Projecting Energy Market Trends until 2030

Energy Outlook 2009

Executive Summary and Abstract

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ENERGY OUTLOOK 2009

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Energy Outlook 2009

Part A

Executive Summary

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Objective

Against the background of a currently shrinking contribution from indigenous energy carriers as well as increasing efforts of climate protection, the **Energy Outlook 2009** (*Energieprognose* 2009) assesses the **development of energy supply and demand in Germany up to 2030**, and further makes an outlook up to 2050.

The Outlook aims to quantify the probable development of energy consumption and energy supply in Germany given assumed energy and climate policy measures and the assumptions concerning uncertain parameters like oil prices.

Approach

An integrated, model-based approach is adopted to illustrate **the German energy markets as part of the European energy system**. This is to account for embedding the German power supply system into the European domestic market as well as to capture in an appropriate way the effects of transnational, EU-wide regulation approaches like the European Emission Trading System.

In the course of this integrated approach of analysis, two cases of energy supply in Germany are examined. They differ only in one aspect: The **Reference Case** assumes a legally regulated nuclear phase-out, whereas the **Lifetime Extension Case,** further divided into two variants, presumes **an extension of the existing nuclear power plants' lifetime to 40 and 60 years**.

Sensitivity analyses evaluate the impact of alterations of key influencing parameters such as the demographic and economic development. These parameters are determined on the basis of established empirical research methods.

The Energy Outlook 2009 was accompanied by a **group of experienced scientists** with extensive expertise in modelling and scenario analysis. The task of the group was an unbiased methodical and contextual consultation, supported by a robust validity check of the Outlook.

Political Framework Conditions

The **prescribed EU energy and climate policy objectives for Germany** are taken into account in the Energy Outlook 2009: As given in the **EU-wide Emission Trading System** (ETS), the participating sectors (particularly electricity generation and energy-intensive industries) must reduce their CO_2 emissions by 21 % in 2020 compared to 2005.

Furthermore, until 2020, 18 % of the gross final energy consumption in Germany should be satisfied by **renewable energy technologies**. The Renewable Energy Act (EEG) and the Renewable Energy Heat Act (EEWärmeG) function as instruments to achieve these objectives. Regarding the **energy efficiency objectives**, it is assumed that corresponding regulations, such as the German Energy Conservation Regulations (EnEV), will be further developed.

Concerning the German national objective to boost the **electricity generation from CHP plants** (CHP), a temporary prolongation of the CHP Act (KWKG) is expected. In addition, a strengthened European integration of the electricity market and an increase in competition in the domestic gas market are assumed.

Energy Prices

Considering the limited availability of crude oil, the potentials to increase supply as well as the substitution possibilities, the price of the various oil types in the OPEC basket is expected to increase to 127 $/barrel (bbl) until 2030 in the Reference Case. Expressed in prices of 2007, this corresponds to a **real oil price of 75 $/bbl**.

The historically observed **correlation between the crude oil prices and the consumer prices** of natural gas, fuel oil, petrol, etc. is also relevant in the future.

Electricity prices are determined by fuel prices as well as legislative factors: Whereas the prescribed Renewable Energy Act (EEG) compensation payment increases, the concession levy, CHP compensation, and electricity tax remain constant in nominal terms.

Electricity prices for the industrial sector and private households, apart from slight fluctuations, remain unchanged between 2012 and 2030.

Population

The population development and the number of private households are decisive factors for the energy consumption of a country. In the Reference Case, a **shrinking population** by 2.5 million to 79.7 million in the year 2030 is assumed.

In contrast, the number of households increases further by 2.3 million to 42 million in 2030. This is associated with an increase in mobility needs and associated energy consumption. With the **ever decreasing household size**, an increase in living space per person and space heating needs is expected.

Economic Development

The **severe worldwide recession** and the resulting slump in economic activities hit the export-oriented German economy very hard. Therefore, a shrinking of the German economy by 5.5 % in 2009 in comparison to 2008 is assumed in the Reference Case. However, a slight recovery of 0.6 % in 2010 compared to 2009 is predicted.

Consistent with the assessments of the International Monetary Fund, it is assumed in the Reference Case that the **global economy returns to the original growth path in the medium term** and that the integration of world markets resumes.

Owing predominately to the aging society and the shrinking population, the available workforce falls and subsequently, a moderate **contraction of the growth potential in Germany** is expected. It is assumed that the annual GDP growth rates between 2012 and 2030 amount on average to 1.2 %. In comparison, the average annual economic growth since the German reunification has been 1.5 %.

Reference Case

The **primary energy consumption** in Germany drops by 21 % until 2030 compared to 2007. This is accompanied by an annual increase of **energy productivity** by 2 %. Petroleum oil remains the most important primary energy carrier despite a consumption downturn. The share of coal in primary energy consumption declines, while the share of natural gas, due to gaining significance, increases moderately. As a whole, the **dependence on energy imports** (share of the net import in primary energy consumption of fossil

energy carriers) increases from approximately 73 % in 2007 to nearly 87 % in 2030.

After the financial crisis, the **domestic electricity demand increases** parallel to a slight decrease of domestic electricity generation. Starting in 2012, demand is satisfied **increasingly** by **electricity imports**. About half of the required fossil power plant capacity in 2030 is constructed after 2012.

There is a slight shortfall in attaining the objective of a 30 % share from renewable energy in the electricity generation in 2020. Likewise, the predefined EU objective for Germany to have a share of 18 % from renewable energy in gross final energy consumption in 2020 is just missed by a 2 % shortfall. This is despite the fact that in 2020 renewable energy covers 15 % of the final energy consumption in the heat market, rather than the required 14 %.

The goal stated in the Kyoto Protocol for Germany to **reduce greenhouse gas emissions by 21 %** by 2012 **compared to 1990's level is markedly exceeded**. Until 2030, greenhouse gas emissions in Germany decrease by 44 % relative to 1990.

Due to the increasing importance of technologies for CO_2 sequestration as well as the increasing contribution from renewable energy, the energy conversion sector makes the biggest contribution to the emissions reduction.

Lifetime Extension Case

The extended operation of nuclear power plants leads to lower greenhouse gas emissions in Germany and lower CO_2-prices in the European Emission Trading System than in the Reference Case. The goal achievements for renewable energy remain unaffected. In contrast, the growth of CHP electricity generation is curbed.

Despite retrofit expenses, nuclear power plants can be operated with low generation costs. In addition, the reduced costs for CO_2 certificates facilitate lower electricity prices, which are up to 9 $€_{2007}$/MWh lower than those stated in the Reference Case.

The less expensive electricity supply is coupled with positive feedback effects for the industrial production, employment and the overall economic development: the GDP in 2020 is up to 0.6 % higher than that stated in the Reference Case, and up to 0.9 % higher in 2030. That represents a cumulative increase of GDP by 122 to 295 bn € (in prices of 2000) compared to the Reference Case between 2010 and 2030 (depending whether the length of the lifetime of nuclear power plants is set to 40 or 60 years).

Reference Case (BAU)	Unit	Absolute Values				%p.a.			
		2007	2012	2020	2030	2007-2012	2012-2020	2020-2030	2007-2030
Oil Price (in real terms)	$_{2007}$/bbl	69	59	69	75	-3.1	2.0	0.8	0.4
Germany									
Population	M	82.3	82.0	81.4	79.7	-0.1	-0.1	-0.2	-0.1
Private Households	M	39.7	40.6	41.5	42.0	0.4	0.3	0.1	0.2
GDP	Bn €$_{2000}$	2242	2254	2526	2784	0.1	1.4	1.0	0.9
No. of Motor Cars	M	46.6	46.8	47.9	46.9	0.1	0.3	-0.2	0.0
Passenger Transport Activity (excl. air traffic)	Bn Person km	1047	1061	1078	1068	0.3	0.2	-0.1	0.1
Freight Transport Activity	Bn tonne km	568	615	737	880	1.6	2.3	1.8	1.9
Prices Households (incl. VAT), €$_{2007}$									
Fuel Oil light	€$_{2007}$/l	0.58	0.60	0.61	0.65	0.7	0.2	0.6	0.5
Natural Gas	ct$_{2007}$/kWh (HHV)	7.75	7.57	7.63	7.85	-0.5	0.1	0.3	0.1
Electricity	ct$_{2007}$/kWh	20.6	22.6	23.4	22.6	1.9	0.4	-0.3	0.4
Unleaded Petrol	€$_{2007}$/l	1.33	1.29	1.35	1.38	-0.6	0.6	0.2	0.2
Prices Wholesale (excl. VAT), €$_{2007}$									
Fuel Oil light (industrial)	€$_{2007}$/t	560	465	530	554	-3.6	1.6	0.4	0.0
Natural Gas (industrial)	€$_{2007}$/MWh	32	31	33	34	-0.6	0.8	0.3	0.3
Electricity (Mixed price)	€$_{2007}$/MWh	103.0	111.2	119.0	117.9	1.5	0.9	-0.1	0.6
Primary Energy Consumption (PEC)	PJ	13993	13403	11979	11021	-0.9	-1.4	-0.8	-1.0
Petroleum Oil	%	33.6	35.0	35.4	35.4	-3.1	-1.2	-0.8	-1.5
Gas	%	22.3	20.5	22.9	24.4	-1.7	0.0	-0.2	-0.5
Hard Coal	%	14.2	13.0	13.0	10.6	-3.0	-1.4	-2.9	-2.4
Lignite	%	11.5	10.6	10.6	10.7	-1.7	-1.4	-0.7	-1.2
Nuclear Energy	%	11.0	10.8	2.1	0.0	-4.8	-19.7	-100.0	-100.0
Renewable	%	7.0	9.0	13.7	16.5	20.5	3.9	1.1	6.0
Final Energy Consumption (FEC)	PJ	8585	8664	8312	7803	0.2	-0.5	-0.6	-0.4
Private Households	%	25.7	27.7	26.8	25.4	-1.5	-0.9	-1.1	-1.1
Tertiary Sector	%	15.6	16.4	15.7	15.9	-0.8	-1.1	-0.5	-0.8
Industrial Sector	%	28.5	26.2	26.7	27.3	-1.3	-0.3	-0.4	-0.5
Transportation	%	30.3	29.7	30.9	31.3	-1.3	0.0	-0.5	-0.5
Petroleum Oil Products	%	37.8	38.3	34.8	32.6	-4.0	-1.7	-1.3	-2.0
Gas + LPG	%	25.3	23.8	23.8	23.2	-3.0	-0.6	-0.9	-1.2
Coals	%	5.6	4.6	3.9	3.7	-5.0	-2.5	-1.2	-2.5
Electricity	%	22.2	23.0	24.3	26.6	2.3	0.1	0.3	0.7
District Heating	%	3.1	3.4	3.8	4.2	2.2	0.9	0.2	0.9
Renewables	%	5.7	6.6	8.9	9.3	23.1	3.4	-0.3	5.7
Net Electricity Generation	TWh	597	603	573	596	0.2	-0.6	0.4	0.0
Hydropower	%	4.2	4.9	5.5	5.2	1.5	0.6	0.0	0.5
Nuclear Energy	%	22.3	20.9	3.8	0.0	-4.7	-19.7	-100.0	-100.0
Hard Coal	%	21.6	20.2	20.6	14.2	-1.9	-0.4	-3.2	-2.0
Lignite	%	24.0	23.4	22.7	22.4	0.7	-1.0	0.2	-0.1
Natural Gas	%	12.3	11.9	19.2	20.7	8.9	5.4	1.1	4.3
Wind	%	6.6	9.1	17.2	25.6	48.6	7.6	4.5	13.9
Others	%	9.0	9.5	11.1	11.9	16.3	1.3	1.1	4.3
Gross Electricity Generation	TWh	638	638	602	621	0.0	-0.7	0.3	-0.1
Hydropower	%	4.4	4.7	5.2	5.0	1.5	0.6	0.0	0.5
Nuclear Energy	%	22.0	20.9	3.8	0.0	-4.7	-19.7	-100.0	-100.0
Hard Coal	%	22.3	21.0	21.5	15.0	-1.9	-0.4	-3.2	-2.0
Lignite	%	23.7	23.8	23.2	23.0	0.7	-1.0	0.2	-0.1
Natural Gas	%	11.9	11.6	18.8	20.4	8.9	5.4	1.1	4.3
Wind	%	6.2	8.6	16.4	24.6	48.6	7.6	4.5	13.9
Others	%	9.5	9.5	11.1	11.9	16.3	1.3	1.1	4.3
Efficiency Indicators									
Primary Energy Consumption per Capita	GJ/Capita	170	163	147	138	-0.8	-1.3	-0.6	-0.9
Energy Intensity (GDP/PEC)	Bn €$_{2000}$/PJ	0.16	0.17	0.21	0.25	1.0	2.9	1.8	2.0
GDP/FEC Industrial	Bn €$_{2000}$/PJ	0.92	0.99	1.14	1.31	1.6	1.7	1.4	1.5
Pers.-km/FEC Pers.-Transport (excl. Air Traffic)	Bn pkm/PJ	0.70	0.73	0.82	1.00	0.7	1.5	1.9	1.5
Tonne-km/FEC Freight Transport	Bn tkm/PJ	0.77	0.86	0.93	1.02	2.2	1.0	0.9	1.2
CO_2-Indicators		1990	2007	2012	2030	1990-2007	1990-2012	2012-2030	1990-2030
CO_2 Emissions	M. t	1032	839	792	584	-1.2	-1.2	-1.7	-1.4
CO_2/GDP	g /€$_{2000}$	600	374	352	210	-2.7	-2.4	-2.8	-2.6
CO_2/person	t/Capita	13.0	10.2	9.7	7.3	-1.4	-1.3	-1.5	-1.4

Variants with lifetime extension to 40 years (Rb)	Unit	Absolute Values				%p.a.			
		2007	2012	2020	2030	2007-2012	2012-2020	2020-2030	2007-2030
Oil Price (in real terms)	$_{2007}$/bbl	69	59	69	75	-3.1	2.0	0.8	0.4
Germany									
Population	M	82.3	82.0	81.4	79.7	-0.1	-0.1	-0.2	-0.1
Private Households	M	39.7	40.6	41.5	42.0	0.4	0.3	0.1	0.2
GDP	Bn €$_{2000}$	2242	2257	2537	2789	0.1	1.5	1.0	1.0
No. of Motor Cars	M	46.6	46.8	47.9	46.9	0.1	0.3	-0.2	0.0
Passenger Transport Activity (excl. air traffic)	Bn Person km	1047	1061	1078	1068	0.3	0.2	-0.1	0.1
Freight Transport Activity	Bn tonne km	568	615	741	881	1.6	2.4	1.7	1.9
Prices Households (incl. VAT), €$_{2007}$									
Fuel Oil light	€$_{2007}$/l	0.58	0.60	0.61	0.65	0.7	0.2	0.6	0.5
Natural Gas	ct$_{2007}$/kWh (HHV)	7.75	7.57	7.63	7.85	-0.5	0.1	0.3	0.1
Electricity	ct$_{2007}$/kWh	20.6	22.1	21.8	22.6	1.3	-0.1	0.4	0.4
Unleaded Petrol	€$_{2007}$/l	1.33	1.29	1.35	1.38	-0.6	0.6	0.2	0.2
Prices Wholesale (excl. VAT), €$_{2007}$									
Fuel Oil light (industrial)	€$_{2007}$/t	560	465	530	554	-3.6	1.6	0.4	0.0
Natural Gas (industrial)	€$_{2007}$/MWh	32	31	33	34	-0.6	0.8	0.3	0.3
Electricity (Mixed price)	€$_{2007}$/MWh	103.0	106.7	110.0	117.9	0.7	0.4	0.7	0.6
Primary Energy Consumption (PEC)	PJ	13993	13601	12502	10924	-0.6	-1.0	-1.3	-1.1
Petroleum Oil	%	33.6	34.4	33.9	35.7	-3.2	-1.2	-0.9	-1.5
Gas	%	22.3	19.8	19.5	26.2	-2.1	-1.2	1.6	-0.2
Hard Coal	%	14.2	12.3	11.7	8.6	-3.7	-1.7	-4.3	-3.3
Lignite	%	11.5	10.4	10.1	10.5	-1.9	-1.4	-1.0	-1.3
Nuclear Energy	%	11.0	13.5	10.1	0.0	-0.1	-4.5	-100.0	-100.0
Renewable	%	7.0	8.7	13.1	16.7	20.0	4.2	1.1	6.0
Final Energy Consumption (FEC)	PJ	8585	8671	8323	7801	0.2	-0.5	-0.6	-0.4
Private Households	%	25.7	27.7	26.8	25.4	-1.5	-0.9	-1.2	-1.1
Tertiary Sector	%	15.6	16.4	15.7	15.8	-0.8	-1.0	-0.6	-0.8
Industrial Sector	%	28.5	26.3	26.7	27.4	-1.2	-0.3	-0.4	-0.5
Transportation	%	30.3	29.7	30.9	31.4	-1.3	0.0	-0.5	-0.5
Petroleum Oil Products	%	37.8	38.3	34.8	32.5	-4.0	-1.7	-1.3	-2.0
Gas + LPG	%	25.3	24.0	23.7	23.4	-2.9	-0.6	-0.8	-1.2
Coals	%	5.6	4.5	4.1	3.7	-5.2	-1.6	-1.7	-2.5
Electricity	%	22.2	23.2	24.3	26.6	2.5	0.0	0.3	0.7
District Heating	%	3.1	3.4	3.7	4.1	2.0	0.7	0.2	0.8
Renewables	%	5.7	6.3	8.9	9.2	22.2	3.8	-0.3	5.7
Net Electricity Generation	TWh	597	616	598	594	0.6	-0.4	-0.1	0.0
Hydropower	%	4.2	4.8	5.2	5.3	1.5	0.6	0.0	0.5
Nuclear Energy	%	22.3	26.1	18.5	0.0	0.0	-4.5	-100.0	-100.0
Hard Coal	%	21.6	18.5	17.4	10.1	-3.2	-1.1	-5.3	-3.4
Lignite	%	24.0	22.7	21.5	21.6	0.5	-1.0	0.0	-0.3
Natural Gas	%	12.3	10.1	10.2	25.4	5.7	-0.3	9.5	5.2
Wind	%	6.6	8.9	16.6	25.7	48.6	7.6	4.4	13.9
Others	%	9.0	8.9	10.6	11.9	15.4	1.8	1.1	4.3
Gross Electricity Generation	TWh	638	651	629	618	0.4	-0.4	-0.2	-0.1
Hydropower	%	4.4	4.6	5.0	5.1	1.5	0.6	0.0	0.5
Nuclear Energy	%	22.0	26.0	18.5	0.0	0.0	-4.5	-100.0	-100.0
Hard Coal	%	22.3	19.2	18.2	10.7	-3.2	-1.1	-5.3	-3.4
Lignite	%	23.7	23.0	22.0	22.3	0.5	-1.0	0.0	-0.3
Natural Gas	%	11.9	9.8	10.0	25.2	5.7	-0.3	9.5	5.2
Wind	%	6.2	8.5	15.8	24.7	48.6	7.6	4.4	13.9
Others	%	9.5	8.9	10.6	12.0	15.4	1.8	1.1	4.3
Efficiency Indicators									
Primary Energy Consumption per Capita	GJ/Capita	170	166	154	137	-0.5	-0.9	-1.1	-0.9
Energy Intensity (GDP/PEC)	Bn €$_{2000}$/PJ	0.16	0.17	0.20	0.26	0.7	2.5	2.3	2.0
GDP/FEC Industrial	Bn €$_{2000}$/PJ	0.92	0.99	1.14	1.31	1.6	1.8	1.4	1.5
Pers.-km/FEC Pers.-Transport (excl. Air Traffic)	Bn pkm/PJ	0.70	0.73	0.82	1.00	0.7	1.5	1.9	1.5
Tonne-km/FEC Freight Transport	Bn tkm/PJ	0.77	0.86	0.93	1.01	2.2	1.0	0.9	1.2
CO_2-Indicators						1990-2007	1990-2012	2012-2030	1990-2030
		1990	2007	2012	2030				
CO_2 Emissions	M. t	1032	839	781	581	-1.2	-1.3	-1.6	-1.4
CO_2/GDP	g /€$_{2000}$	600	374	346	208	-2.7	-2.5	-2.8	-2.6
CO_2/person	t/Capita	13.0	10.2	9.5	7.3	-1.4	-1.4	-1.5	-1.4

Variants with lifetime extension to 60 years (Rc)	Unit	Absolute Values				%p.a.			
		2007	2012	2020	2030	2007-2012	2012-2020	2020-2030	2007-2030
Oil Price (in real terms)	$_{2007}$/bbl	69	59	69	75	-3.1	2.0	0.8	0.4
Germany									
Population	M	82.3	82.0	81.4	79.7	-0.1	-0.1	-0.2	-0.1
Private Households	M	39.7	40.6	41.5	42.0	0.4	0.3	0.1	0.2
GDP	Bn €$_{2000}$	2242	2257	2542	2810	0.1	1.5	1.0	1.0
No. of Motor Cars	M	46.6	46.8	47.9	46.9	0.1	0.3	-0.2	0.0
Passenger Transport Activity (excl. air traffic)	Bn Person km	1047	1061	1078	1068	0.3	0.2	-0.1	0.1
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Prices Households (incl. VAT), €$_{2007}$									
Fuel Oil light	€$_{2007}$/l	0.58	0.60	0.61	0.65	0.7	0.2	0.6	0.5
Natural Gas	ct$_{2007}$/kWh (HHV)	7.75	7.57	7.63	7.85	-0.5	0.1	0.3	0.1
Electricity	ct$_{2007}$/kWh	20.6	22.1	21.2	20.9	1.3	-0.5	-0.1	0.0
Unleaded Petrol	€$_{2007}$/l	1.33	1.29	1.35	1.38	-0.6	0.6	0.2	0.2
Prices Wholesale (excl. VAT), €$_{2007}$									
Fuel Oil light (industrial)	€$_{2007}$/t	560	465	530	554	-3.6	1.6	0.4	0.0
Natural Gas (industrial)	€$_{2007}$/MWh	32	31	33	34	-0.6	0.8	0.3	0.3
Electricity (Mixed price)	€$_{2007}$/MWh	103.0	106.7	105.4	105.4	0.7	-0.1	0.0	0.1
Primary Energy Consumption (PEC)	PJ	13993	13605	12860	11919	-0.6	-0.7	-0.8	-0.7
Petroleum Oil	%	33.6	34.4	33.0	32.7	-3.2	-1.2	-0.9	-1.5
Gas	%	22.3	19.7	18.5	20.5	-2.2	-1.5	0.3	-0.9
Hard Coal	%	14.2	12.4	10.7	6.2	-3.6	-2.5	-6.0	-4.3
Lignite	%	11.5	10.4	9.8	9.2	-1.9	-1.4	-1.4	-1.5
Nuclear Energy	%	11.0	13.5	14.3	15.4	-0.1	0.0	0.0	0.0
Renewable	%	7.0	8.7	12.8	15.3	20.1	4.2	1.0	6.1
Final Energy Consumption (FEC)	PJ	8585	8668	8344	7824	0.2	-0.5	-0.6	-0.4
Private Households	%	25.7	27.7	26.8	25.5	-1.5	-0.9	-1.1	-1.1
Tertiary Sector	%	15.6	16.4	15.6	15.6	-0.8	-1.1	-0.6	-0.8
Industrial Sector	%	28.5	26.2	26.8	27.5	-1.2	-0.2	-0.4	-0.5
Transportation	%	30.3	29.7	30.8	31.4	-1.3	0.0	-0.5	-0.5
Petroleum Oil Products	%	37.8	38.3	34.7	32.4	-4.0	-1.7	-1.3	-2.0
Gas + LPG	%	25.3	23.9	23.5	23.1	-3.0	-0.7	-0.8	-1.3
Coals	%	5.6	4.6	4.4	3.9	-5.0	-1.0	-1.8	-2.2
Electricity	%	22.2	23.3	24.5	27.2	2.5	0.1	0.4	0.8
District Heating	%	3.1	3.4	3.7	3.7	2.0	0.6	-0.4	0.4
Renewables	%	5.7	6.3	8.8	9.1	22.1	3.7	-0.3	5.7
Net Electricity Generation	TWh	597	616	627	663	0.6	0.2	0.6	0.5
Hydropower	%	4.2	4.8	5.0	4.7	1.5	0.6	0.0	0.5
Nuclear Energy	%	22.3	26.0	25.6	24.2	0.0	0.0	0.0	0.0
Hard Coal	%	21.6	18.4	14.3	5.8	-3.2	-2.9	-8.1	-5.3
Lignite	%	24.0	22.7	20.5	18.5	0.5	-1.0	-0.4	-0.4
Natural Gas	%	12.3	10.1	8.5	13.1	5.7	-1.9	5.0	2.7
Wind	%	6.6	8.9	16.1	23.0	48.6	7.9	4.2	13.9
Others	%	9.0	9.0	10.1	10.7	15.6	1.7	1.1	4.3
Gross Electricity Generation	TWh	638	651	659	691	0.4	0.1	0.5	0.3
Hydropower	%	4.4	4.6	4.7	4.5	1.5	0.6	0.0	0.5
Nuclear Energy	%	22.0	26.0	25.7	24.5	0.0	0.0	0.0	0.0
Hard Coal	%	22.3	19.2	14.9	6.1	-3.2	-2.9	-8.1	-5.3
Lignite	%	23.7	23.0	20.9	19.1	0.5	-1.0	-0.4	-0.4
Natural Gas	%	11.9	9.8	8.3	12.9	5.7	-1.9	5.0	2.7
Wind	%	6.2	8.5	15.3	22.1	48.6	7.9	4.2	13.9
Others	%	9.5	9.0	10.1	10.7	15.6	1.7	1.1	4.3
Efficiency Indicators									
Primary Energy Consumption per Capita	GJ/Capita	170	166	158	150	-0.5	-0.6	-0.5	-0.6
Energy Intensity (GDP/PEC)	Bn €$_{2000}$/PJ	0.16	0.17	0.20	0.24	0.7	2.2	1.8	1.7
GDP/FEC Industrial	Bn €$_{2000}$/PJ	0.92	0.99	1.14	1.30	1.6	1.7	1.4	1.5
Pers.-km/FEC Pers.-Transport (excl. Air Traffic)	Bn pkm/PJ	0.70	0.73	0.82	1.00	0.7	1.5	1.9	1.5
Tonne-km/FEC Freight Transport	Bn tkm/PJ	0.77	0.86	0.93	1.02	2.2	1.0	0.9	1.2
CO_2-Indicators		1990	2007	2012	2030	1990-2007	1990-2012	2012-2030	1990-2030
CO_2 Emissions	M. t	1032	839	781	537	-1.2	-1.3	-2.1	-1.6
CO_2/GDP	g /€$_{2000}$	600	374	346	191	-2.7	-2.5	-3.3	-2.8
CO_2/person	t/Capita	13.0	10.2	9.5	6.7	-1.4	-1.4	-1.9	-1.6

Projecting Energy Market Trends until 2030

Energy Outlook 2009

Part B

Abstract

Table of Contents

Result Summary

Energy and Climate Policy Objectives

	Status Quo (2008)	Target 2020	Annotation	Reference prognosis with nuclear energy withdrawal (Ra)		Variants with extension of lifespan for nuclear energy	
				2020	2030	2020	2030
GHG-Emissions	-20% (1990-2007)	-21% (until 2012) (-40%)	-40% only if EU reduces by 30%	-34%	-44%	-35% to -37%	-44% to -49%
CO_2-Emissions	-19% (1990-2007)			-33%	-43%	-34% to -36%	-44% to -48%
Energy from renewable sources	9.3% (2007)	18%	Share of gross final energy consumption	16%	20%	16%	20%
Electricity from renewable sources	14%	Minimum 30%	Share of gross electricity consumption	27%	36%	27%	35% to 37%
Heat from renewable sources	appr. 6%	14%	Share of renewables in final energy consumption for heat production	15%	17%	15%	17%
Energy efficiency	1.84%/a (1990-2008)	Doubling (=+100%) of energy productivity (GDP/PEC)	Base year: 1990	+83%	+119%	+71% to +76%	+104% to +121%
				(1990-2020)	(1990-2030)	(1990-2020)	(1990-2030)
		-9% final energy (until 2016, indicative target)	Base: average FEC of 2001-2005	-14.2%	-19.7%	-13.9% to -14.1%	-19.5% to -19.8%
Biofuel share	7.3%	7%	Measured as GHG reduction (revised systematics)	10.5%	10.5%	10.5%	10.5%
Electricity from CHP	appr. 12% (2008)	Doubling to appr. 25%		19%	20%	15% to 17%	16% to 20%
Electricity from nuclear energy	149 TWh			22 TWh	0 TWh	111 to 160 TWh	0 to 160 TWh

In line with the **objectives of the EU Energy Efficiency Directive**, a final energy consumption reduction of 9 % between 2008 and 2016 is **complied within** both the **Reference Case** and in the **Lifetime Extension Case**, in particular because Germany took measures for efficient energy use early.

Equally, **the targets for the renewable energy extension are almost achieved** or even surpassed slightly.

On account of the comprehensive political promotion of renewable energy, **the extended nuclear energy application has virtually no effect on the shares of renewable energy** in gross final energy consumption, heat generation and power generation and on the use of biofuels.

The **target for Germany stated in the Kyoto-Protocol,** which specifies the reduction of greenhouse gas emissions by 21 % until 2012 compared to 1990, **is significantly surpassed.**

The German national objectives of **doubling the share of CHP electricity** to 25 % compared to 1990, and of **doubling energy productivity** between 1990 and 2020 **are not reached**.

This goal was, however, very ambitiously set. It assumes an annual increase of energy productivity by approximately 3 % for the period 2005 through 2020, while it was on average merely 1.84 % between 1990 and 2008.

Introduction and Assumptions

Objective and Approach

Against the background of a presently shrinking contribution from indigenous energy carriers as well as increasing efforts of climate protection, the **Energy Outlook 2009** assesses the **development of supply and demand for energy in Germany up to 2030** and includes an outlook to 2050. The quantitative findings in the Energy Outlook 2009 represent one probable development of energy consumption in Germany, provided that the assumed energy and climate policy measures and the assumptions regarding uncertain parameters like the oil prices materialize.

An integrated, model-based approach is adopted and it illustrates **the German energy markets as part of the European energy system**. This is to account for embedding the German power supply system into the European domestic market as well as to capture in an appropriate way the effects of transnational, EU-wide regulation approaches like the European Emission Trading System.

In the course of this integrated approach of analysis, two cases of energy supply in Germany are examined. They differ only in one aspect: The first, called the **Reference Case**, assumes the legally regulated nuclear phase-out, whereas in two variants, the **Lifetime Extension Cases**, **an extension of the existing nuclear power plants' lifetime to 40 and 60 years** is presumed.

Additionally, **sensitivity analyses** evaluate the impact of alterations of key influencing parameters such as the demographic and economic development. These parameters are determined on the basis of established empirical research methods.

The Energy Outlook 2009 was accompanied by a **group of experienced scientists** who have extensive expertise in modelling and scenario analysis. The task of this group was an unbiased methodical and thematic consultation backed by a plausibility check of the Outlook.

Assumptions of the Reference Case

	Unit	2007	2012	2020	2030
Population	M	82.3	82.0	81.4	79.7
Households	M	39.7	40.6	41.5	42.0
Living space	M m^2	3 444	3 574	3 788	4 015
Gross domestic product	Bn $€_{2000}$	2 242	2 254	2 526	2 784
Passenger transport activity (without aviation)	Bn pkm	1 047	1 061	1 078	1 068
Freight transport activity	Bn Tkm	568	615	737	880

Source: Destatis, UBA, IER

The demographic and economic developments represent important determinants for the energy consumption.

The Reference Case **assumes a shrinking population to 79.7 million in 2030**, which represents a reduction of 2.5 million compared to the end of 2007 in Germany.

Despite the fall in population, **the number of households continues to grow**. The household forecast shows an increase in the number of households to 42 million in 2030, which are **2.3 million households more than in 2007**. This can mainly be attributed to the increase in one and two person households.

Due to the falling household size, the living space per capita and consequently the need of space heating increases. **The total living area rises** between 2007 and 2030 by approximately 18 % to around 4 billion m^2. Each person has therefore on average around 50.4 m^2 of living space in 2030.

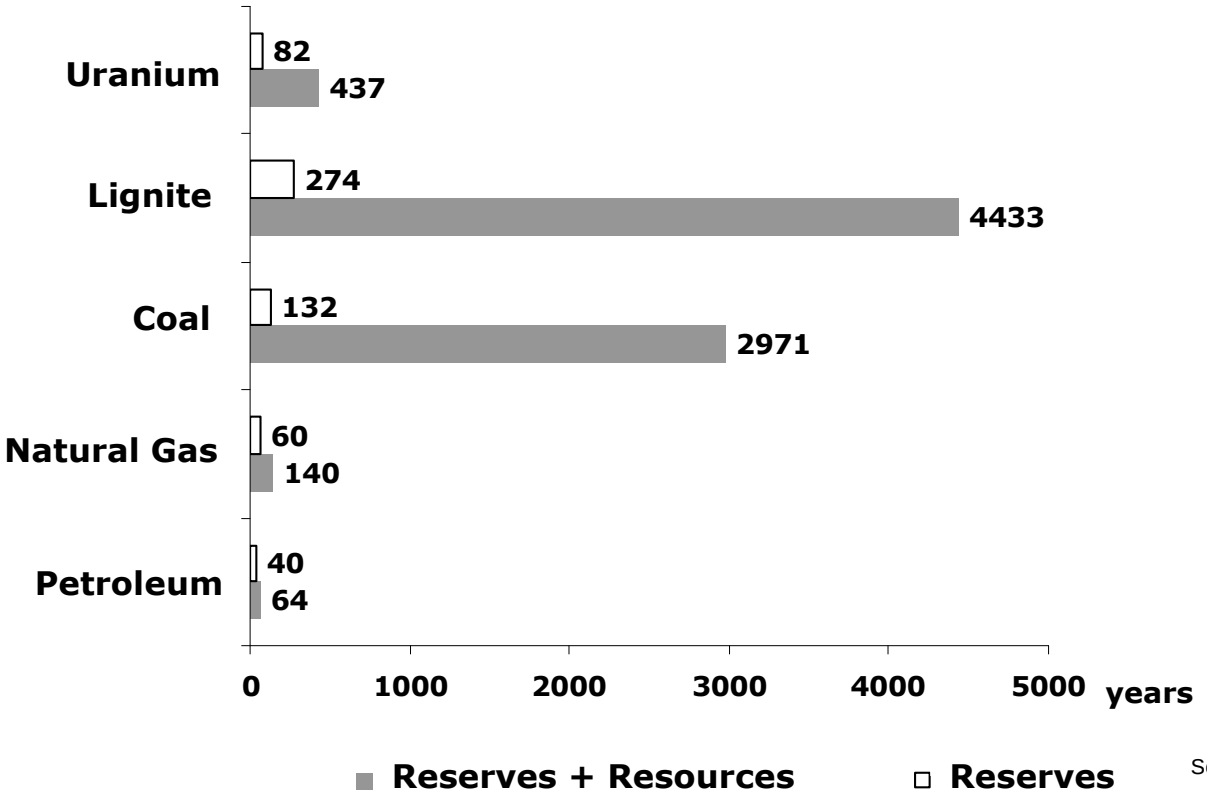
Between 2012 and 2030, an **average GDP growth of 1.2 % per year** is assumed. The shrinking and ageing of the population leads to a fall in the labour force potential. Consequently, the economic growth potential steadily decreases until 2030.

Because of the severe global recession, a decline in gross domestic product in Germany by 5.5 % in 2009 compared to the previous year is presumed in the Reference Case. For 2010, a slight recovery by 0.6 % compared to 2009 is expected. **The original growth path** of the German economy is **only regained in 2014**.

A slight increase in the **passenger transport activity** until 2020 is assumed. Afterwards, due to the decline in population, it dwindles again to approximately the level of 2012 until 2030.

The **freight transport activity** is heavily dependant on the development of economic production. With the beginning of the economic recovery, freight traffic increases notably again and is around 55 % higher than in 2007 with approximately 880 billion tonne-km in 2030.

Sufficient Energy Reserves and Resources



Source: BGR

Around four-fifths of the worldwide energy consumption is currently covered by the three fossil fuels petroleum oil, natural gas and coal.

An exhaustion of these energy commodities **is not expected** in the timeframe of the current outlook. The same applies to uranium. Based on today's **reserves** and with consumption remaining stable, it is expected that **coal** can be sufficient for about the next **130 years**, **lignite** even for around **270 years**. Given the continuation of the current level of production, the reserves of **natural gas** still suffice for the next **60 years** and **oil** for **40 years**.

When the resources which are presently still not economically extractable are taken into account, oil suffices for 64 years and gas for 140 years. Coal would be sufficient for approximately 3 000 and lignite for over 4 000 years.

Although these **energy commodities** are **in principal sufficiently available** in the next two decades, it is expected that, **their extraction becomes increasingly expensive for a number of reasons,** for example because they must be obtained in **remote areas**. This has **effects on world market prices** and thus on the domestic demand for energy. **Of particular concern** is the fact that the **deposits of crude oil are concentrated to a great extent in a few regions** of the world.

On the other hand, certain factors have a stabilising effect on oil prices, like an improvement in the exploitation of conventional oil fields, an intensified use of unconventional deposits and alternative fuels, or an increased substitution of petroleum oil products by alternative energy sources, for example in the industry or the transport sector.

Increase of Crude Oil Price in Nominal and Real Terms

	Real crude oil prices of the OPEC-basket in US $\$_{2007}$/bbl		Nominal crude oil prices of the OPEC-basket in US $/bbl	
Period	Reference	„High Oil price“	Reference	„High Oil price“
2007	69	69	69	69
2012	59	67	66	75
2015	63	75	76	91
2020	69	87	93	117
2025	73	95	110	143
2030	75	100	127	169

Source: BMWi, IER

The Reference Case expects a rise in the real oil price between 2010 and 2030. The average price of crude oil of the OPEC baskets increases to 75 $/bbl (in 2007 prices) until 2030. Assuming an inflation rate of 2.3 % per year, the nominal **oil price would be 127 $/bbl in 2030**.

In order to **accommodate the uncertainty regarding the future oil price development, a second price path („high oil price")** is employed in the sensitivity analyses of the Energy Outlook 2009. There, a crude oil price of 100 $\$_{2007}$/bbl (nominal 169 $/bbl) is reached in 2030.

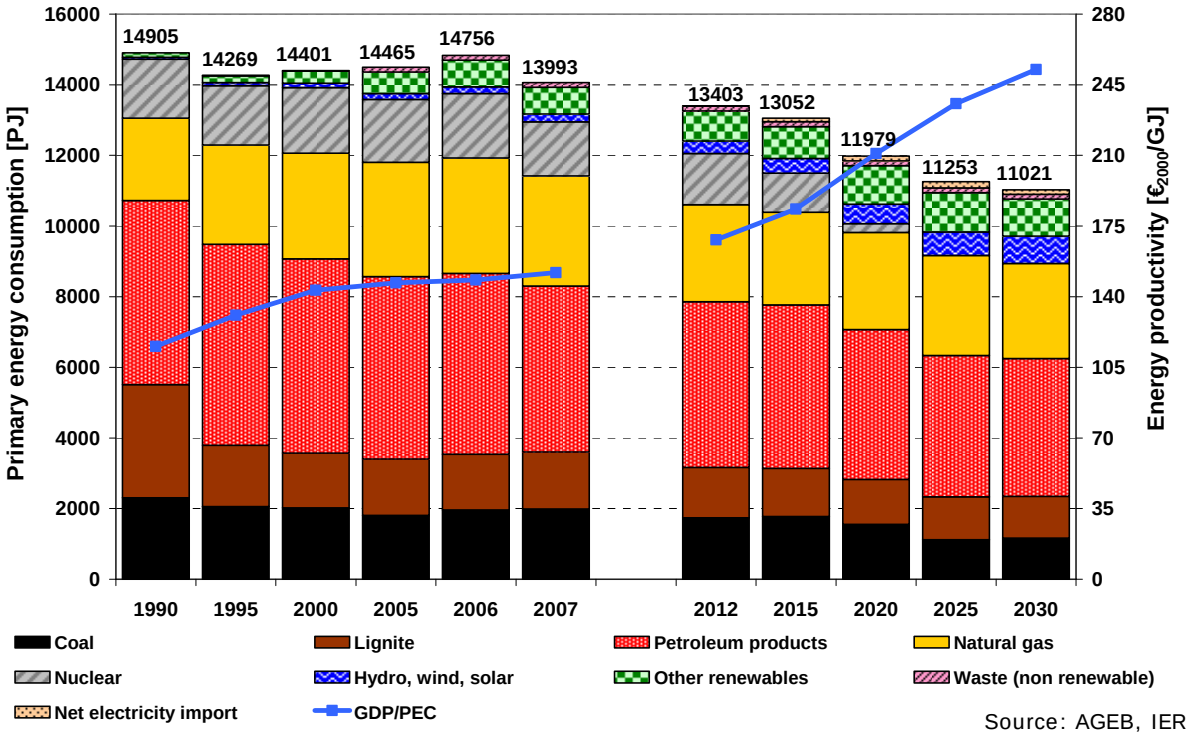
There is a **strong correlation** between the **world price for crude oil and the import price as well as the consumer prices** in Germany. Therefore, the future import prices and the retail prices can be derived from the crude oil price assumptions.

Regarding the price development of **steam coal**, a damping effect on demand is taken into consideration, which is caused by the pricing of CO_2-emissions through the Emission Trading System. Consequently, it gives rise to a less intensive price increase for steam coal compared to the crude oil prices.

Consumer prices are derived from the correlation with the crude oil prices and therefore **increase significantly** over time. Consequently, the nominal petrol prices for households rise from an average of 1.33 € per litre in 2007 to around 2.30 € per litre in 2030. The diesel prices increase from 1.17 € per litre in 2007 to 2.14 € per litre in 2030. For the industrial sector, the nominal price for light fuel oil increases from 560 €/ton in 2007 to 936 €/ton in 2030.

Reference Case

Primary Energy Consumption falls, Energy Productivity increases



Source: AGEB, IER

The **primary energy consumption** (PEC) decreases in Germany by 14 % until 2020 versus 2007, and even by 21 % until 2030.

This is accompanied by an annual increase of macroeconomic **energy productivity**, the ratio of gross domestic product (GDP) to primary energy consumption, by 2 %. Until 2020, energy productivity rises by approximately 83 % compared to 1990.

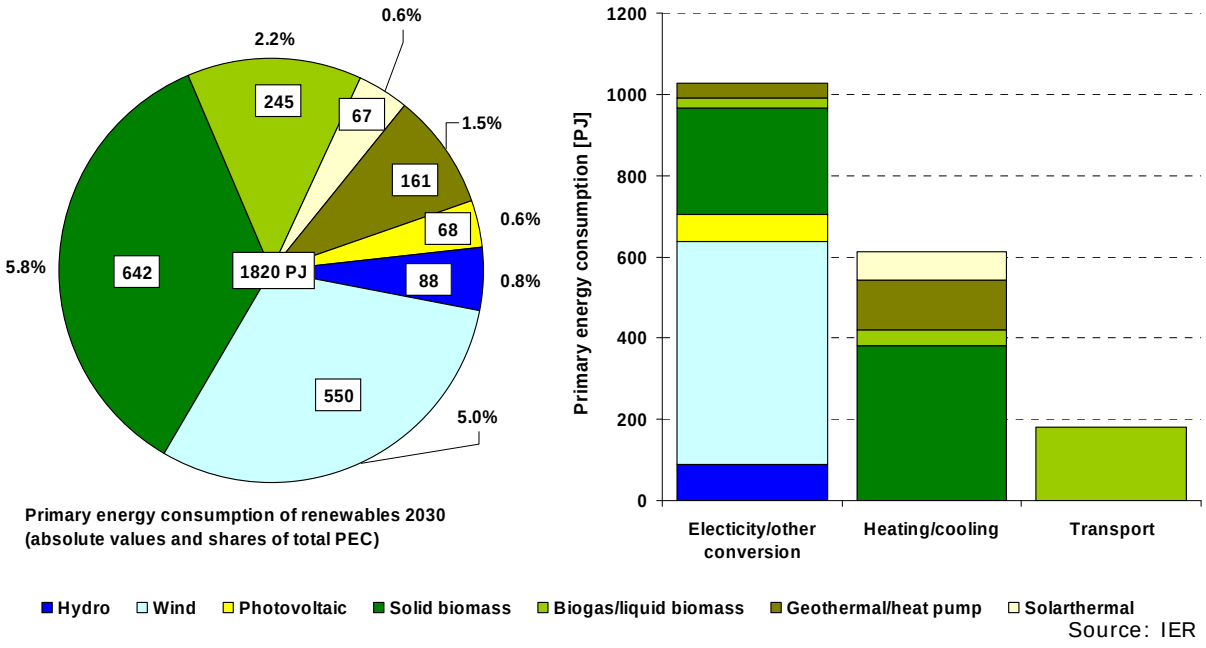
Renewable energy becomes considerably more important in the future: Based on a share of 7 % in primary energy consumption in 2007, their contribution increases to about 13.5 % (1 637 PJ) until 2020 and further to 17 % (1 820 PJ) in 2030.

In contrast, the use of fossil sources of energy dwindles in the future. Thus, the consumption of **hard coal and lignite** decreases by almost 35 % until 2030, from 3 602 PJ in 2007 to approximately 2 347 PJ.

Contrary to the trend of the past decades, the consumption of **natural gas** decreases by around 14.5 % until 2030, from 3 118 PJ in 2007 to 2 690 PJ. Due to the even greater reduction of primary energy consumption, the share of this energy source in primary energy consumption rises.

The **consumption of petroleum oils diminishes by 17 % until 2030**, from around 4 700 PJ in 2007 to approximately 3 900 PJ. In the Reference Case, **nuclear energy operation** is withdrawn gradually **until 2022**.

Application of Renewable Energy



Source: IER

Renewable energy contributes primarily to electricity generation in 2030. This use accounts for a share of 56 % in the total primary energy consumption of renewable energy.

Wind energy dominates in the renewable electricity generation, with a share of 53 %, followed by biomass (28 %) and hydropower (9 %).

The **marked increase in electricity generation from renewables** is based particularly on the development of the offshore wind potential. In 2030, 54 % of electricity from wind energy is generated in offshore plants.

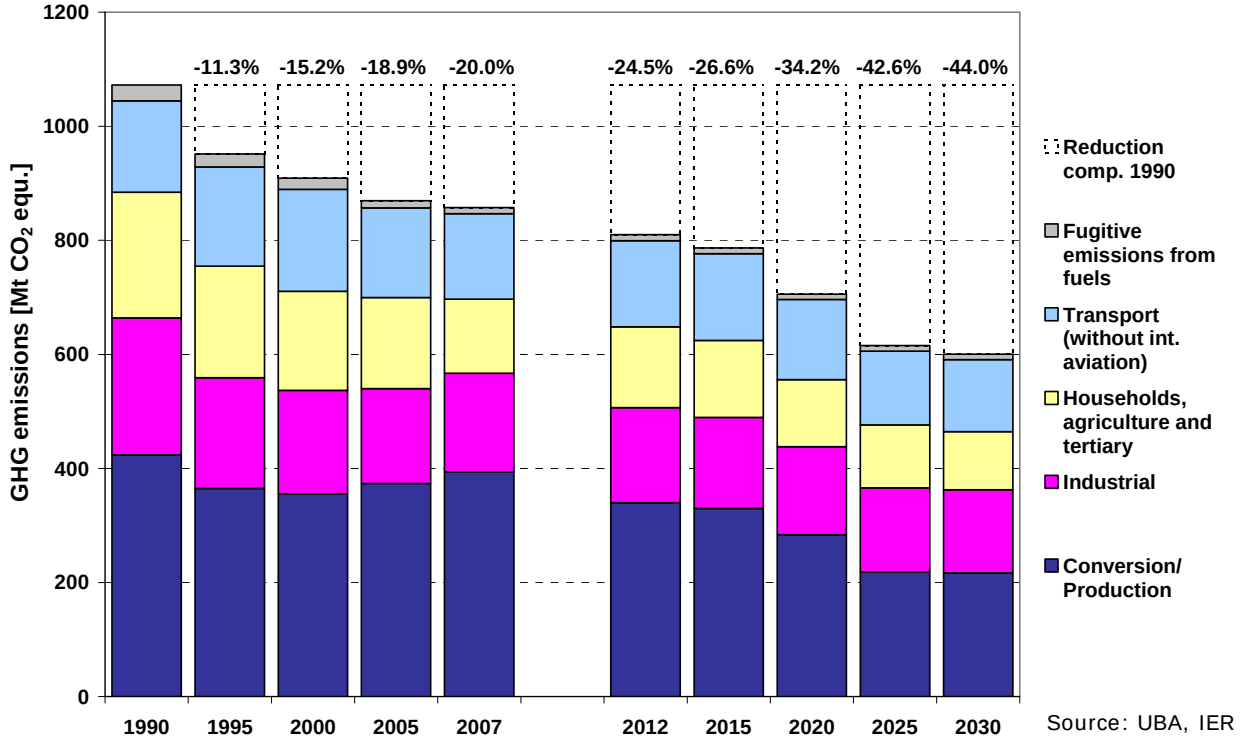
The most important renewable energy sources are, however, biogenic commodities. Biomass, renewable wastes and bio-fuels provide almost half of the primary energy consumption on the basis of renewable energy in 2030.

32 % of the biogenic resources are used for electricity generation in 2030. 47 % are applied for heating and cooling in the industrial sector, households and the tertiary sector and another 20 % are used in the transport sector.

In the heat market, the **Renewable Energy Heat Act (EEWärmeG)** is decisive for the use of renewable energy. In the long-term, the expansion of renewable energy for heat generation is limited by the falling space heating demand (resulting from the provisions of the Energy Conservation Regulation (EnEV)).

The use of bio-fuels in the transport sector develops in line with the statutory minimum quotas. Resulting from a decline in total fuel consumption, the consumption of bio-fuels also decreases in absolute terms in the long-term.

GHG Emissions drop by 34 % until 2020 and by 44 % until 2030



The emissions of greenhouse gases (GHG) decrease in Germany by approximately 34 % until 2020, and by 44 % until 2030 compared to 1990. In 2012, the reduction is nearly 25 %, such that the **reduction commitment of 21 %** fixed in the Kyoto Protocol for Germany is **significantly exceeded.**

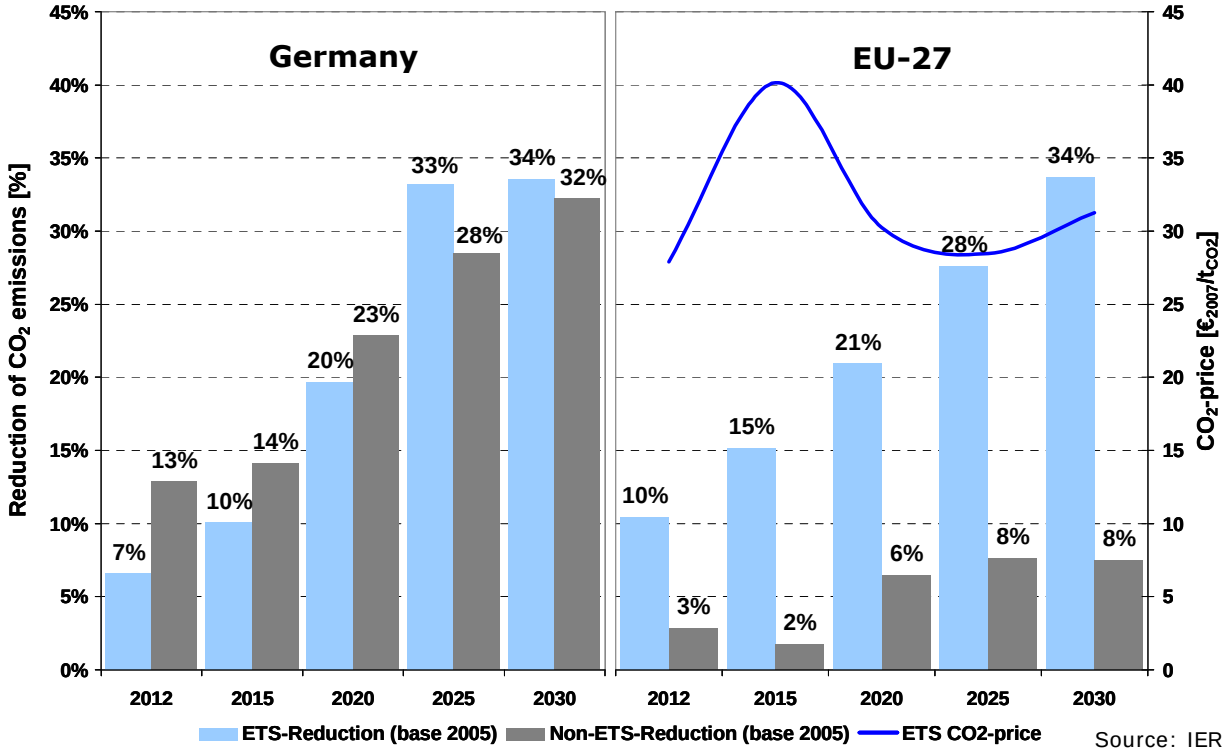
The GHG emissions in the **conversion sector** (public electricity and heat generation, refineries, other conversion) decrease almost by half between 1990 and 2030, making it **the biggest contributor to the emission reduction**. Thus, the share of this sector in the entire GHG emissions decreases from 46 % to 36 % between 2007 and 2030. In particular, **CCS technologies (Carbon Capture and Storage) play an increasingly more prominent role after 2020. Carbon Capture climbs** to 53 million t CO_2 until 2030.

The industrial GHG emissions diminish by 11 % or 20 million t of CO_2 equivalent **between 2007 and 2020 and by nearly 17 %** or 29 million t CO_2 equivalent **up to 2030**.

The **share of the sectors of households, agriculture and tertiary** in total emissions amounts to **approximately 17 %** over the observation period.

In the **transport sector**, a fall **of GHG-emissions by 6 % until 2020 and by 23 % until 2030** is expected. The transport sector accounts for around 21 % of the GHG emissions in 2030. When taking into account the emissions from international aviation, which are not considered in the Kyoto Protocol, the GHG emissions of the transport sector would be approximately 28 million t of CO_2 equivalent higher in 2020 and approximately 32 million t of CO_2 equivalent higher in 2030.

EU Emission Certificate Trading and CO_2 Prices



Source: IER

The Energy Outlook 2009 **takes the EU climate policy targets for 2020 into account**: in the scope of the European Emission Trading System (ETS), the participating sectors (particularly electricity generation and energy intensive industries) must reduce their CO_2 emissions EU-wide by 21 % until 2020 compared to 2005. For the non-participating sectors (especially households and transport), an EU-wide reduction target of 10 % is applied. For Germany, the national non-ETS reduction target is 14 % compared to 2005.

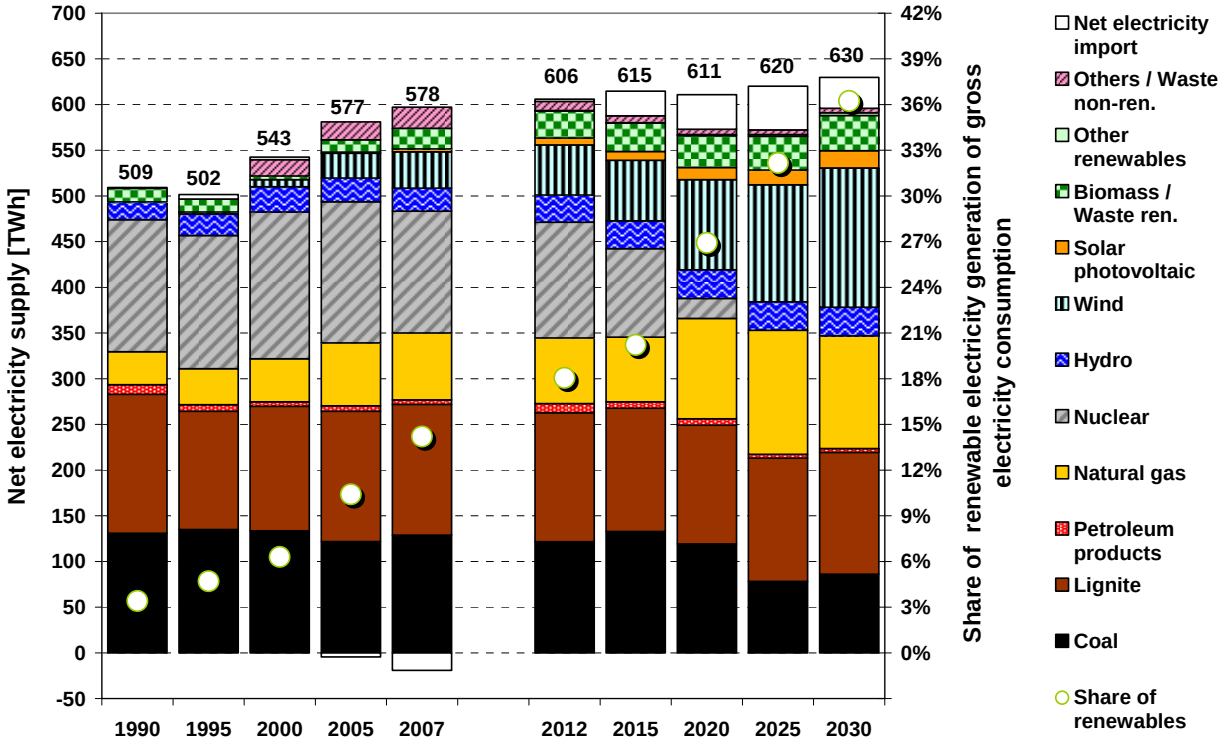
This national target in the context of EU burden sharing is considerably surpassed: **Until 2020, the emissions from the non-ETS sectors diminish by almost 23 % in Germany.**

In contrast, the corresponding EU-wide target of a 10 % reduction is not fulfilled.

The Emission Trading System ensures, however, that **the EU emissions reduction target of 21 %** for the participating sectors **is attained**.

The price for emission certificates increases in real terms to approximately 40 $€_{2007}$/t CO_2 in 2015. This is primarily due to a fall in the annual certificate allocation, the continued rise in electricity demand in the EU-27 after the financial crisis, and the contraction of electricity generation from nuclear energy in Germany as well as the restricted capacity extension of new power plants in the first few years. After 2015, owing to the new CO_2 reduction options, the prices of the certificates decrease to 28 $€_{2007}$/t CO_2 until 2025. After 2030, however, drastic price surges are expected (to 53 $€_{2007}$/t CO_2 in 2040 and 88 $€_{2007}$/t CO_2 in 2050).

Share of Renewable Energy in Gross Electricity Consumption increases to 27 % until 2020



Source: AGEB, IER

Electricity generation from nuclear energy is discontinued no later than 2022. That makes the **net electricity generation**[1] **decrease by slightly over 4 %** until 2025 compared to 2007. The net electricity generation increases again thereafter and amounts to 596 TWh in 2030, which is comparable to the level of 2007.

In order to satisfy the **renewed rise in domestic electricity demand** after the financial crisis in a time of falling generation, from 2012 onwards **more electricity** is **imported**. Net electricity imports reach a maximum in 2025 with 48 TWh.

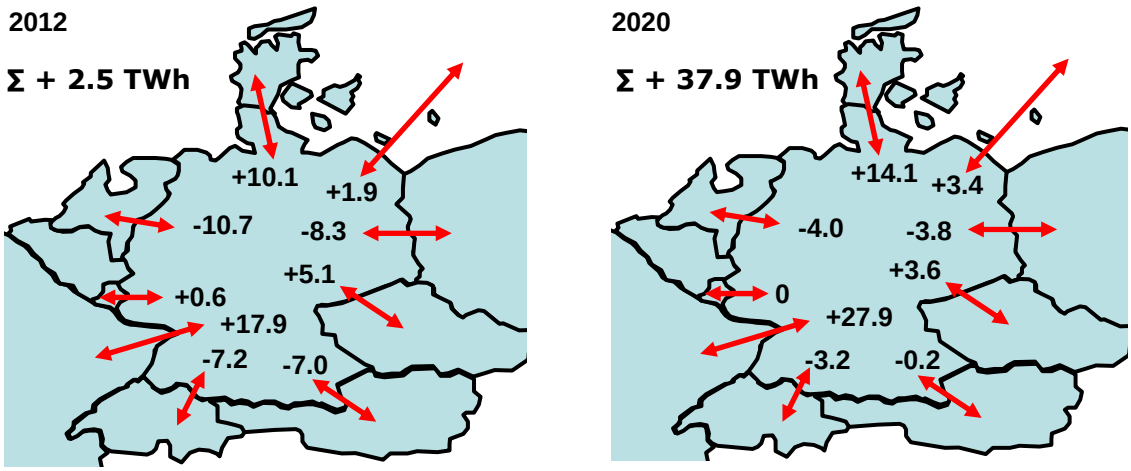
Electricity generation from renewable energy rises continuously, from 91 TWh in 2007 to 173 TWh in 2020 and 239 TWh in 2030.

Amounting to around 14 % in 2007, the **share of renewable energy** in gross electricity consumption increases to **27 %** until **2020** and to more than 36 % in 2030. Therefore, the objective for the year 2020 to generate at least 30 % of gross electricity consumption from renewable energy technologies is missed only slightly.

Fossil fuels still account for 58 % of the electricity generation in 2030. Whereas the share of hard coal decreases from nearly 22 % in 2007 to 14 % in 2030, the share of natural gas increases from approximately 12 % to almost 21 % in the same period. Lignite has a share of around 22 % in 2030, almost the same share as in 2007.

[1] The difference between net electricity generation and gross electricity consumption lies in the own electricity consumption of the power plants and in the electricity imports. The sum of net electricity generation and the power plant's own consumption represents the gross electricity generation. The sum of gross electricity generation and net electricity imports forms the gross electricity consumption.

Electricity Imports to Germany rise



Source: IER

Electricity imports and exports almost balance each other out in 2012.

In the case of a nuclear phase-out, a **rise in electricity imports** is expected after 2012. Due to the differences in electricity prices among neighbouring countries, intensified net electricity imports with approximately 38 TWh in 2020 contribute to a cost-efficient electricity provision in Germany.

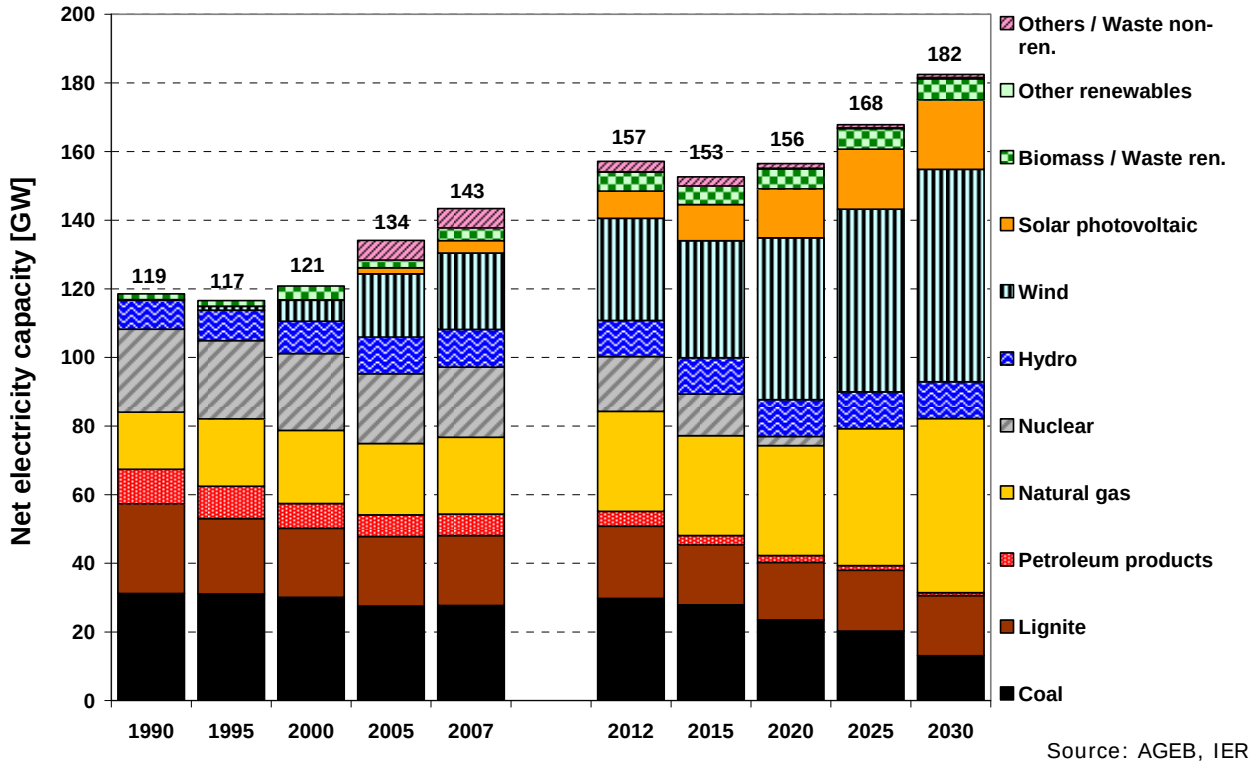
The majority is imported from France, where a net 18 TWh of electricity is imported in 2012. In comparison, this corresponds to around 3 % of the net electricity generation in Germany. A further 12 TWh are imported from Scandinavia in 2012.

Net electricity exports or negative import balances are recorded primarily for **Austria** and **Switzerland** as well as the **Netherlands** and **Poland**.

The rising **electricity imports** to Germany after 2012 are predominantly imported from France: the **net imports from France increase by nearly 60 %** between 2012 and 2015. In addition, the net imports from Scandinavian countries rise to almost 18 TWh in 2020.

By contrast, the **net electricity exports** to Poland, to the countries of the Alpine region and to the Netherlands **drop drastically**. In 2020, a fall by almost 5 TWh in net exports to Poland compared to 2012 is recorded, for the countries of the Alpine region by 11 TWh and for the Netherlands by 7 TWh.

Wind Power Capacity and Natural Gas Power Plant Capacity increase substantially



Source: AGEB, IER

The net power generation capacity of the German power plants increases by 27 % until 2030 versus 2007. It amounts then to around 180 Gigawatt (GW_{el}).

The net power generation capacity based on renewables rises considerably: **renewable energy technologies have a capacity of 93 GW_{el} in 2030, which corresponds to around half of the installed power plant capacity.**

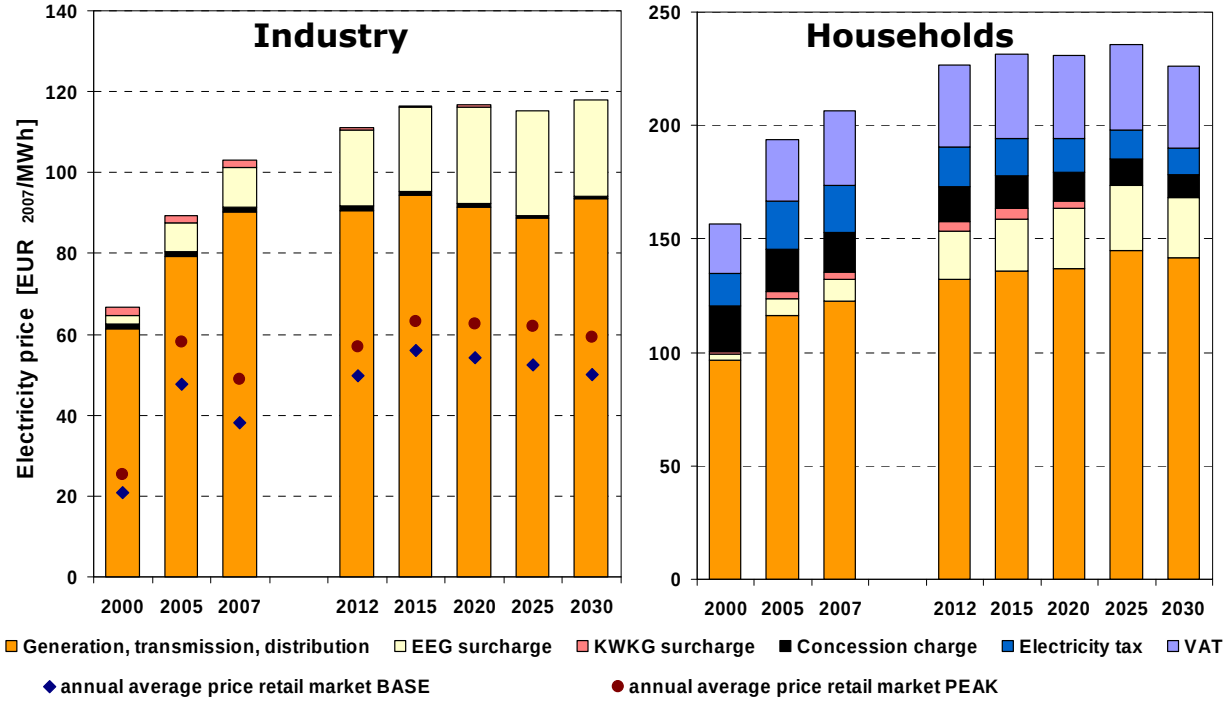
Wind energy has by far the biggest share in the power plant capacity based on renewable technologies. This is due to the accelerated expansion of offshore wind capacities, which amount to around 25 GW_{el} in 2030.

In view of the nuclear energy phase-out and the decommissioning of old power plants, around **46 GW_{el} of fossil fuel fired power plant capacity is constructed** between 2012 and 2030, which corresponds to around half of the installed fossil fuel fired power plant capacity in 2030.

Subsequently, the **installed capacity of fossil power plants varies merely slightly** and progresses to a level of around 80 GW_{el}.

The capacity of natural gas power plants is doubled until 2030 to 51 GW_{el}. A large proportion of this power plant capacity is used to compensate the fluctuating electricity generation from renewable energy technologies and to replace the decommissioned nuclear and coal power plants. The power plant capacity from coal dwindles by 18 GW_{el} till 2030 and amounts then to 31 GW_{el}.

Only a Slight Rise in Electricity Prices



Source: EEX, IER

Wholesale prices of electricity (average annual prices) hold in the long-term a level of approximately 50 €$_{2007}$/MWh in the case of base load electricity prices and of approximately 59 €$_{2007}$/MWh in the case of peak load electricity prices.

The **level of the electricity prices** for final consumers is determined essentially by the **generation costs**, but also by the statutory **taxes and duties**.

The **industrial electricity prices** (excluding electricity and sales tax) **rise** to a level of around 118 €$_{2007}$/MWh **until 2030**.

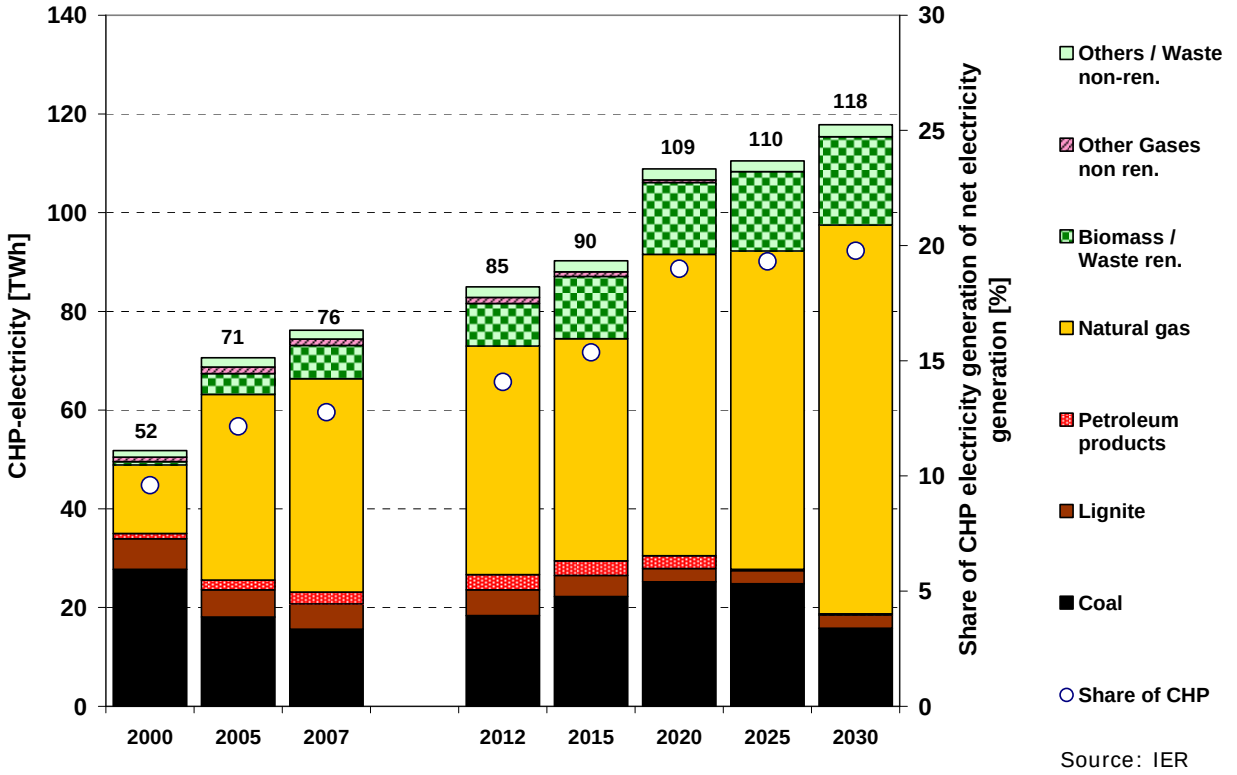
The price components for generation, transportation and distribution remain nearly constant and amount to almost 94 €$_{2007}$/MWh in 2030 (expressed in real terms). In contrast, the extension of electricity generation from renewables induced by the EEG gives rise to an increase of the statutory levy. Therefore, the price components based on taxes and duties double from 12 €$_{2007}$/MWh in 2007 to around 24 €$_{2007}$/MWh in 2030.

The **electricity price for households increases** to 226 €$_{2007}$/MWh (about **23 €-Cent$_{2007}$/kWh) in 2012. This price level is maintained until 2030**, except for insignificant fluctuations.

The **costs for generation, transportation and distribution rise slightly** to around 142 €$_{2007}$/MWh in 2030 and account for 60 % of the household electricity price.

Owing especially to the additional installed capacity of offshore wind energy farms, the portion of the feed-in-tariff (EEG) in the household electricity price is expected to increase from 9.3 % in 2012 to 11.7 % in 2030. The CHP (KWKG) levy is equal to 4 €$_{2007}$/MWh in 2012, and is discontinued after 2020.

CHP Electricity increases, yet the National Goal to double the Share in Total Electricity Generation is not attained



Source: IER

In order to boost the electricity generation from Combined Heat and Power (CHP) plants, a **temporary extension of the CHP Act** (KWKG) is assumed.

By means of the support measures set in the CHP Act, CHP electricity is increased continually from 76 TWh in 2007 to about 118 TWh in 2030.

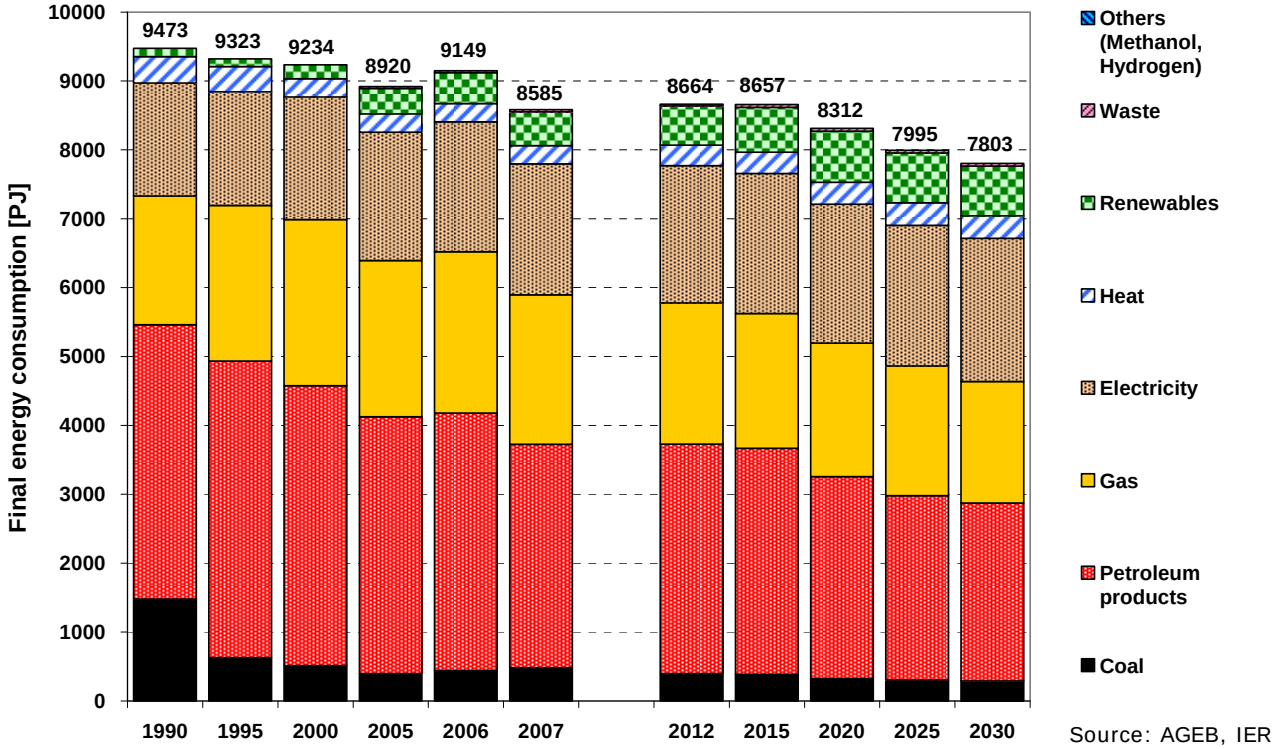
The national goal to increase the **share of CHP electricity** in net electricity generation from 12 % in 2008 **to about 25 %** until 2020 **is not attained**. The share of CHP electricity amounts to 19 % in 2020.

Besides natural gas, which has a share of 67 % in the generation of CHP electricity in 2030, biomass (including renewable wastes) becomes more important in the CHP electricity generation, and reaches a share of nearly 15 % in 2030.

The **district heat extraction** from CHP plants **rises** from 274 PJ in 2007 to 321 PJ in year 2030. As a result, the share of CHP plants in district heating reaches 85 % in 2030. Apart from that, district heat is produced in heating plants and through the use of waste heat.

Predominantly due to a **rise in industrial self-generation through CHP plants**, the increase of CHP electricity generation is greater than that of CHP district heating.

Final Energy Consumption decreases by 15 % until 2030



Source: AGEB, IER

The **final energy consumption** falls **by about 15 %** until 2030 compared to 2006[2].

This can be mainly explained by the **decline in heat demand**, which results in particular from increased energy efficiency in buildings.

The targets of the **EU Energy Efficiency Directive** to reduce the final energy consumption by 9 % until 2016 compared to the average consumption in the period 2001 to 2005 is already **surpassed** in 2012.

On account of the reduced heat demand, the **consumption of petroleum products and natural gas declines significantly**.

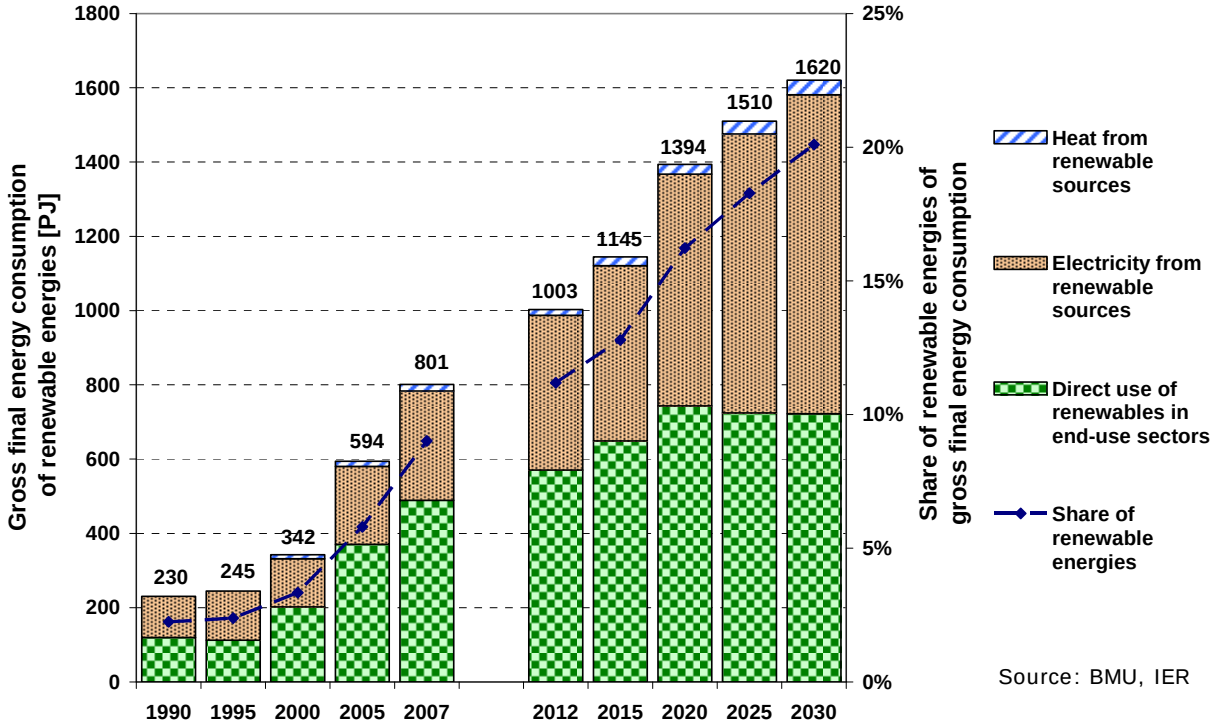
Through the regulations of the Renewable Energy Act (EEG), the Renewable Energy Heat Act (EEWärmeG) and the mandatory bio-fuel quota, the renewable energies can by contrast win market shares. In particular, the heat demand in newly built houses is in the future increasingly covered by renewable energy.

A rise **in electricity demand** is expected in all final consumption sectors. This is mainly due to the increasing number of households, the amplified application of heat pumps for heat supply, the intensified use of electricity for information and communication technologies and for cooling and air conditioning, as well as the growth in electric mobility.

The final energy consumption of electricity is 2 079 PJ in 2030, about 10 % above the value of 2006.

[2] Due to the mild weather conditions and low sales, quantities of fuel oil in this year, the statistical data on final energy consumption for 2007, can not be considered as representative. For that reason, the data for final energy consumption in 2006 is used as the reference year.

Doubling of Renewable Energy Contribution to Final Energy Consumption by 2030



Between 2007 and 2030, the **contribution of renewable energy to gross final energy consumption[3] can be nearly doubled**. The share reaches nearly 20 % in 2030, compared to around 16 % in 2020.

The EU-target of an 18 % share of renewable energy in gross final energy consumption by 2020 falls short by 2 percentage points, despite the fact that renewable energy in the heat market covers by then already 15 % of the final energy consumption.

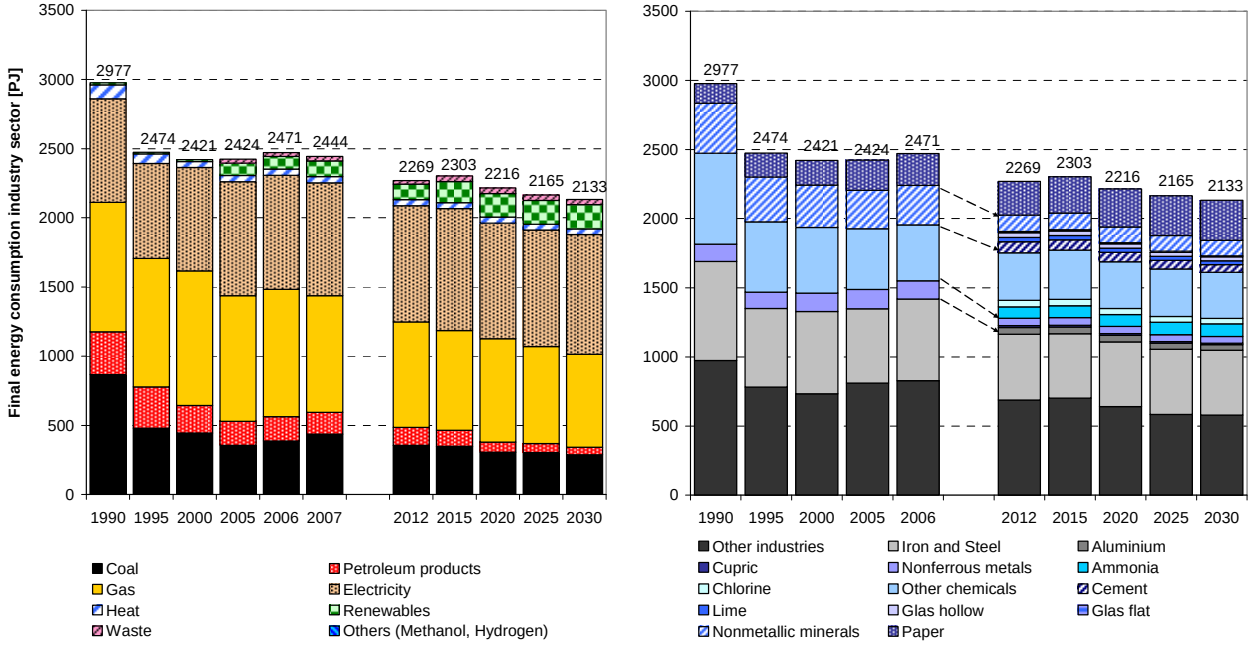
The use of renewable energy in the final consumption sectors (Industry, Households and Tertiary Sector) arises on the one hand from the direct application of renewable energy sources, for example in the form of bio-fuels or wood for decentralized space heating supply. On the other hand, the contributions which result from the application of electricity and district heat generated from renewables must also be taken into consideration.

In particular, through the strengthened application of heat pumps, solar thermal collectors as well as wood pellet heating systems, the direct use of renewable energies in the final consumption sectors increases also in the future. The rise in the shares of electricity from renewable sources is expected, however, to be even more intense.

Electricity from renewables has a share of 53 % in the contribution of renewable energy to gross final energy consumption in 2030, while the direct application accounts for 45 % and district heat from renewables for 2 %.

[3] The gross final energy consumption is defined as the sum of final energy consumption, transmission and distribution losses and the own consumption in electricity and heat generation.

Final Energy Consumption of the Industrial Sector



Source: AGEB. IER

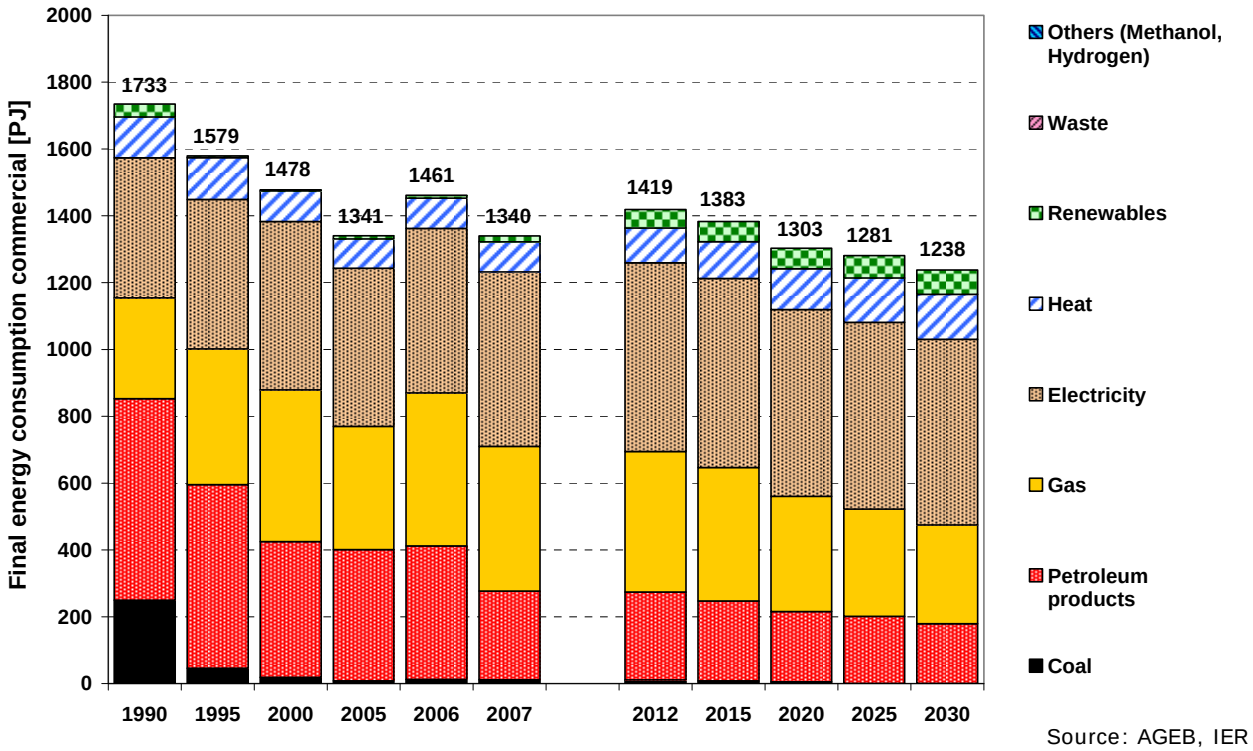
The severe **worldwide recession** has a strong effect on the export-oriented German economy. Concerning the industrial production outputs, a severe decline that affects all sectors is expected in the short-term in Germany (2009/2010), before a recovery takes place. In the long-term (by 2030), mainly constant or falling production levels are presumed, with structural shifts between the various sectors of industry.

Despite the re-emergence of industrial production, **the final energy consumption of the industrial sector falls** in comparison to the average consumption of the years 2001-2005 until 2015 by 109 PJ, and until 2020 by 196 PJ. Consequently, the **objectives of the National Energy Efficiency Action Plan for the industry sector are reached**. According to the plan, a reduction of the industrial final energy consumption of 45 to 64 PJ until 2016 is fixed compared to the average of the years 2001-2005. Until 2030, energy productivity rises further, so that the final energy consumption of the industrial sector falls continuously.

Different and partially opposing effects overlap in the development of final energy consumption of the individual industrial branches. While **increases in efficiency** through improvements in production processes or cross-section technologies lead to reductions in energy consumption, the variation of the **industrial production levels** shows no clear tendencies with respect to the final energy consumption, owing to industry specific differences (e.g. increase in production in paper industry, decline in cement production).

Electricity and renewable energy have a higher share in final energy consumption of the industrial sector in the future, whereas the contributions of petroleum products, gas and coal decrease.

Final Energy Consumption of the Tertiary Sector falls substantially



Source: AGEB, IER

In the tertiary sector (trade, commerce and services, including agriculture), **the final energy consumption** falls by 15 % until 2030 compared to 2006.

This is due to a **reduction in space heating demand**, resulting from improvements in thermal insulation and in the efficiency of the installed heating systems. By contrast, rising demands are found in the area of information and communication technologies as well as for air conditioning and cooling purposes.

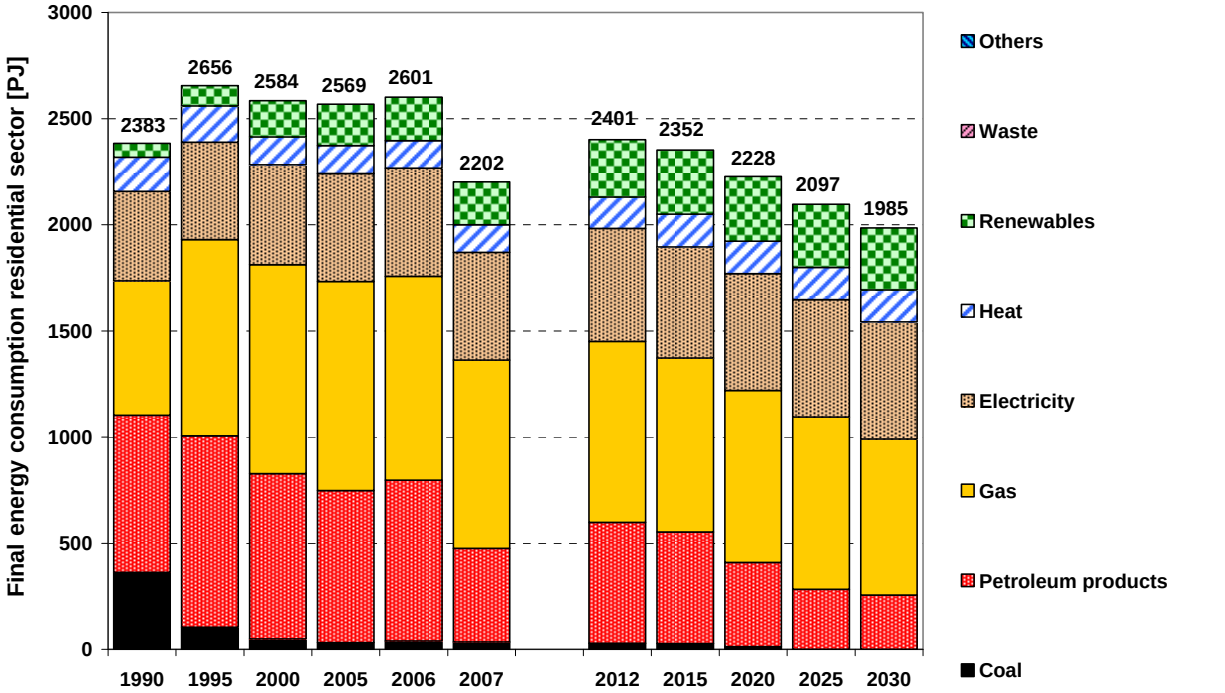
Predominately attributable to the provisions prescribed in the Renewable Energy Heat Act (EEWärmeG), **the share of renewable energy increases** between 2005 and 2020 from 0.7 % to 4.7 % of the final energy consumption.

The application of district heating rises by 50 % in comparison to 2006. This development is also benefited by the EEWärmeG, which allows for the application of district heating as an alternative to the use of renewables for the heat supply of new buildings.

In contrast, the **consumption of petroleum oil products and natural gas shrinks continually until 2030.**

The share of electricity in final energy consumption increases. This is due to the increased electricity consumption for space heating generation through the amplified application of heat pumps as well as growing electricity demand for air-conditioning or cooling purposes.

Final Energy Consumption of Households decreases, despite the Rise in the Number of Households



Source: AGEB, IER

The resident population and the number of private households are important determinants for a country's energy consumption. The Reference Case assumes a **shrinking population** from 82.2 million in 2007 to 79.7 million in 2030. **In contrast, the number of households grows further** to 42.0 million in 2030.

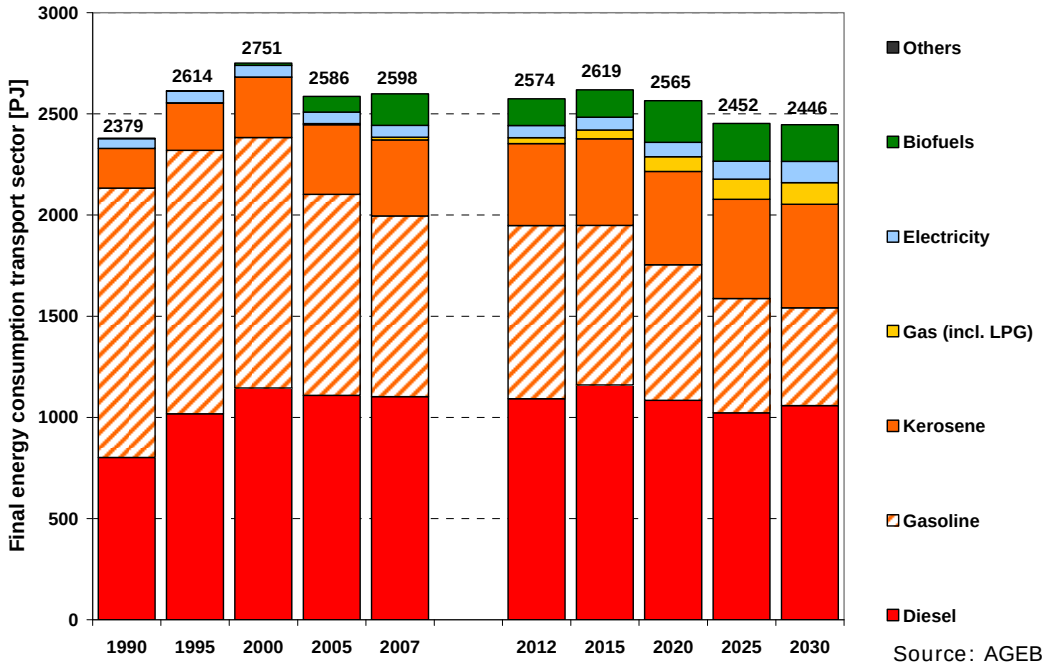
The **final energy consumption of households shrinks** by 24 % until 2030 in comparison to 2006, despite the rise in total living space by 17 % over the same time period. This contraction can be ascribed to the regulations defined in the **German Energy Conservation Regulation** (EnEV) for new and old properties, which aims to strengthen heat insulation.

The **share of petroleum oil in the energy mix falls** from 29 % to approximately 13 % between 2006 and 2030. By contrast, **the natural gas share** of 37 % **remains** almost **constant** until 2030.

The **share of renewable energy in the final energy consumption of households increases from 8 % to nearly 15 % between 2006 and 2030**, mainly due to the provisions of the EEWärmeG. Biomass, solar and geothermal energy as well as ambient heat are the primary contributors to this rise.

The electricity consumption increases by 8.4 % from 2006 to 2030. Although the specific consumption of many electrical appliances falls, electricity consumption grows, primarily owing to a rise in the use of information and communication technologies, the increased application of electrical heat pumps as well as the growing demand for air conditioning.

Final Energy Consumption of the Transport Sector falls after 2015



Source: AGEB, IER

The final energy consumption of the transport sector diminishes continually by around 7 % **starting from 2015** until 2030.

Crude oil based fuels, like **diesel, petrol and kerosene, dominate further** and still account for 84 % of the final energy consumption in 2030. As a result of improvements in efficiency and an **increasing share of diesel cars**, petrol turnover drops almost by half. The diesel consumption remains in contrast almost constant, mainly because the considerable increase of freight transport activity outweighs the efficiency improvements in road freight transport.

The growth of air traffic is reflected in the **increasing kerosene consumption**, which rises by 37 % between 2007 and 2030.

The **share of natural gas and liquefied petroleum gas** in the final energy consumption of the transport sector grows continuously to 4.3 % in 2030, mainly because of the petroleum oil tax exemption.

The **consumption of bio-fuels develops in accordance with the statutory minimum quotas**, so that the share of bio-fuel in petrol and diesel fuel sales amounts to 10.5 % in the years 2020 to 2030.

With a nearly constant passenger transport activity and a **reduction of average fuel consumption of motor cars to 4.9 $l_{Petrol\ equivalent}$/100 km**, the **final energy consumption of motorised individual transport** drops substantially until 2030. Factors that contribute to this reduction are improvements of conventional engines and the increasing use of hybrid, gas and electrical vehicles.

In spite of decreasing specific fuel consumptions and increasing load factors, the **final energy consumption of road freight transport increases** by 18 % between 2007 and 2030 because of a growth of freight transport activity by 63 % in the same time period.

Variants with Lifetime Extension

Positive Macroeconomic Effects of Lifetime Extension

	2012		2015		2020		2025		2030	
Lifetime Extension [a]	**40**	**60**	**40**	**60**	**40**	**60**	**40**	**60**	**40**	**60**
GDP [Bn €$_{2000}$]	2 257	2 257	2 400	2 401	2 537	2 542	2 656	2 673	2 789	2 810
GDP [Deviation from Reference in %]	0.13	0.13	0.26	0.27	0.42	0.62	0.17	0.79	0.16	0.92
GDP [Deviation from Reference in Bn €$_{2000}$]	3	3	6	7	11	16	4	21	4	26
Gross Value Added [Bn €$_{2000}$]	2 040	2 040	2 162	2 162	2 274	2 279	2 373	2 387	2 480	2 497

Source: IER

The longer operation times of nuclear power plants facilitate the achievement of the EU targets for climate protection and at the same time have a positive impact on economic development and employment in Germany. The causes lie in significant cost reductions associated with climate protection, energy imports, and electricity provision.

In spite of higher costs due to power plants being back-fitted, relatively low variable production costs for nuclear power and the reduced costs for CO_2 certificates **enable a decrease in electricity prices.** Relative to the Reference Case, reductions of up to 6 €$_{2007}$ per MWh are realized in the case of a lifetime extension to 40 years, and of up to 9 €$_{2007}$ per MWh in the case of a lifetime extension to 60 years.

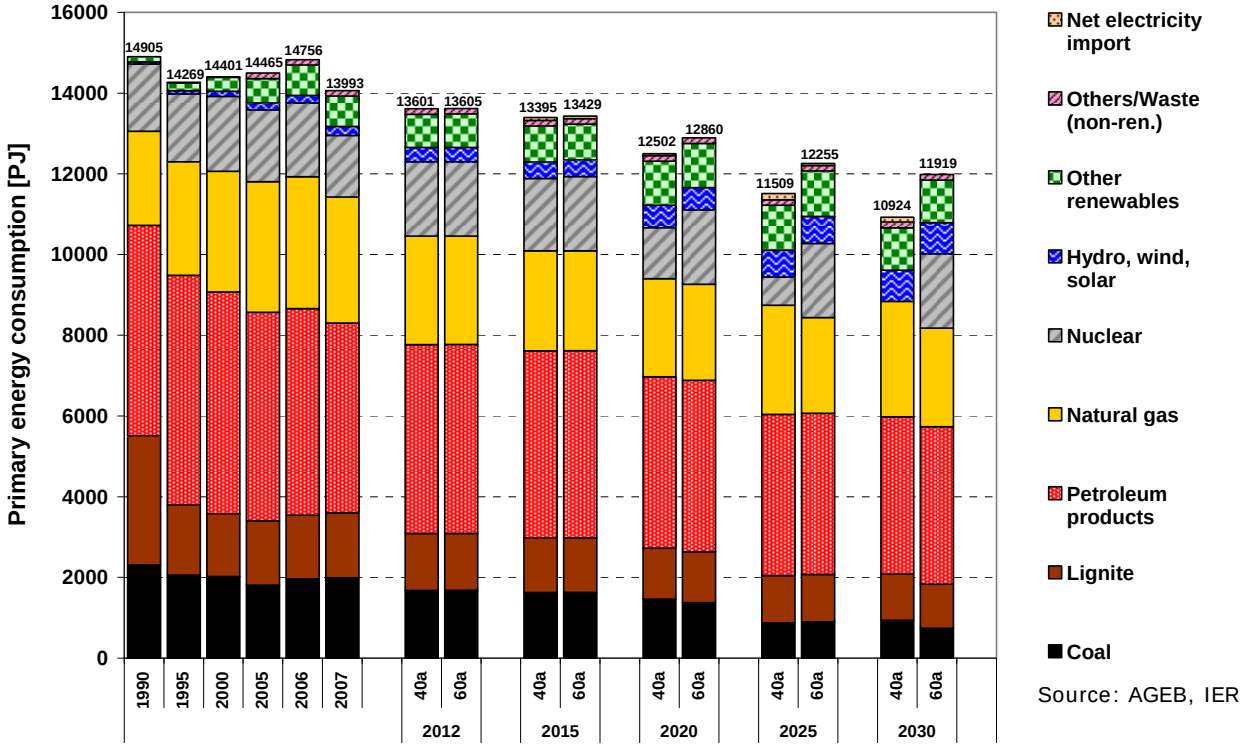
These direct cost reductions multiply when considering the whole national economy, e. g. through the channels of changed prices, sector-specific inputs and general demand. This results in positive effects in production, consumption, and investments.

Compared to the Reference Case, GDP is expected to be 0.4 % to 0.6 % higher in 2020 and 0.2 % to 0.9 % higher in 2030 (depending on whether nuclear power plants are operated 40 or 60 years).

For the whole period from 2010 to 2030, the **cumulated GDP exceeds** the GDP derived in the Reference Case **by 122 billion € to 295 billion €** (in prices of 2000).

Depending on how long nuclear power plants operate, **employment figures also increase** relative to the Reference Case: by up to 191,000 jobs in 2020 and 233,000 jobs in 2030.

Primary Energy Consumption with Lifetime Extension



Source: AGEB, IER

Until 2020, **primary energy consumption** develops similarly in both variants of delayed nuclear phase-out. During that period, **its decrease is significantly less than in the Reference Case**. For 2020, primary energy consumption is expected to be 7 % higher than in the Reference. This can mainly be attributed to better economic performance as well as to lower electricity prices.

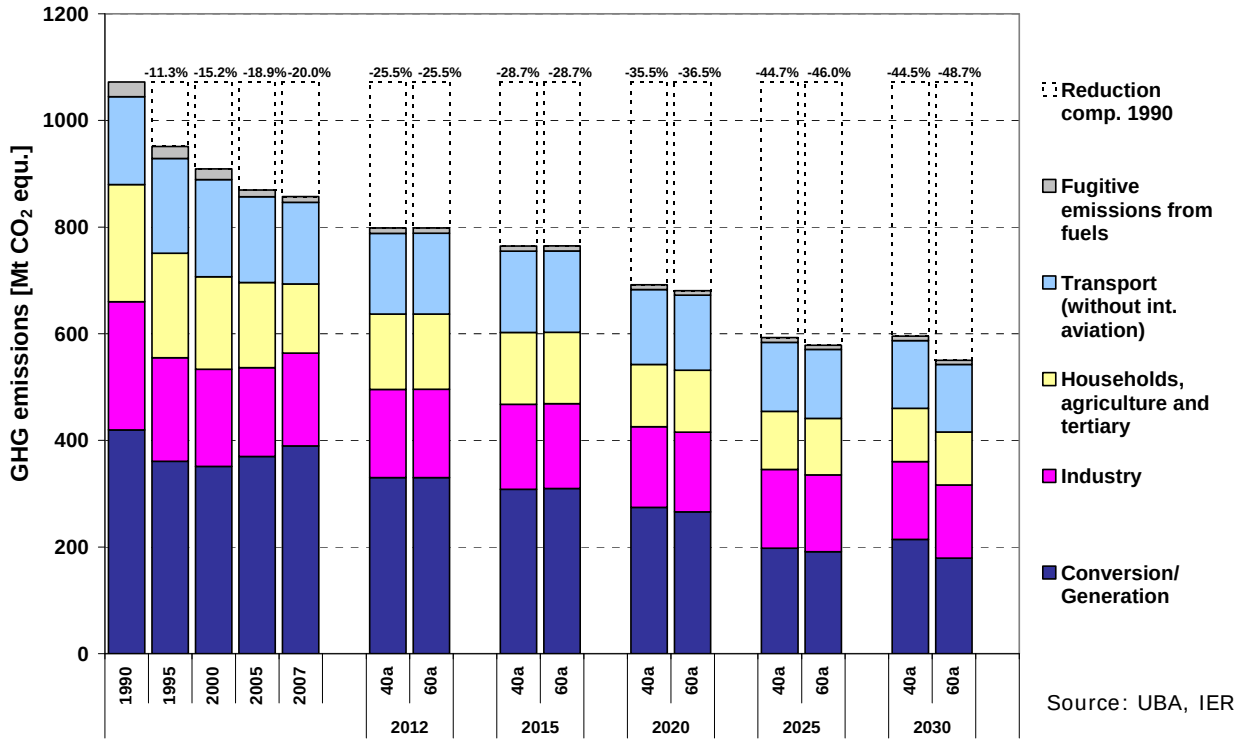
Longer operation of nuclear power plants results in lower inputs **of coal and natural gases in electricity production**. This is reflected in the primary energy mix. For instance, the consumption of natural gas in 2020 is cut by 11 % to 13 % as compared to the Reference Case.

Figures of **petroleum consumption** do not differ significantly between both variants of operation time or in comparison to the Reference Case.

Assuming a lifetime of nuclear power plants of 40 years, the use of nuclear power considerably decreases from 2020 on. As a consequence, the primary energy consumption after 2020 aligns to the Reference Case. In the variant with an operational lifetime of 60 years, however, the primary energy consumption remains constantly above the Reference level.

Political incentives and subsidies promote the **increased use of renewable energies**. Hence, the **issue of phase-out can largely be separated from a discussion about renewables**.

Lower GHG Emissions and CO_2 Prices with Lifetime Extension



Longer operation of nuclear power plants leads to a stronger reduction of greenhouse gas (GHG) emissions in Germany than in the Reference Case and proves to be a **cost-efficient variant to avoid emissions**.

The result is a **noticeable decrease in prices of emission certificates that are traded in the EU,** while total emissions in the ETS-sector on the European level remain unchanged. For 2020, the price of such a certificate is up to 5.1 $€_{2007}$/t CO_2 lower in comparison to the Reference Case. In 2030, the difference maximally amounts to 10.1 $€_{2007}$/t CO_2.

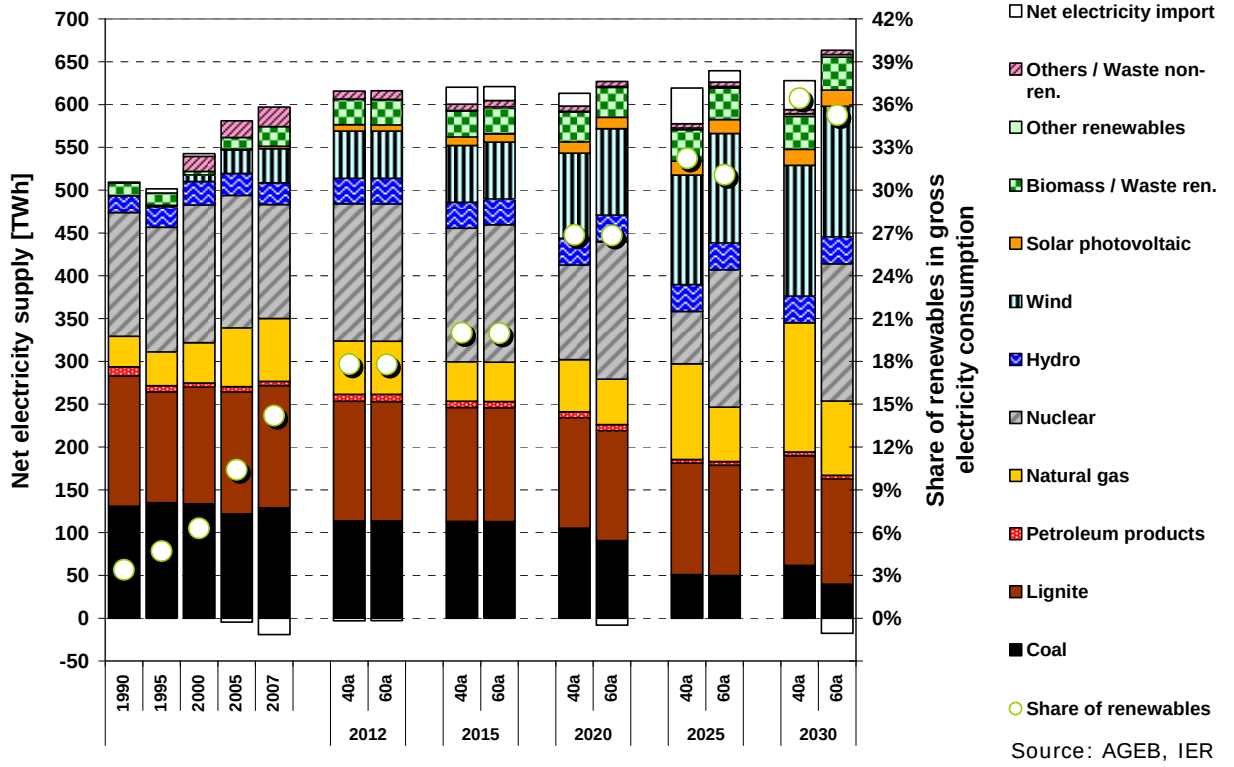
In the Reference Case, German GHG emissions are significantly higher than in the variants assuming a delayed nuclear phase-out. In 2020, figures increase by 14 to 25 Mio t CO_2 equiv. or 2 % to 4 %, respectively. In 2030, GHG emissions in the Reference Case are some 4 to 50 Mio t CO_2 equivalent or 1 % to 8 % higher, respectively.

Relative to 1990, GHG emissions in Germany decrease by up to 37 % in 2020 and 49 % in 2030 when longer operational times of nuclear power plants are given. This is 3 % points to 5 % points more than in the Reference Case.

Accordingly, Germany's contribution to the EU target, set for 2020 to reduce CO_2 emissions by 21 % in industries participating in the Emission Trading System, increases. The additional electricity produced without CO_2 allows for a reduction of emissions compared to 2005 between 22 % and 24 %, instead of 20 %.

While CO_2 emissions in transformation are lower during the observed period than in the Reference Case, the industrial sector features a higher level of emissions when one neglects the falling emissions caused in the industries' electricity self-production.

Electricity Generation with Lifetime Extension



Source: AGEB, IER

With the longer lifetimes for nuclear power plants, less additional power capacity is needed in Germany. In the mid-term (app. 2020), a longer operational time of 40 years reduces the additionally needed capacity by 7 Gigawatts (GW_{el}). With an extension to 60 years, this figure rises to 15 $GW_{el.}$

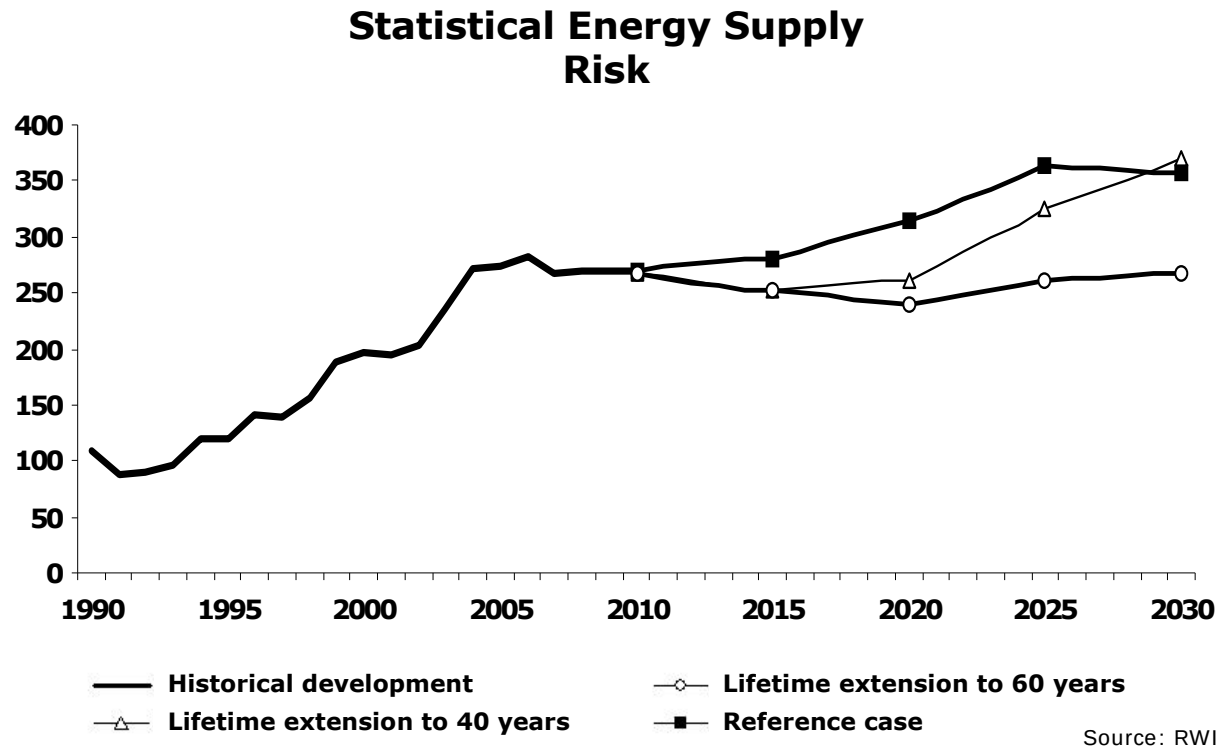
With a delayed phase-out, less natural gas power plants are built in the mid-term compared to the Reference Case. In the long-term, this development applies only to operational times of 60 years. With an extension to only 40 years, serious investments are necessary due to the dwindling of nuclear capacity, primarily in natural gas power plants.

The changed composition of the electricity production mix as a consequence of substituting coal and natural gas through nuclear power leads to **lower specific CO_2 emissions in electricity production** than in the Reference Case. Instead of 409 kg CO_2/MWh in the year 2020, figures decrease to a range between 324 and 358 kg CO_2/MWh. Until 2030, specific emissions decrease to 186 kg CO_2/MWh at most, instead of 289 kg CO_2/MWh.

Longer operational times promote **domestic electricity production,** which is **expected to increase** from 616 bn kWh (TWh) in 2012 to maximally 663 TWh in 2030. This is due to a higher aggregate demand for electricity, while electricity imports shrink.

Also with a delayed nuclear phase-out, the defined target for the share of renewable energies in the gross electricity consumption (30 % until 2020) is missed only marginally.

As in the Reference Case, the national goal concerning the expansion of combined heat and power generation is missed.



Source: RWI

All values refer to Germany's energy supply risk in 1980, which was set to 100.

Germany's energy supply risk climbed by 140 % between 1990 and 2008, reaching a level second only to Italy's among G7 countries.

This statistical trajectory can be attributed to several factors, among the most important of which is the fall in the share of domestically supplied hard coal and natural gas since 1980. The decrease in the use of hard coal coincided with a massive increase in the domestic demand for natural gas, which necessitated a substantial increase in gas imports.

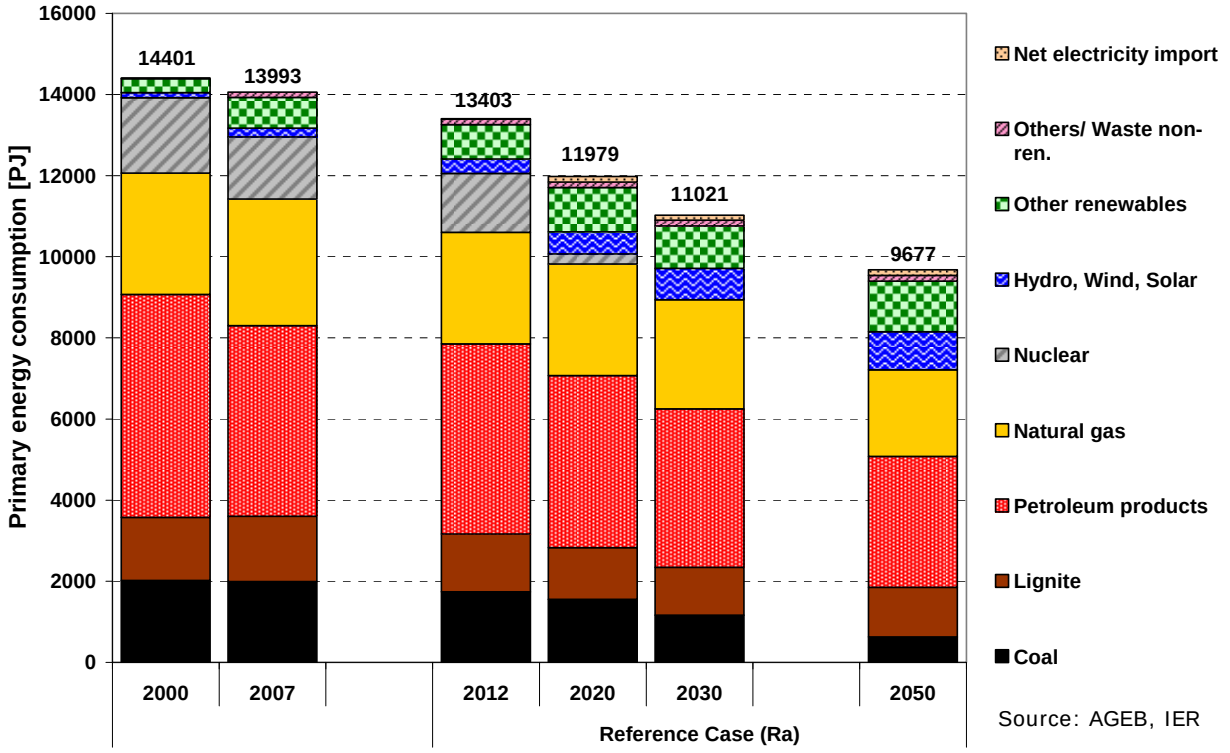
As in the case of oil, an increasingly large share of these imports has originated from Russia. By contrast, one-third of Germany's demand for natural gas in 1980 was covered by domestic production.

In the case of a **lifetime extension** of existing nuclear power plants **to 60 years, the supply risk remains virtually unchanged.** In the **Reference Case**, and also with a lifetime extension to 40 years, however, **it rises considerably until 2030**.

This is explained by two factors: First, the reduction in the share of nuclear power cannot be completely compensated by the substantial increase in the share of renewable energies. Second, Germany's consumption of natural gas is almost completely dependent on imports by 2030.

Given falling imports from the Netherlands and Norway and an increasing share of natural gas in the primary energy mix in 2030, Germany becomes increasingly dependent on imports from Russia. The associated risk is moderately attenuated by a substantial reduction in the consumption of oil and a small decrease in the absolute demand for gas by 2030.

Outlook to 2050



Source: AGEB, IER

The **long-term trends** projected until 2030 in the Reference Case **also continue past 2030**.

For example, there is continued **strong growth in energy productivity**. By 2050, primary energy consumption in Germany sinks to below 10 000 PJ, despite a simultaneous increase in economic growth. In addition, the **shift in the structure of primary energy consumption away from fossil fuels and toward renewable energy** continues past 2030.

In **electricity generation**, an **expansion in decentralised supply** is expected until 2050. Substantial cost decreases in energy conversion on the basis of renewables further ensure their growing contribution to electricity generation. The **share of renewable energy in gross electricity generation increases** to 45 % by the year 2050.

All **end-use sectors** are expected to undergo large decreases in energy consumption, owing primarily to **efficiency improvements**. Moreover, a continuation in the structural change of industry to less energy intensive branches is anticipated. Energy-saving retrofitting of buildings and homes in the residential as well as the tertiary sectors reduce space heating requirements. In the transport sector, energy reductions are primarily attributed to improved fuel economy as well as demographic changes that reduce transport demand.

Under the assumptions of the Reference Case, **CO_2 emissions in Germany** decrease **by 65 % in 2050 relative to 1990**. An important contributing factor is the application of technologies for the capture and storage of CO_2 both in power plants and in industrial production processes.

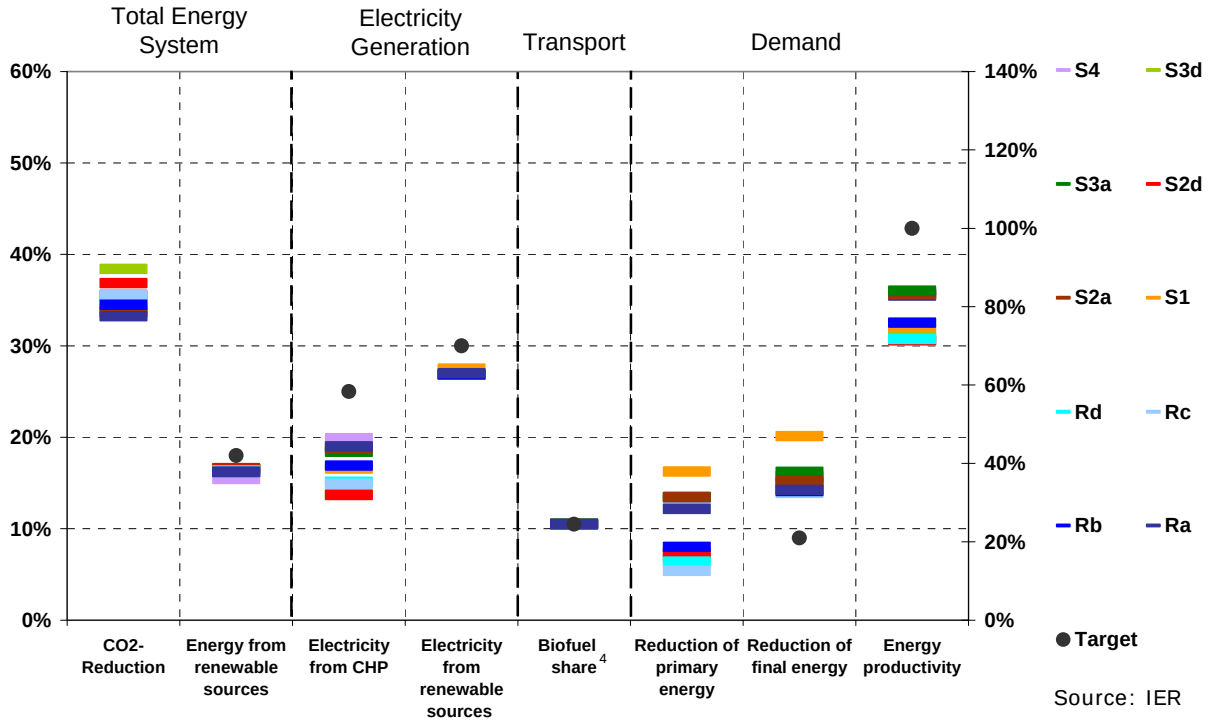
Sensitivity Analyses

	Reference Case/ Lifetime Extension Cases	Sensitivities			
		Long Economic Crisis	High Oil Price	Strengthened Climate Protection	Low Population Development
Nuclear Phase-out	Ra	S1	S2a	S3a	S4
Lifetime Extension in Germany to 40 (b) / 60 (c) years and in Europe to 60 years (d)	Rb / Rc / Rd		S2d	S3d	

The **implications of a variation in the key determinants** of future energy use are gauged by employing sensitivity analyses to both the Reference Case and a Lifetime Extension Case encompassing an extension of the lifetime of nuclear power plants in Europe to 60 years. To this end, alternative values for the following four determinants are analysed: economic development, the level of energy prices, climate targets, and demographic change.

For the Lifetime Extension, the analysis focuses on the effects of higher energy prices and stricter climate targets.

Achievement of Energy and Climate Policy Targets 2020



Source: IER

[4] The aim consists in a reduction of GHG emissions by 7 % until 2020 through the use of biofuels. The target value of a 10.5 % share of biofuels in total petrol and diesel sales results when the GHG emissions that arise from the cultivation and production of biofuels are taken into consideration.

The **reduction of CO_2 emissions** in the sensitivity analyses without stricter climate targets **range from 34 % to 37 % in the year 2020 relative to 1990**. The biggest emission reduction occurs under the assumption of higher oil prices and a simultaneous lifetime extension of nuclear power plants (S2d). In the sensitivity analyses with stricter climate targets, CO_2 emissions fall by a maximum of 38 % in 2020 relative to 1990. By 2030, the emission reduction in this analysis increases to 62 %, while the sensitivity analyses without stricter CO_2 targets reach a maximum reduction of 49 % relative to 1990.

All sensitivity analyses indicate that the EU requirement to increase **the share of renewable energies in gross final energy consumption** to 18 % **by 2020** is **not quite reached**. The same applies to the national goal of reaching a 30 % share of renewable energies in gross electricity consumption by 2020.

Irrespective of the sensitivity analysis, the **bio-fuel share reaches 10.5 % in the year 2020** and is primarily determined by quota requirements.

The national goal to **double the electricity production from combined heat and power generation by 2020 is not met in any of the sensitivity analyses**. In the sensitivity analyses with lifetime extension, the CHP electricity generation is slightly lower.

The ambitious goal of doubling **energy productivity** by 2020 compared to 1990 is not reached in any of the sensitivity analyses.

The **variation of individual base-assumptions** leads to **differentially strong reductions of primary energy consumption.** The strongest reduction emerges in sensitivity analysis S1 (extended financial crisis). A comparative reduction is seen with stricter climate targets and a simultaneous nuclear phase-out (S3a). The sensitivity analyses with lifetime extension of nuclear power plants reveal a notably weaker reduction in consumption.

Final energy consumption is reduced considerably in all sensitivity analyses due to significant improvements in energy efficiency. The **requirement of the EU Directive to reduce final energy consumption by 9 % in 2016** relative to the average over the interval 2001-2005 **is already met** in all of the sensitivity analyses **by 2012**.