trade in greenhouse gas emission rights was officially launched in the EU's 15 countries on 1 January 2005. A major impact is not expected during the initial allocation period.

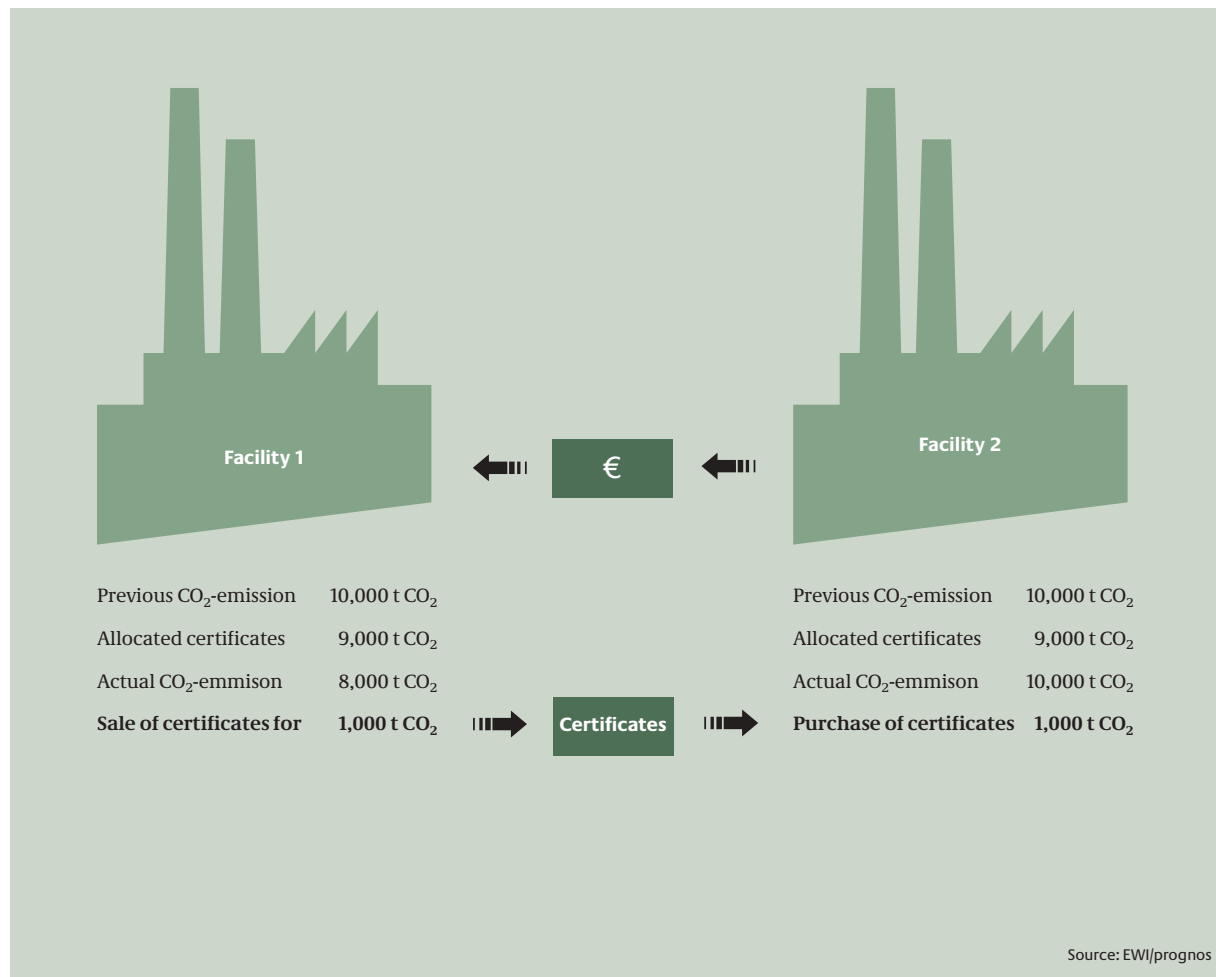
The idea behind emissions trading is cost-efficient prevention of climate-damaging greenhouse gas emissions in the European Union. During the first allocation period (2005 – 2007), all of the large-scale installations of energy-intensive industries are included in the trading system.

The allocation of emission certificates as specified in the National Allocation Plan, and the reduction path it sets forth lead us to anticipate only relatively slight effects on the economical efficiency of these

installations. Households, services sector, and transport will initially not participate in emissions trading.

In the first allocation period, emissions trading in Germany will be relatively limited. The price of the emission certificates is likely to be below 10 EUR/t CO₂. In the longer term, emissions trading will take on increasing importance worldwide. With moderate climate protection policies, prices will be as much as 15 EUR(2000)/t CO₂ in 2030.

Design of the Emissions Trading System



International Framework

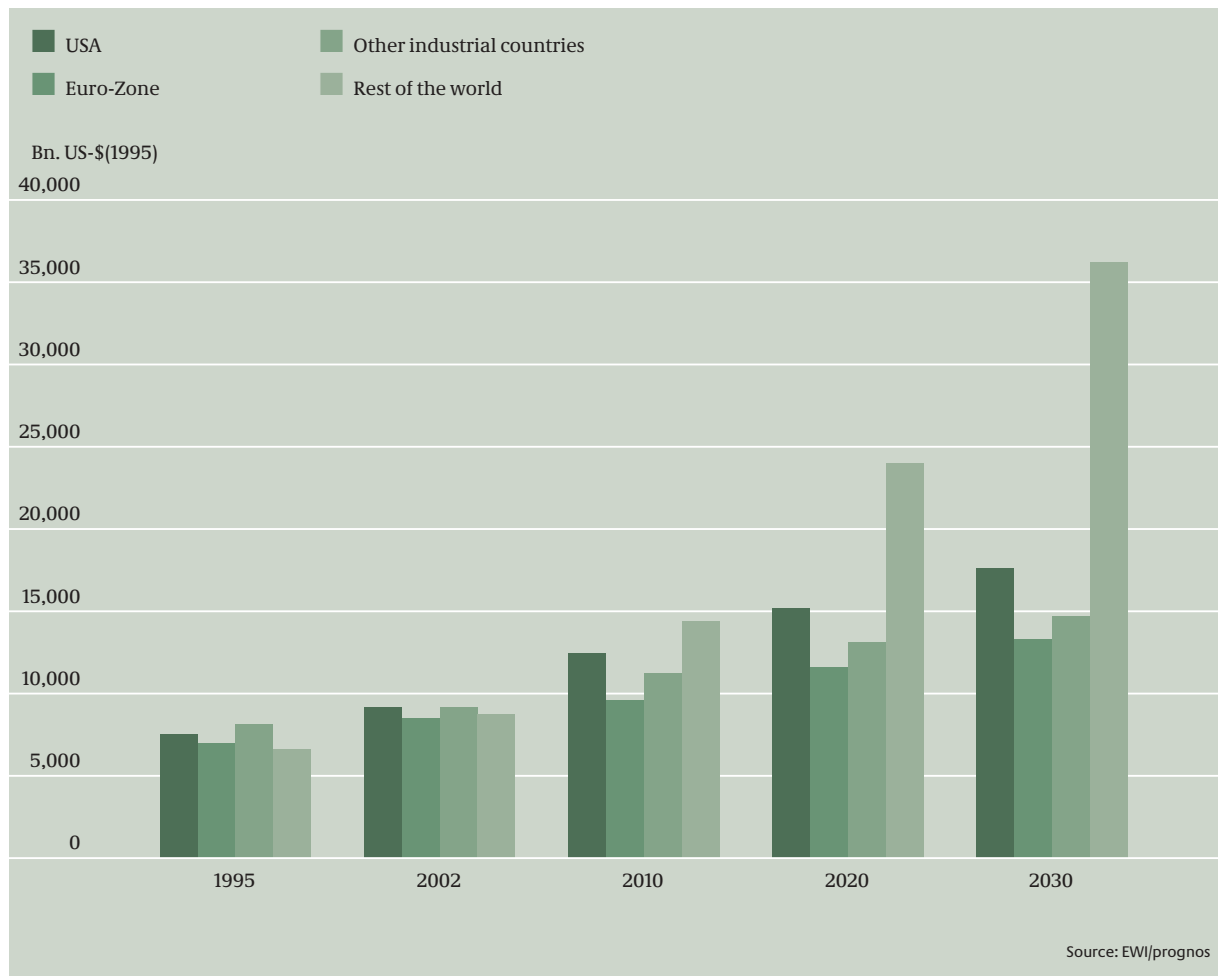
The world economy will expand by an annual average 3% between 2002 and 2030. Risks will increase as the result of the increasing worldwide interdependencies.

The globalization process is going to continue. Technological innovation, especially in the information and communication technologies, will contribute to this process. Multinational corporations will exploit regional differences in cost structures, thus reinforcing global trade flows.

The ongoing international globalization and increasing interdependencies will increase the danger of potential crises being passed on from country to country. Particular risks are generated by the instabilities in the Near East.

During the forecast period, the global economy will grow at an annual average of 3%. The highest growth rates will be achieved in Asia, above all in China. The new Member States of the EU can look forward to a relatively good outlook. The classic industrialized countries will grow at roughly 2%. Growth rates in the United States and Europe will begin to merge.

Real Gross Domestic Product by Countries and Country Groups 1995 – 2030



Real Gross Domestic Product and Resident Population 2002 – 2030

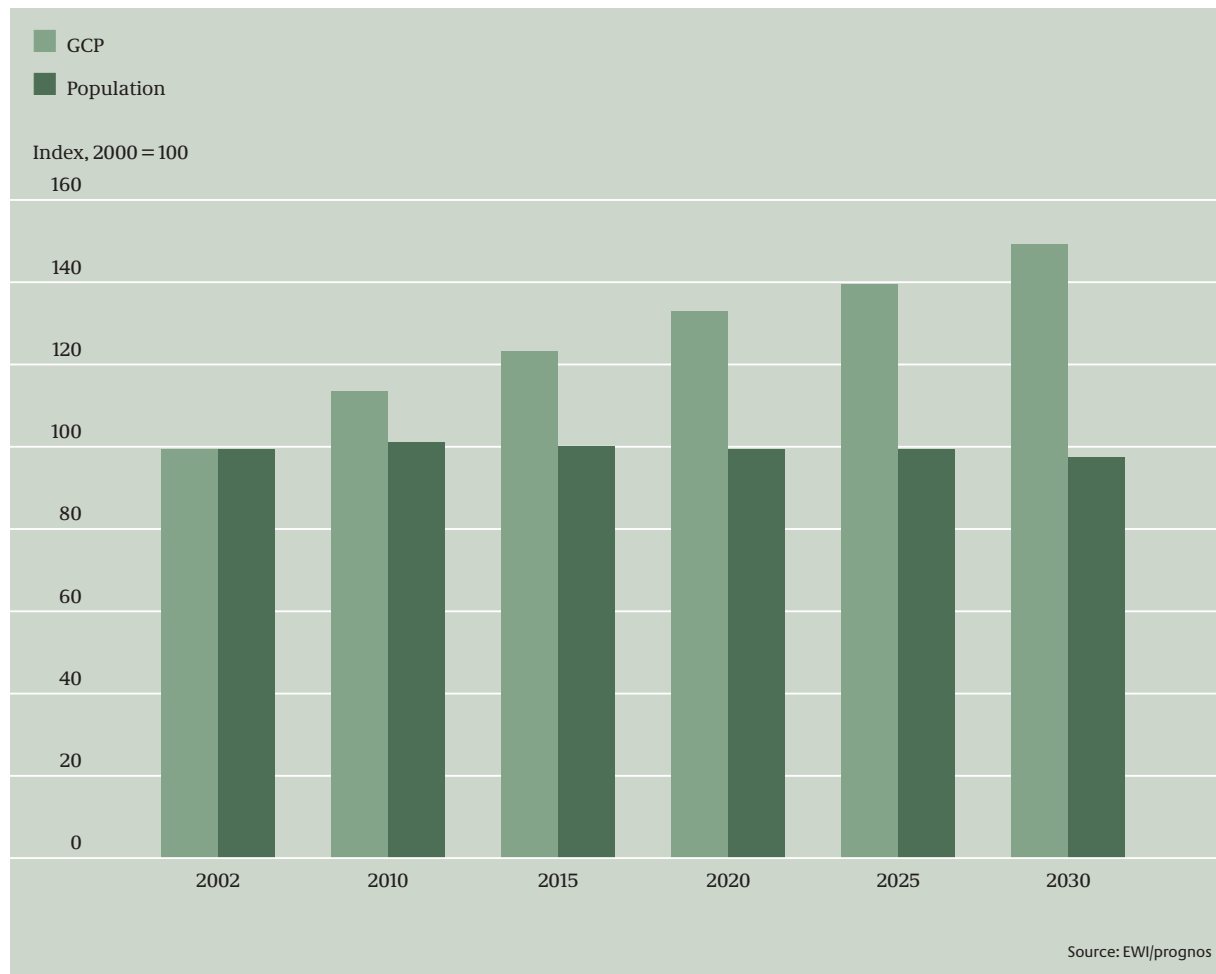
Germany's economy will experience an annual average 1.4% growth. The population will decline and age rapidly.

Germany's population will decline during the forecasting period. Continuing net immigration will slow this trend. In 2030, roughly 79.4 million people will live here, some 3.6 % less than today.

From 2020 onwards there will be a tendency toward shortages on the labor market. In connection with the declining population and weaker impulses from the global economy, growth will slow.

Industry will safeguard its international competitiveness through technological advances and innovative products.

Real Gross Domestic Product and Resident Population 2002 – 2030



Technological Trends in Energy Demand

Technical innovation will continue to influence the form and scope of energy use. The new technologies will only gradually find their way into everyday application as the result of long investment cycles.

Technological innovation will decisively influence energy consumption. Its impact will be seen above all in a reduction of specific wastages. Technological interfaces help lower consumption in numerous fields (e.g. stand-by modes on electrical appliances), and dedicated energy conservation technologies in individual applications (e.g. membrane technology for chlorine production).

Technological progress will continue to be implemented as part of normal investment cycles. To some extent, this will be done in the form of multiple smaller contributions.

Alongside individual technologies, developments in the field of nano technology and bio technology will offer considerable potential for energy conservation in the future. But substantial R&D efforts must still be invested if these potentials are to be fully exploited. Quantum leaps in technology, with massive impacts on energy consumption, should not be anticipated.

Technological Trends in Energy Demand



Total Final Energy Consumption

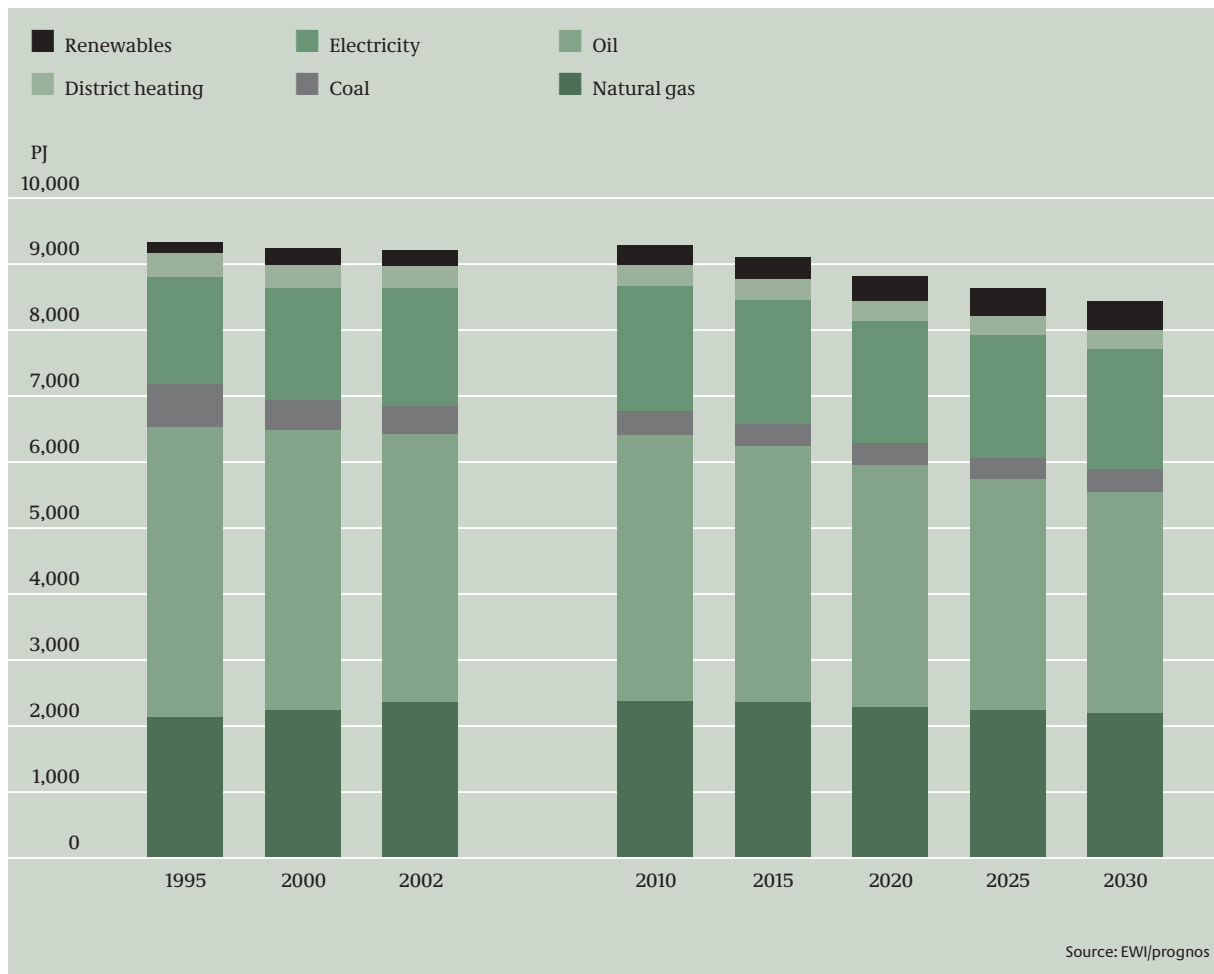
Final energy consumption will decline in all demand sectors by 2030. Electricity and natural gas will increase their respective shares.

The energy market will continue to contract on an ongoing basis. In 2030, just under 9% less final energy will be consumed in Germany than today.

This trend is visible in all areas of consumption: in the services sector consumption will decline 21%, for households the figure is 9%, industrial consumption will fall 7%, and transport will require just under 4% less energy. If the trend is adjusted to take account of climate factors, the reduction in energy needs will be even more pronounced.

Electricity consumption will increase slightly; in 2030 it will be a good 4% higher than in 2002. The market for oil products will continue the decline already underway since 2002. The same applies for coal, but to a greater extent. Gas sales will decline after 2010. The consumption of renewable energies will increase by more than 87% in the forecast period. In 2030, they will cover a good 5% of final energy needs.

Final Energy Consumption by Energy Sources 1995 – 2030



Final Energy Consumption in Households

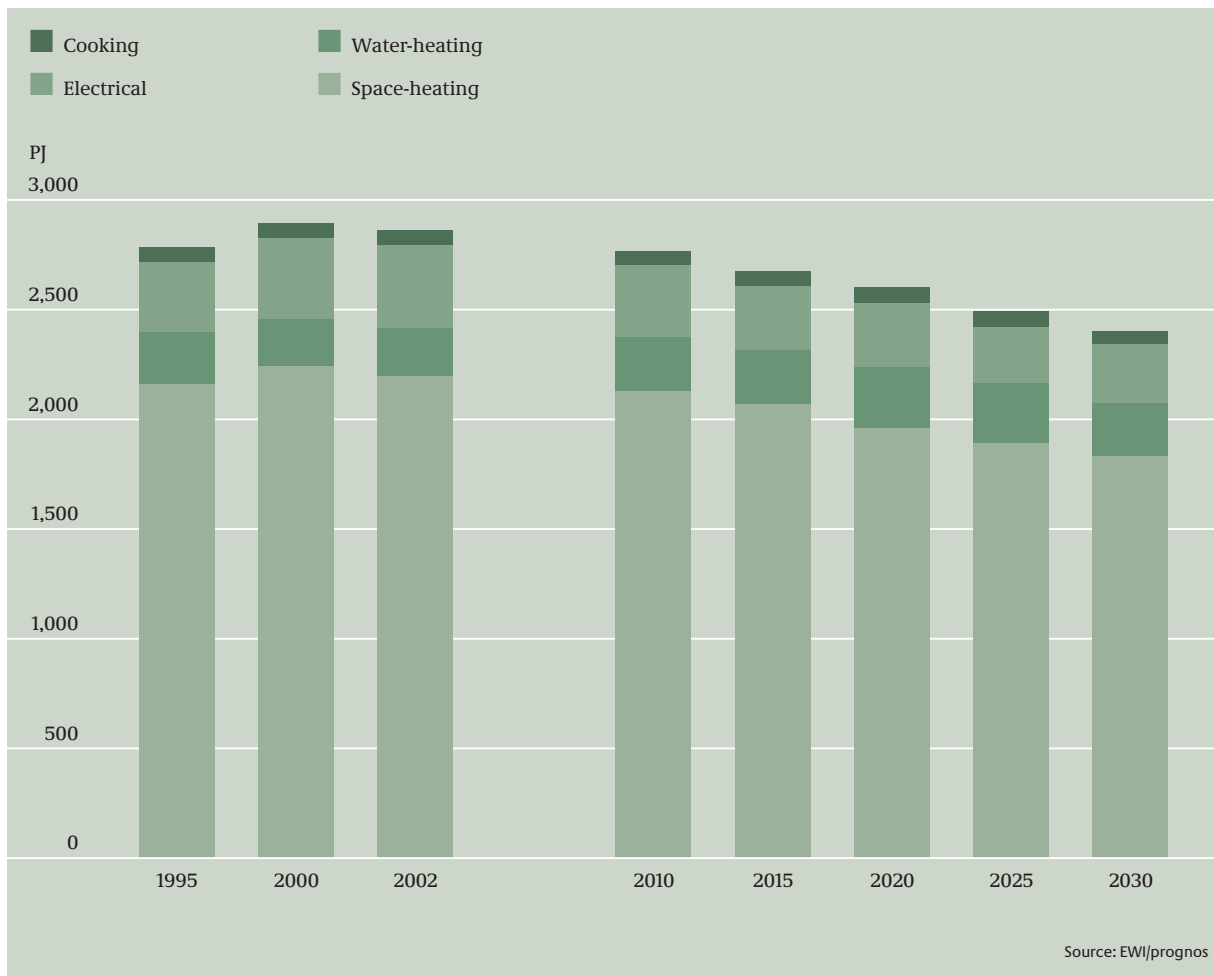
Households will consume some 14 % less energy in 2030 than in 2002. Owing to the increasing use of electrical devices, electricity consumption will not decline until after 2020.

Energy consumption in households will decline on an ongoing basis in the forecast period. In 2030 the figure will be 14 % after adjustment for climate factors, or 229 PJ lower than in 2002.

Despite an expansion of housing areas by just less than a third by 2030, some 17 % less heating energy will be required than in 2002. The improved quality of new and renovated buildings as well as more efficient heating units, are responsible for the drop in energy consumption.

Electricity consumption by households will rise in the years up to 2015, and fall significantly after 2020. Contributing to the increased consumption will, in particular, be the growing use of electrical appliances in households. This effect will be over-compensated only after 2020 by the smaller number of households and increasingly energy-efficient devices.

Final Energy Consumption of Households by Applications 1995 – 2030



Final Energy Consumption in Agriculture, Commercial, Services and Other Consumption Areas

Energy demand will decline by 23% in the sector agriculture, commercial, services and other consumption areas by the year 2030. The energy mix will change considerably. Consumption of all energy sources will fall except for renewable energies.

The sector agriculture, commercial, services and other consumption areas covers, among others, all service areas that are of increasing importance for economic growth and employment. In this sector some 16.5% of all final energy was consumed in 2002.

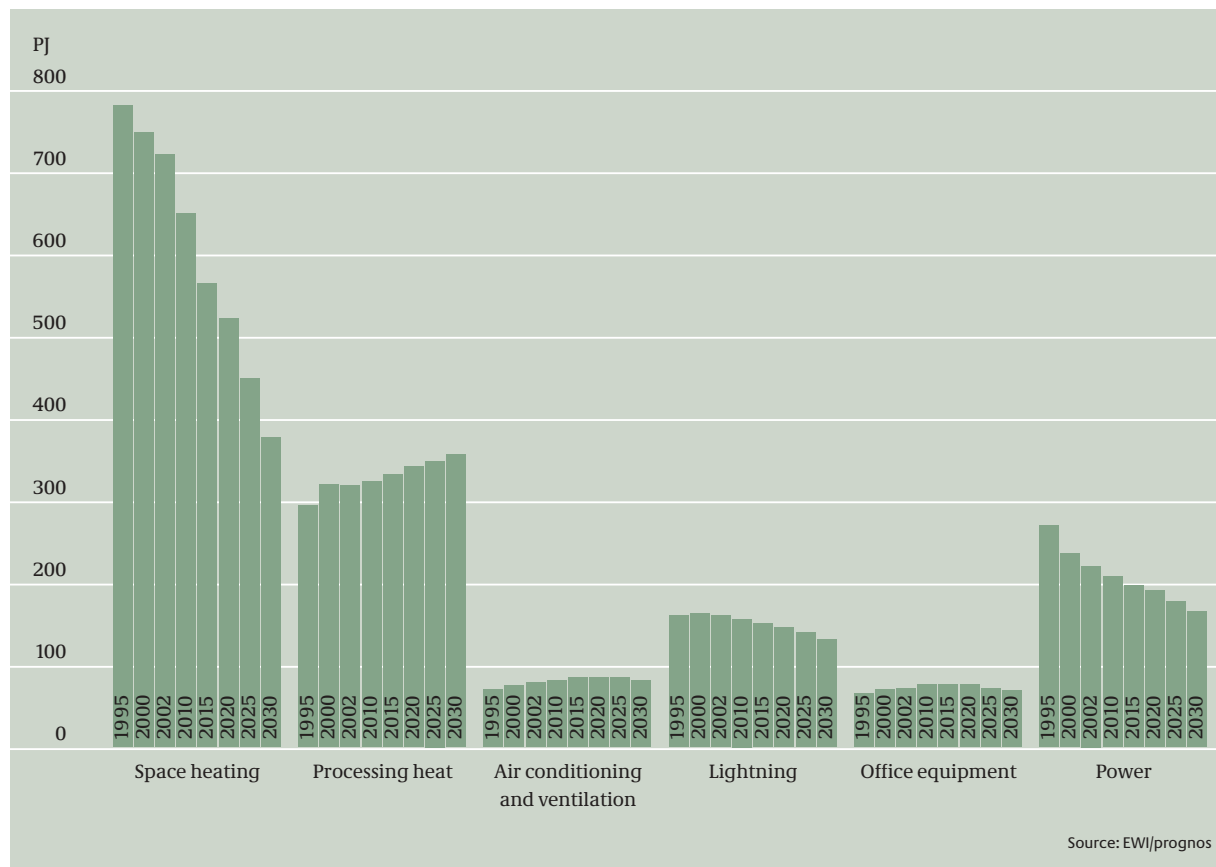
After adjustment for climate factors, energy consumption will decline by 23% from 2002 to 2030. This corresponds to a decrease of just under 1% a year.

Energy consumption in the space heating sector will decline by 46%. Increases will occur in the demand for energy for process heat and for cooling and the operation of office equipment.

The branches with the sharpest drops in energy consumption will be the public sector and agriculture. By contrast, the decline of consumption in banking and insurance, and in other private service providers, will not be significant.

There will be considerable shifts within the energy mix during the forecast period. Electricity's share will rise from 31% to 37%. Gas will also gain ground, while oil's share will decline. Consumption of all energy sources will fall except for renewable energies.

Final Energy Consumption in Agriculture, Commercial, Services and Other Consumption Areas 1995 – 2030



Final Energy Consumption in Industry

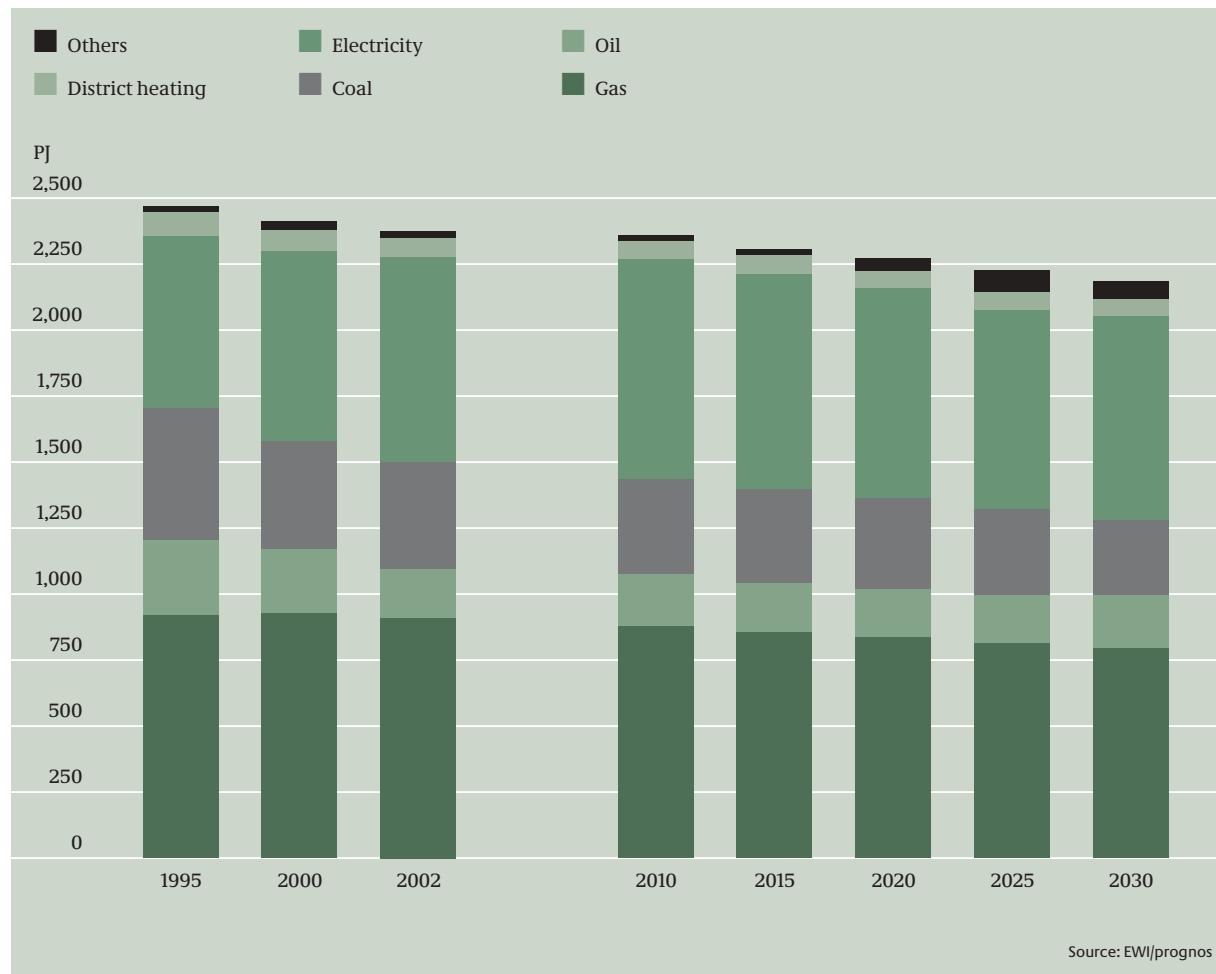
Final energy consumption in industry will decline by a total of 7% by 2030. The demand for electricity will increase.

Final energy consumption in industry will decline on an ongoing basis by a total of 7% by 2030. It will then stand at 2,177 PJ.

While fuel demand will be on the decline, electricity consumption will increase by 10% from 2002 to 2030. Electricity's share in the industrial energy mix will therefore rise from a good 32% to more than 38%. Gains in market share will otherwise be registered only by the renewable energies.

Energy efficiency in industry will improve during the forecast period. Specific final energy consumption related to production values will fall from 5.9 PJ/EUR billions in 2002 to 3.6 PJ/EUR billions in 2030, corresponding to an annual 1.7% decline.

Final Energy Consumption in Industry by Energy Sources 1995 – 2030



Final Energy Consumption in Transport

Final energy consumption in the transport sector will decline by just under 4% by 2030 owing to increasingly efficient vehicles. Conventional diesel fuel and bio fuels will take on considerably more importance.

At 2,580 PJ, final energy consumption in the transport sector in 2030 will be 3.7% lower than the 2002 level. The decline in consumption will for the most part occur after 2015.

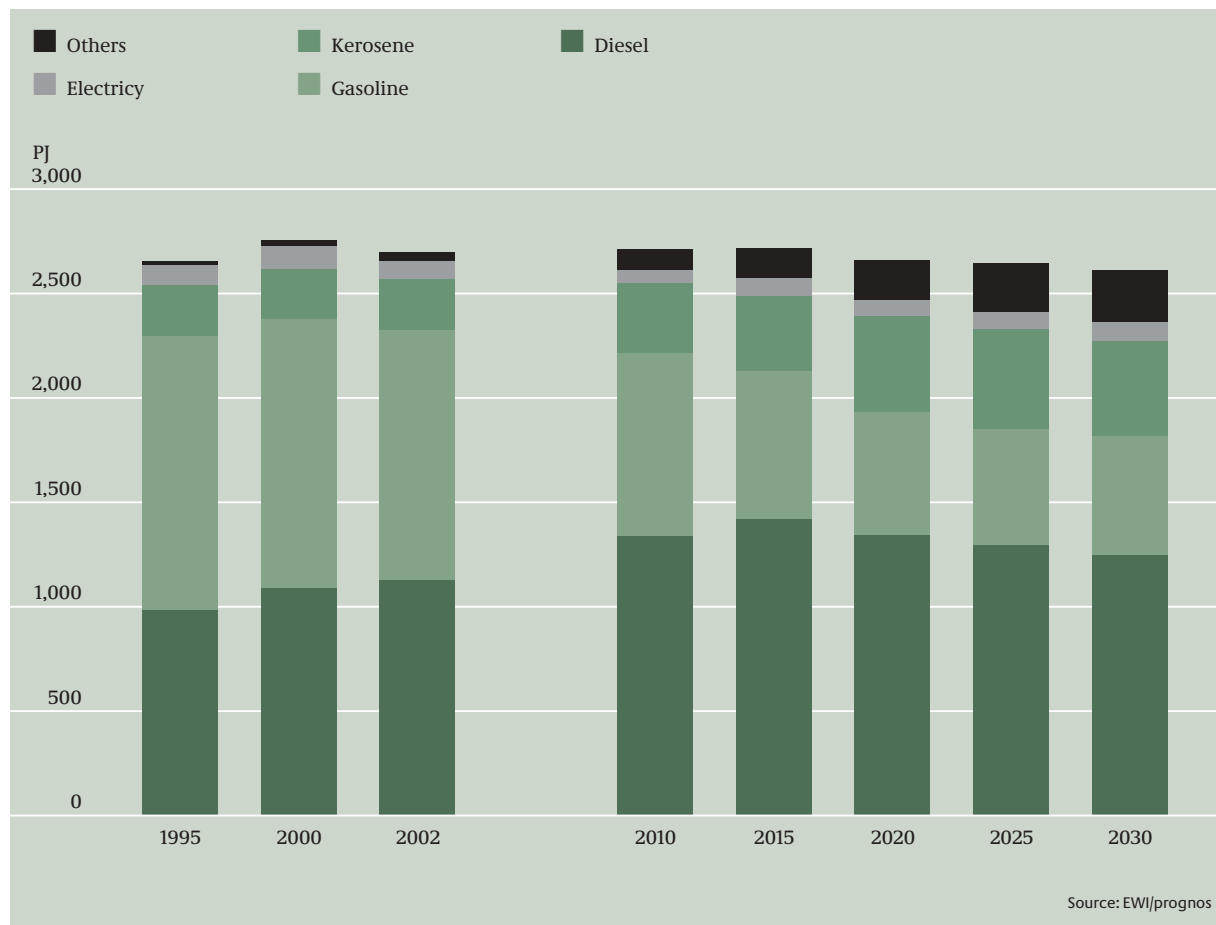
Passenger transport will show little change up to the year 2030; freight transport will increase by 58%. More efficient vehicles will prevent an increase in fuel consumption. Road transport's overall share of energy consumption will fall from 85% to 78% between 2002 and 2030.

There will be 6% more cars in 2030 than in 2002, and within the overall numbers there will be a massive shift toward diesel vehicles with better fuel consumption profiles. In overall terms, the energy consumed by passenger cars will drop by nearly 29% by 2030. The total number of trucks and tractors will increase 19% by 2030, and energy consumption in road freight transport will rise by 13%.

Natural-gas powered passenger cars will account for approximately 6% of all passenger cars in 2030. Fuel-cell powered vehicles will occupy a niche role. Bio fuels will account for 8% of energy consumption in the road transport sector.

At more than 2% a year, aviation will feature the highest growth rates in the transport sector. In the freight sector, rail transport will increase its market share.

Final Energy Consumption in Transport by Energy Sources 1995 – 2030



Electricity Production

Electricity will increasingly be produced in Germany from natural gas. Domestic lignite will move up to second place. The renewables will account for 38 % of power station capacities and cover 26 % of gross electricity production at the end of the forecast period.

During the forecast period, more than half of existing power station capacities will be replaced.

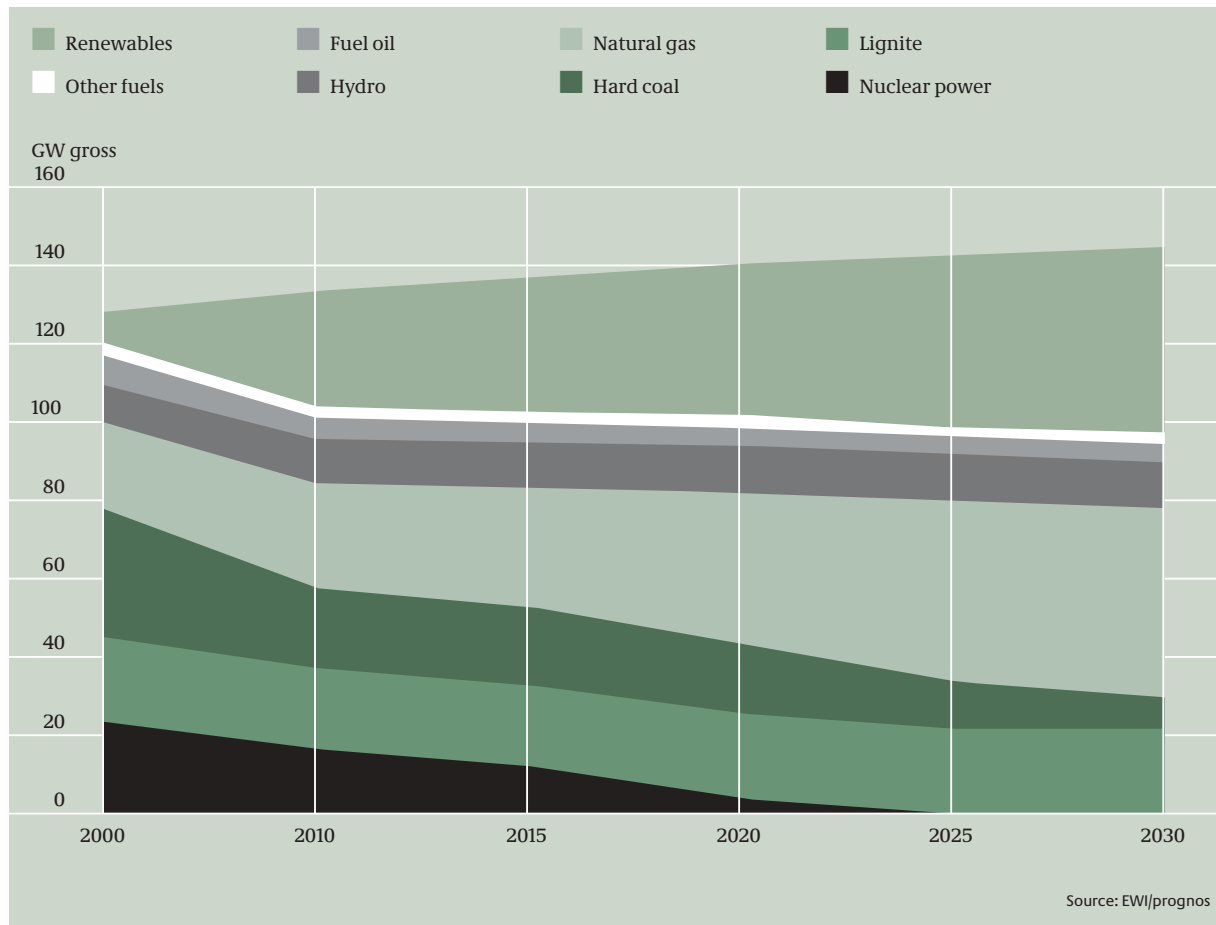
In keeping with the phase-out decision, nuclear power plant capacities, which accounted for 19 % of overall power station capacity and 29 % of gross electricity production in 2000, will be shut down during the forecast period.

In 2030, renewable energies will fuel 38 % of power station capacities and 26 % of gross electricity production.

Climate protection policy will bring about massive changes in energy price relations. The CO₂ levy presupposed in the Reference Forecast will double the price of hard coal in 2030 and increase lignite prices threefold. This will enable lignite to remain competitive.

The most important input-fuels in 2030 – measured in terms of gross electricity production – are natural gas (33 %), lignite (29 %), wind power (16 %), and hard coal (8 %).

Power Station Capacities by Energy Sources 2000 – 2030



District Heating

District heating will decline. Responsible for the drop will be savings in the heating sector. The share of final energy consumption accounted for by district heating will remain unchanged at some 3%. Hard coal, lignite, and fuel oil will be nearly entirely displaced in district heating by waste, biomass, and natural gas.

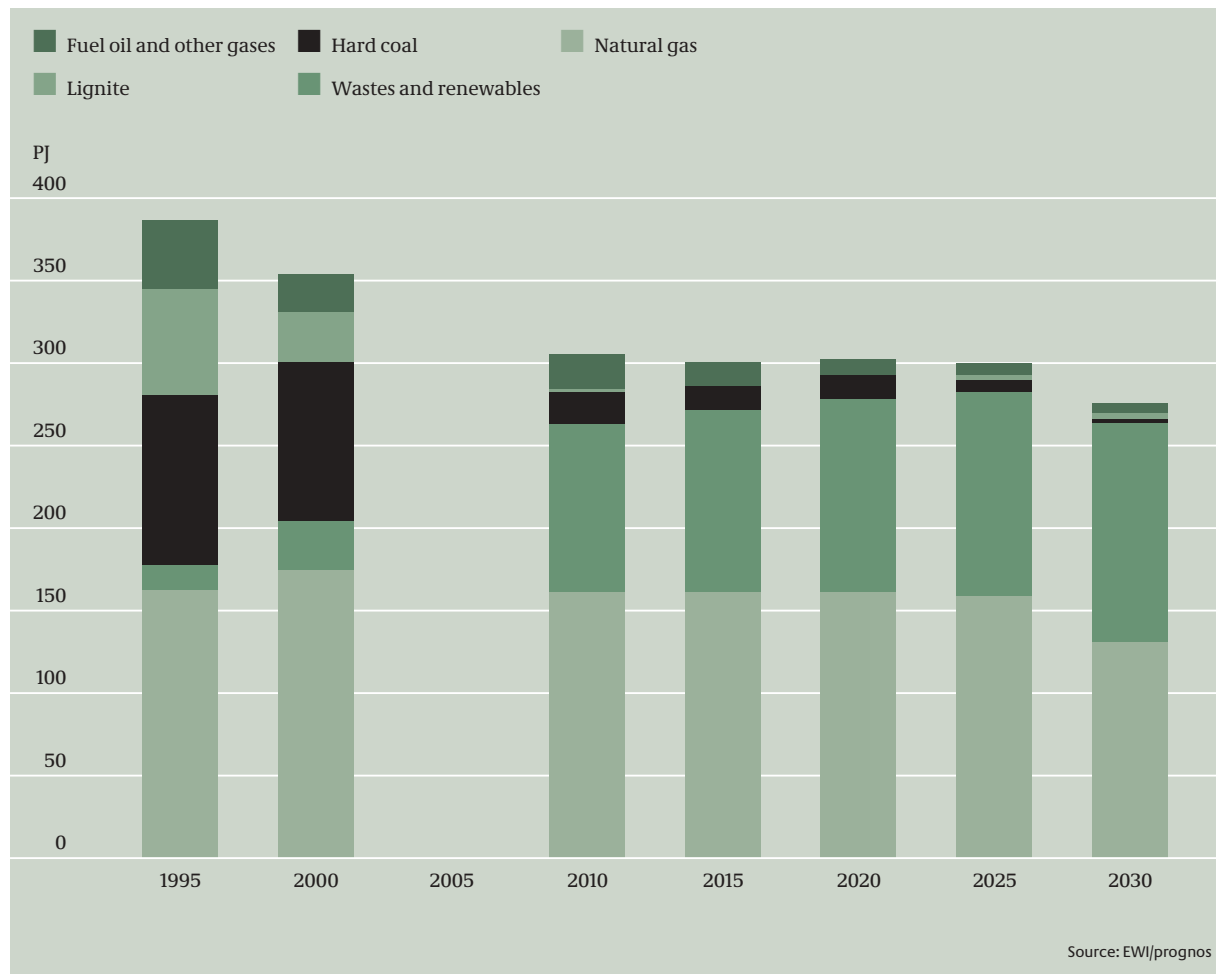
Energy used to produce district heat will decrease in the period 2000 to 2030 by a good 20 %, thus following the trend of district heat consumption.

Hard coal and lignite will be nearly entirely displaced from district heating production.

In the long term, the use of natural gas for district heating will decline; its share in total energy converted to district heat will increase slightly.

As the result of the increasing thermal treatment of wastes, the amount of domestic waste to be processed will rise sharply up to 2005. The share of biomass will increase as the result of the construction of additional wood-fired cogeneration plants. In some cases, geothermal energy will be used for the production of district heat.

District Heating Production by Energy Sources 1995 – 2030



The Use of Renewable Energies in Germany

Renewable energies' share of primary energy consumption will rise from 3.4% in 2002 to 11.5% in 2030. More than half of the increase will be accounted for by electricity production, a good one-fourth of which will rely on renewable energies in 2030. Renewable fuels will cover 8% of fuel needs in 2030.

The use of renewable energies will increase more than threefold in the forecast period. Their share of primary energy consumption will rise from 3.4% in 2002 to 11.5% in 2030.

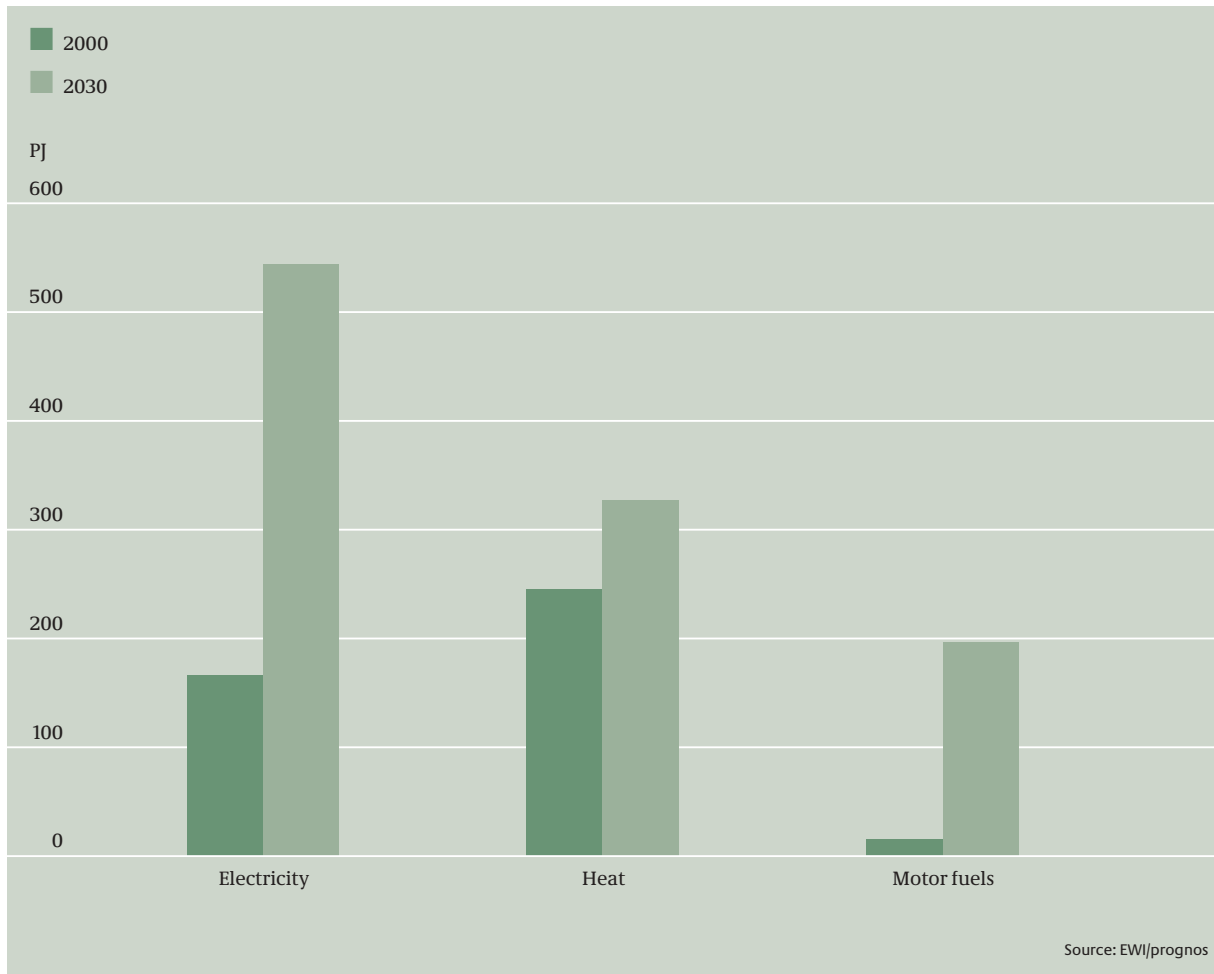
In 2000, the major portion of renewable energies, above all wood, straw, and other renewable fuels, will be employed in the heating market. This share of the market will grow by a good third by 2030.

More than half of the increase of renewable energies will be used for electricity production.

The market for motor fuels is the smallest input sector for the renewables (3.3% of renewable energies in 2000); however, it is growing the fastest. In 2030, regenerative fuels will claim a share of 8% of total motor fuel supplies.

Wind energy will become the most important source of renewable energies. In 2030 it will account for 31% of total renewable energy used and just under 61% of the renewables used for electricity production.

The Use of Renewable Energies by Sectors 2000 – 2030



Primary Energy Consumption

Primary energy consumption in Germany will fall in the long term. This represents a new trend and a break from the past. Per capita energy consumption will be 12% lower.

In the forecast period, primary energy consumption will decline and economic performance will increase. This represents a new trend and a break from the past.

Between 2002 and 2030, GDP will expand by almost 50%. Owing to the 1.9% yearly rise in energy productivity, primary energy consumption will decline by more than 15% during the same period: from 14.3 EJ to 12.1 EJ. The decoupling of economic performance and energy consumption will pick up speed. Per capita energy consumption will fall by 12%.

Real GDP and Primary Energy Consumption 1960 – 2030 (up to 1990, only Germany's western states)



Structure of Primary Energy Consumption

The structure of primary energy consumption will change considerably in the forecast period. The share of gas and renewable energies will expand while coal will lose significance.

There will be a shift – to some extent significant – in the mix of energy sources making up primary energy consumption.

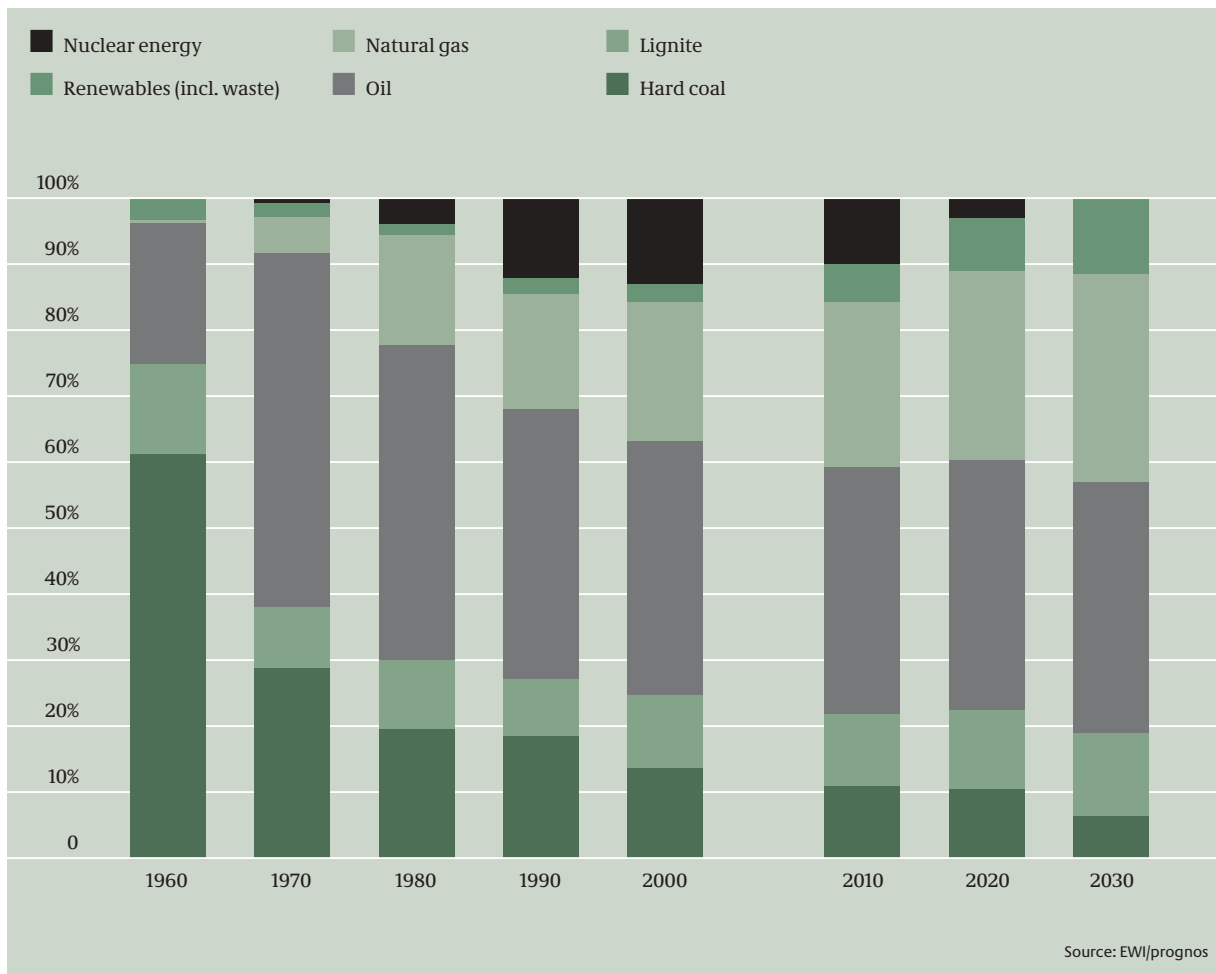
The share accounted for by natural gas will increase from 22 % in 2002 to 32 % in 2030. With a jump from 3.4 % to 11.5 %, the renewables will experience a pronounced increase in importance.

As politically desired, nuclear energy will no longer be a part of the energy mix in 2030.

Hard coal's contribution will decline from 13 % to less than 7 %. Lignite's share will increase slightly.

Oil, at 38 %, will continue to be the most important source of energy. Its share will expand slightly.

Structure of Primary Energy Consumption 1960 – 2030 (up to 1990, only Germany's western states)



Energy-Related Emissions

Energy-related greenhouse gas emissions will decline by 18.6% between 2002 and 2030. At the end of the forecast period they will be 32% lower than 1990 levels. The Kyoto commitments will be met.

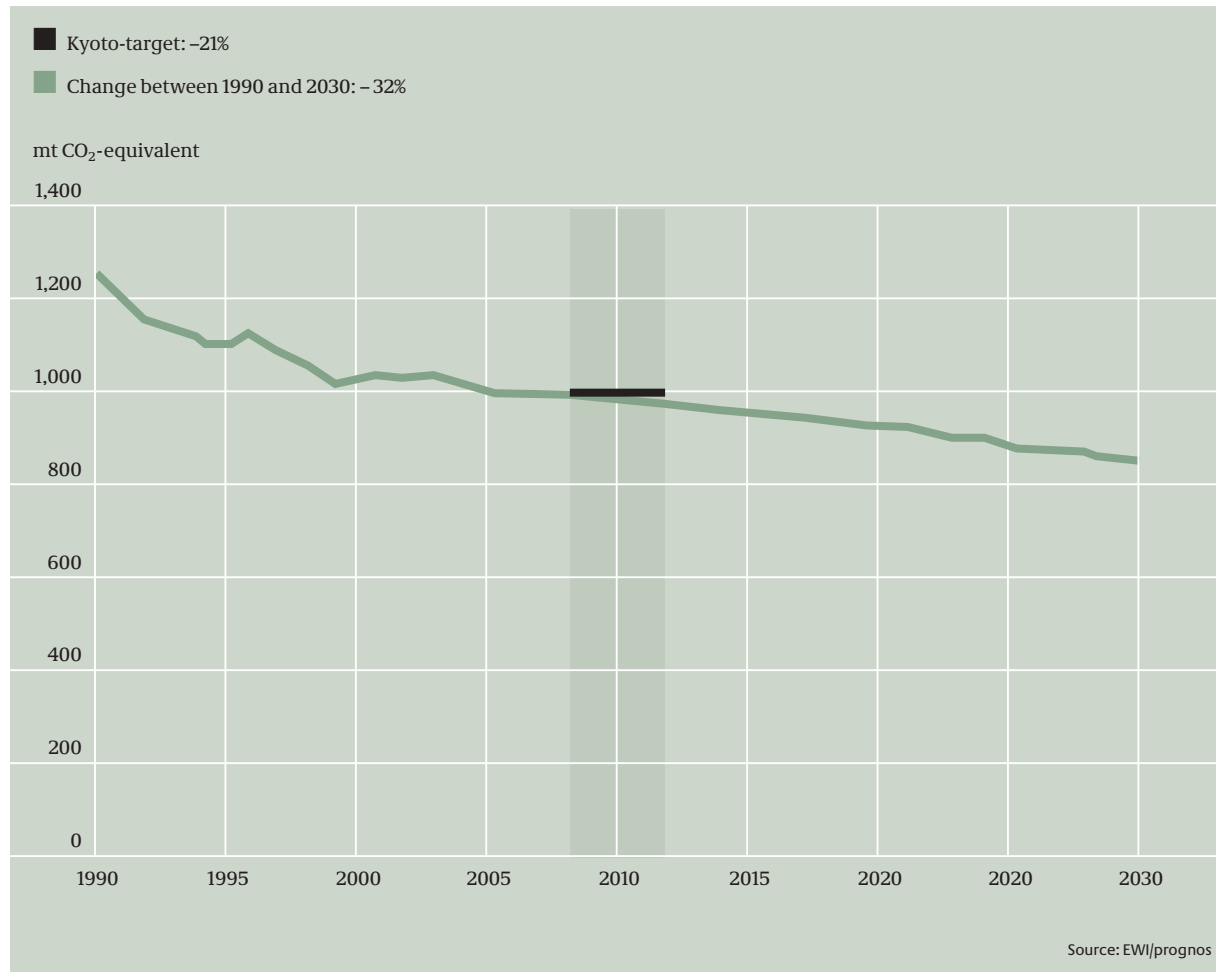
Under the economic and energy-policy presuppositions of the Reference Forecast, energy-related greenhouse gas emissions will decline by 18.6% between 2002 and 2030. The decline will accelerate after 2020.

The energy-related greenhouse gas emissions will be 32% lower in 2030 than in the Kyoto base year 1990. The decline from 1990 to 2010 will be a good 19%. If the trend of non-energy-related greenhouse gases is additionally considered, the figure amounts

to just under 22%. The commitments for reducing greenhouse gases undertaken by Germany under the Kyoto Protocol and the EU burden sharing agreement would thus be fulfilled.

The highest percentage of emission reductions between 2002 and 2030 are anticipated for the classic pollutants dust (-54%) and SO₂ (-56%), and the lowest percentages for CO₂ (-18%) and NO_x (-24%). It will be possible to reduce the other pollutants (N₂O, CO, NMVOC, and CH₄) by 30% to 50%.

Energy-Related Emissions 1990 – 2030



Methodology of Energy Forecasts

The methodology used for energy forecasts and the future trends of energy technologies were discussed in two interdisciplinary expert workshops.

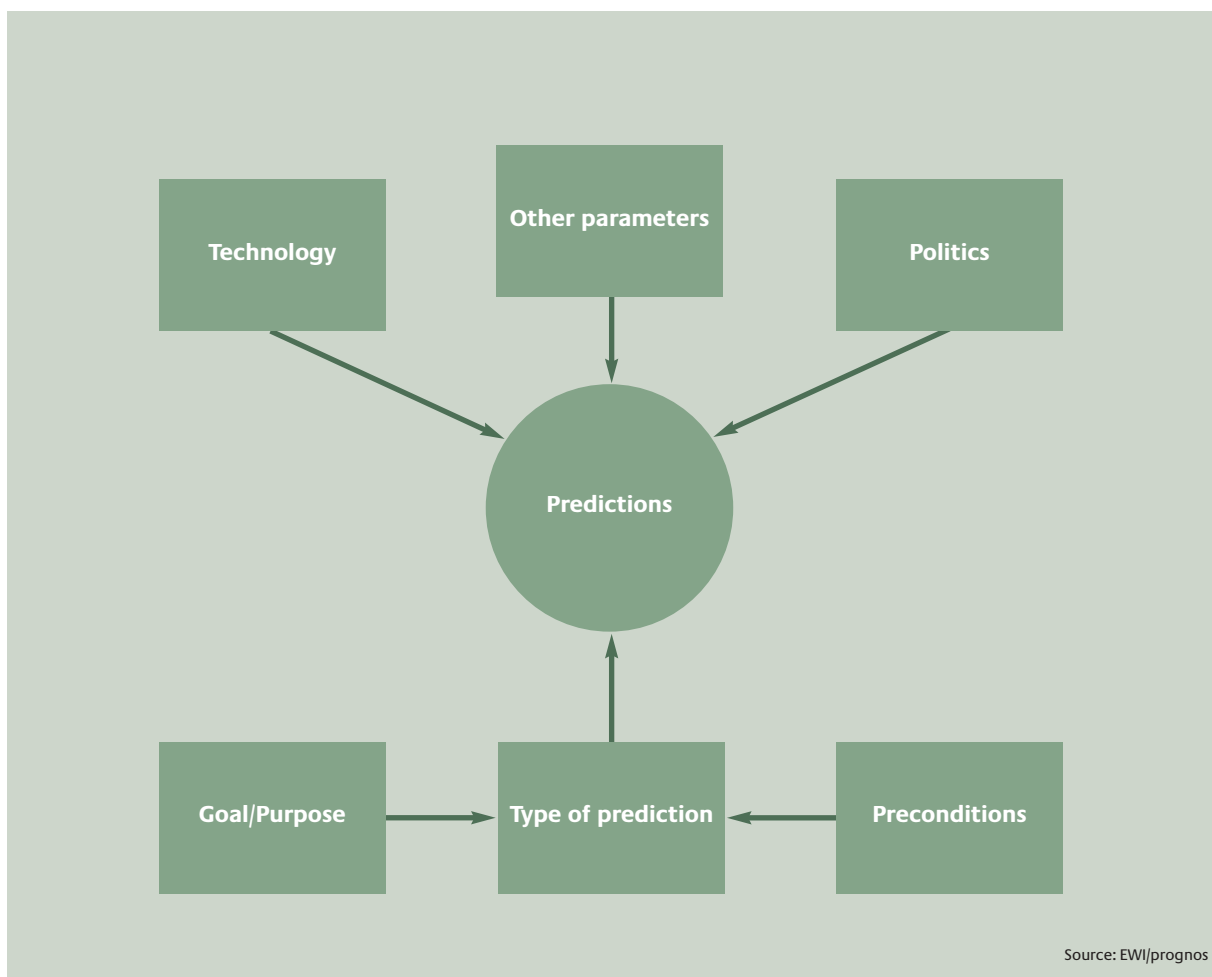
In the methodology workshop, the character and reliability of statements about the future were discussed from the perspective of various scientific disciplines. Above all, the influence of societal transformation on predictions was analyzed.

It was found that: the usefulness of the methodology is a function of the purpose of the predictions. Reference forecasts play a role of central importance in this context. They are the point of reference for policy and target scenarios and serve to identify the need for action in the future.

In the technology workshop, important trends in the field of energy technologies were outlined. Particular attention was paid to the influence of bio technology and nano technology on energy consumption and availability.

The result was that: new energy technologies will induce substantial change. Owing to the long investment cycles in the energy sector, they will find their way into everyday application only gradually.

Predictions for Energy Systems



Comparison of Current Studies on the Trend in the Energy Sector in Germany

The results vary greatly. Depending on the objectives, methods, and time frames, the studies inevitably yield differing results.

The studies surveyed differ in terms of purpose and methods. The present Reference Forecast seeks to determine the probable trend of energy consumption and the energy-related emissions. By contrast, target scenarios set specific goals (e.g. a defined reduction) and look at the measures that would be required to achieve them. On the one hand, the methodology makes use of simulation models and, on the other hand, of optimization models.

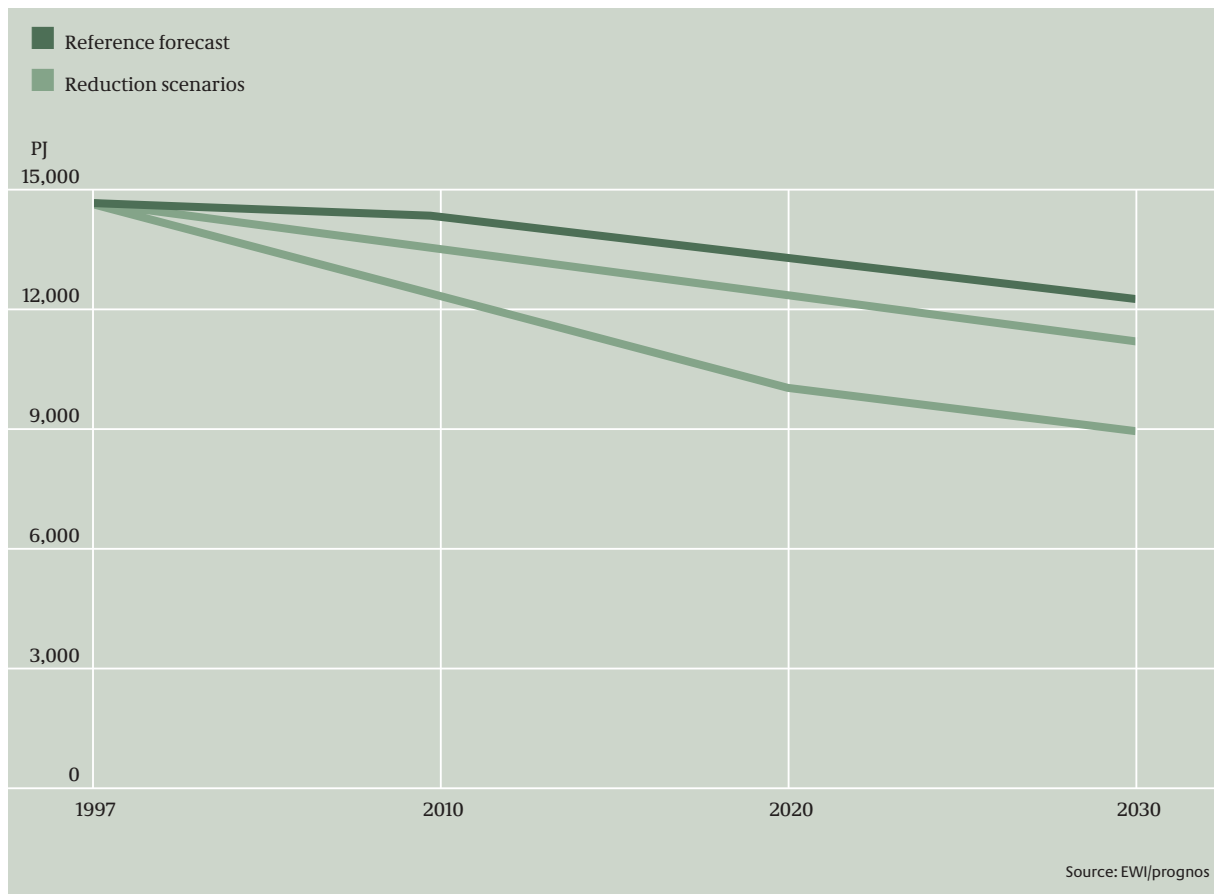
Simple comparisons of results are therefore not meaningful and can be misleading. By contrast, examining and comparing the applied methodologies and the fundamental assumptions of the various studies is useful.

The most important assumptions and results of current forecasts and scenarios were systematically compared.

Regardless of differing purposes and methods, all of the analyzed studies show a long-term reduction of primary energy consumption and greenhouse gas emissions.

In the context of our Reference Forecast, the results of most of the target scenarios would appear to be very ambitious.

Trend of Primary Energy Consumption 1997 – 2030



Determination of the Costs of Energy Supplies (value balance of energy)

For the first time, the attempt is being made to draft a value balance of energy. This serves to integrate the economy's outlays on energy into the Reference Forecast. Real expenditure on primary energy will double by 2030 at declining primary energy consumption. Energy spending by consumers (without taxes and other charges) will rise by a real one-third.

The attempt is being made for the first time to draw up a value balance of energy and provide an outlook for energy expenditure up to 2030. This raises problems of data and methods, which can only be partially solved at this initial step.

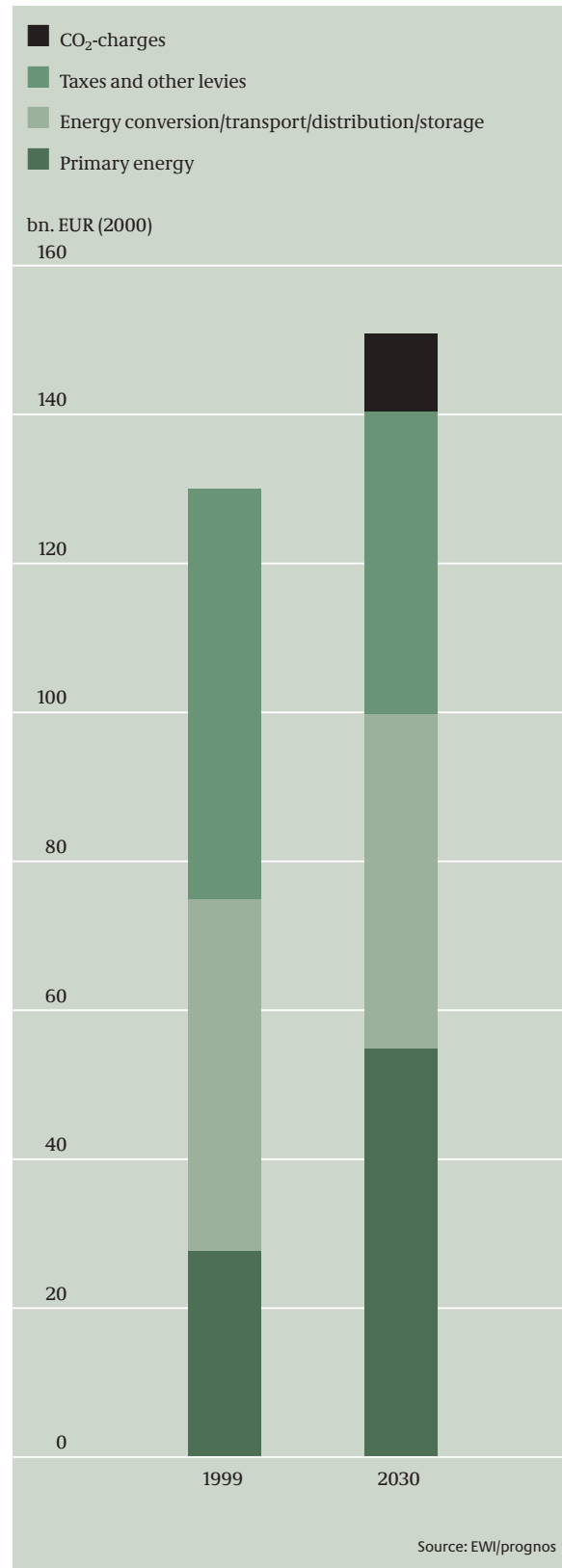
While primary energy consumption will decline 15 % and final energy consumption 9 % by 2030, real expenditure by the economy on the supply of primary energy sources will double and outlays by final users (without taxes and other levies) will climb by a real 30 %.

The costs of processing/transport/distribution/storage/marketing were more than 70 % higher in 1999 than spending on primary energy and will move at approximately the same level as spending on primary energy in 2030.

Energy taxes and other levies in 1999 were twice as high as expenditure on primary energy. Taxes on petroleum products account for the predominant share of energy taxes. They will decline by 2030, largely because the consumption of petroleum products will decrease.

In view of the moderate rise in CO₂ prices assumed in the Reference Forecast, the CO₂ surcharges to be paid by energy consumers will be slight in 2030 by comparison with the other spending categories.

Energy Expenditure 1999 – 2030



External Costs of Energy Supplies

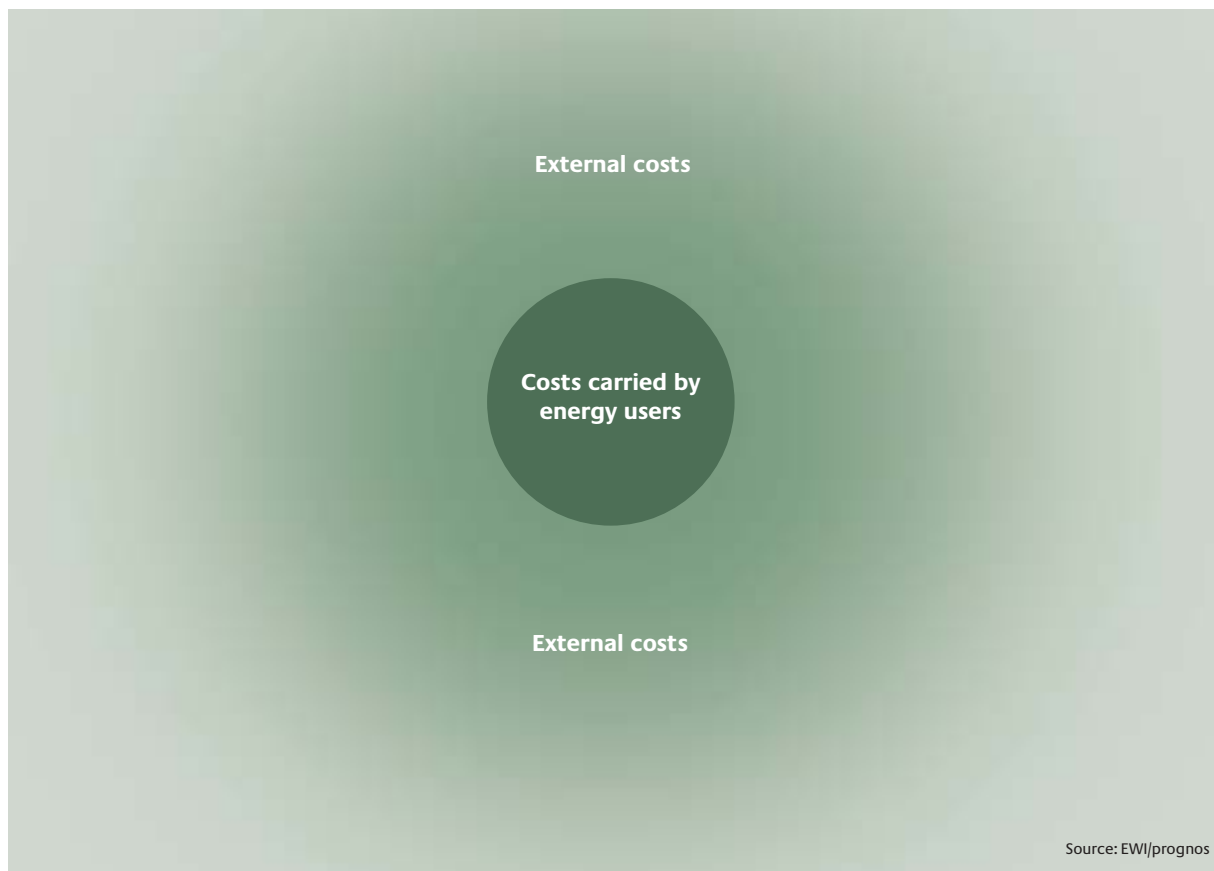
Market prices for energy cover only part of the costs associated with energy supplies. More recent approaches attempt to take comprehensive account of the external costs of energy supplies. Methodological and statistical problems have still not been satisfactorily solved.


The use of energy creates costs. A portion of the costs are assigned to the consumers. The remainder are borne by society as external costs, e.g. in the form of depreciation, damage, losses, and a limited scope of action for future generations.

With regard to the determination of the external costs of energy supplies, considerable uncertainties still prevail. This is implied by the results of an analysis of various studies on the identification and weighting of the external costs of energy supplies, which show widely different cost estimates.

A new attempt, the "correlation approach," is based on pollutant emissions released by energy generation. The first step is to estimate the spread of these pollutants and their chemical transformation and, possibly also, their transformation by radiation in the air, ground, and water. Proceeding from substance concentrations, the second step then calculates on the basis of the exposure-impact relationship the damage to human health, plants, animals, and materials; this is then assessed in monetary terms in the third and final step with the help of a damage-cost procedure.

External Costs of Energy Supplies





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