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Climate Protection in the German Electricity Market: Opportunities for Coal Technologies Through CO_2 Capture and Storage?

Claudia Kemfert and Katja Schumacher

The German electricity market is facing two major challenges: competition and climate protection. The liberalization of the electricity sector in Europe following the directive on the single internal market is increasing competition between suppliers of electricity, while the trading in emissions certificates, which started in January 2005, aims at reducing emission of carbon dioxide. This gives a competitive advantage to electricity suppliers who can produce cost-efficiently while protecting the environment and the climate. As conventional power stations retire and have to be shut down there will be a need for major replacement of generation capacities in the next two decades.

In the longer term a technology that enables CO_2 to be captured and stored could enable electricity to be generated from coal without damage to the climate. If emissions certificates cost more than 30 euros per tonne of carbon dioxide electricity generation both in coal-fired power stations with CO_2 capture and storage (CCS) and from renewable energy sources – especially in more advanced wind power plants – could become economical. Hence the development of both these technologies is important to secure future energy supplies.

Can liberalization promote sustainable technologies?

Germany introduced full liberalization of the electricity market as early as 1998. Whether this will also bring sustainable environmentally-friendly development is open. If the nuclear power phase-out led to higher electricity generation costs, the result, on a liberalized European internal market, could be rising imports of comparatively less expensive electricity, for example from France and Poland. From an environmental viewpoint, this may not necessarily be an advantage. Almost all the relatively less expensive electricity from France is produced in nuclear power plants that are already fully depreciated. Nuclear power does have the advantage for climate policy of emitting very little greenhouse gases, like carbon dioxide, but it contains other risks and dangers to the environment that are not included in calculating production costs. A large part of the electricity generated in Poland comes from coal-fired power stations of relatively low efficiency that emit large quantities of carbon dioxide.

The problem for environment policy remains that liberalizing the electricity market does offer great advantages and greater flexibility on the market, which can also be advantageous for electricity consumers, but further regulation and incentives will be needed to ensure sustainable development of environmentally-friendly electricity generation. In Germany, for example, the renewable energy law provides incentives to increase electricity generation from 'green' sources in the form of priority purchase requirements and minimum charges. Whether under the conditions of a fully liberalized European electricity market this legislation and comparable regulations in other countries will lead to greater harmonization in Europe in the longer term remains questionable.

The increase of competition in the German electricity market since 1998 initially led to a strong fall in electricity prices, particularly to industrial customers.[1] Tendentially, demand, and with it emissions, have increased. To meet the objectives of the Kyoto Protocol Germany committed itself to reduce its greenhouse gas emissions by 21% from the 1990 level. This requires reducing emissions especially in the electricity sector. Moreover, in the next ten to twenty years considerable conventional power station capacities will go off-line in Germany as the plants retire.[2] The decision to phase out nuclear power, which has now become law, will also require extensive replacement investment. However, the decisions that will soon have to be made on investing in new power station technologies very largely depend on the developments in the liberalized electricity market in Europe and in climate policy. If emissions trading leads to a very high price for emission certificates power stations with high emissions might become uneconomical.[3] This crucially depends on which longer-term climate protection objectives are being pursued and which allocation procedures are chosen for emission rights.

The amount of CO_2 emitted by an individual power station depends mainly on the fuel used and the degree of efficiency achieved in converting energy. In Germany, electricity generation increased by 10% between 1990 and 2003. Nevertheless, the quantity of CO_2 emitted through electricity generation during that period decreased by around 6%, and specific emissions (per kilowatt hour generated) actually fell by around 15% in the same period.[4] This is primarily due to the increase in electricity generation from natural gas, nuclear power and wind power plants. Furthermore, this effect can be explained by the renewal of the power stations in east Germany with substantially increased conversion efficiency.

At present electricity generation in Germany is based mainly on nuclear power, lignite and hard coal.[5] Lignite based power production causes relatively the highest CO_2 emissions, while natural gas power stations, which only account for around 10% of the electricity generated in Germany, emit very much less environmentally harmful greenhouse gases. Electricity generation in combined heat and power plants (CHP) is highly efficient in the use of the fuel, as it produces heat as well as power. Electricity generation from nuclear power, on the other hand, does not directly produce any harmful greenhouse gases, but the operation and waste disposal involve many other environmental risks. The CO_2 emitted by a fossil fuel power station could be reduced by increasing its efficiency, that is, the efficiency of the conversion of the fossil energy source into heat or power. A number of new power station technologies are being developed for this purpose.

In this context technical carbon management could become particularly interesting. It is a process in which carbon dioxide is captured and permanently stored (CCS). The carbon dioxide is captured immediately at the power station (or any other industrial plant) before or after the combustion process. This prevents it from entering the atmosphere. The captured carbon dioxide can then be converted into liquid or solid components and stored permanently in suitable geological formation sites or the deep ocean.[6] The CCS option offers the opportunity of using fossil energy sources with less risk

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[1] Cf. Hans-Joachim Ziesing: 'Worldwide Climate Protection Policy – Still No Visible Success', in: *DIW Economic Bulletin,* vol. 41, no. 10, October 2004; Jochen Diekman, Manfred Horn, Claudia Kemfert and Uwe Kunert: 'Upward Movement in Energy Prices', in: *DIW Economic Bulletin,* vol. 41, no. 12, December 2004.

[2] Cf. Hans-Joachim Ziesing and Felix-Christian Matthes: 'Energiepolitik und Energiewirtschaft vor großen Herausforderungen', in: *Wochenbericht des DIW Berlin,* no. 46/2003.

[3] Cf. Claudia Kemfert: 'The European Electricity Market: The Dual Challenge of Liberalisation and Climate Protection', in: *DIW Economic Bulletin,* vol. 41, no. 9, September 2004.

[4] However, CO_2 emissions from electricity generation have risen again noticeably since 1999, and in 2003 they were 9.5% higher than in 1999 with an increase in electricity generation at the same time of 8.5%. So specific CO_2 emissions in this sector have actually risen again slightly recently. Cf. Hans-Joachim Ziesing: 'Stagnation der Kohlendioxidemissionen in Deutschland im Jahre 2004, in: *Wochenbericht des DIW Berlin,* no. 9/2005.

[5] Cf. Franz Wittke and Hans-Joachim Ziesing: 'Primärenergieverbrauch in Deutschland von hohen Energiepreissteigerungen und konjunktureller Belebung geprägt', in: *Wochenbericht des DIW Berlin,* no. 7/2005.

to the climate. The CO_2 separation processes capture about 90% of the emission.

The future of this technological option will crucially depend on the emission reduction targets that are set in Europe. The higher these are, the higher will be the price of emission certificates, as will the variable costs of emission-intensive electricity generation technologies. Electricity generation from hard coal and lignite, in particular, will become relatively expensive. Conversely, a high certificate price will favour both low-CO_2 fossil technologies and renewable energy sources.

Technologies for CO_2 capture and storage

CO_2 capture can on principle be performed at any point source of emissions, like coal and gas-fired power stations, cement factories, steel plants and oil refineries. Three processes are currently being developed, although they still need considerable research and development. None of the three has so far passed the test in practice, so none is as yet available for commercial operation.

- Process 1 is a post-combustion process and takes the form of cleaning the flue gas, similarly to the way sulphur dioxide is now separated from the flue gas through absorption or adsorption, using membranes or distillation procedures (end-of-pipe or chimney technology).
- Process 2 additionally tackles the fossil fuel combustion process, in that instead of normal air pure oxygen is used for the oxidation (oxy fuel process). This enriches the CO_2 in the flue gas and enables it to be easily captured.
- In Process 3 the separation is performed before combustion. First a syn gas rich in hydrogen is formed from coal or natural gas by gasification or steam reforming, and the CO_2 is removed before combustion. This process is currently regarded as the most promising, but so far it is the least advanced. It is less expensive than processes 1 and 2 but it requires a relatively elaborate power station technology, many industrial components of which have not yet been tested.

The captured CO_2 can be led through pipelines or taken in some other way to the site where it is to be utilized or stored. There are various ways of utilizing or storing CO_2. Small amounts can be used by the foodstuffs industry, for example, or for biomass production. But by far the greater part would have to be stored in such a way as to prevent it entering the atmosphere for as long as possible. Possible storage sites are deep geological formations like salt plugs, deep coal seams, exhausted and still active gas and oil fields, deep saline aquifers and ocean depths. Not all these options are suitable for long time storage. CO_2 is used in oil extraction as it makes the oil flow more easily; it is also injected into deep coal seams that cannot be mined to produce methane. The average time the CO_2 remains stored in these sites is relatively short, lasting from a few months to a few years.[7]

Of importance in connection with storing CO_2 is the risk of leakage, that is, the risk of CO_2 escaping from the store.[8] A leakage would increase its concentration in the atmosphere, and if it was considerable suffocation might result. The likelihood of these dangers is not yet sufficiently known. Exhausted gas and oil fields and to a lesser extent salt caverns can so far be regarded as safe permanent storage sites.

The potential for capturing and storing CO_2 depends on the commercial availability of the appropriate technologies and the storage capacity. It is not only a question of large-scale technical feasibility and social and political acceptance, but above all a question of how economical the process is compared with other CO_2 reduction strategies. CO_2 capture and storage (CCS) increases costs, mainly because the system as a whole becomes less efficient. The separation technology, the transport and storage all require additional energy input of up to 20%.[9] Electricity costs for consumers could rise by 40% to 100%.[10] These costs can be calculated as cost per tonne of CO_2 emission avoided, and compared with the certificate price. If the certificate price is higher than the cost of avoiding CO_2 emission, then investment in the capture and storage process will be economically viable.

Research programmes have been started worldwide to accelerate the development of the capture and storage technologies. In Germany, the Ministry of Economics has launched the COORETEC development programme for this purpose, and major projects and networks are being promoted in the EU. In the United States the Vision 21 programme was introduced some years ago. According to the US Federal Energy Technology Center (FETC) the costs of CO_2 sequestration are to be reduced by the factor 10 to 30 by 2015. The main challenges of

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6 Wissenschaftlicher Beirat der Bundesregierung für globale Umweltveränderungen: 'Welt im Wandel: Energiewende zur Nachhaltigkeit', Berlin 2003, pp. 94-96.

7 Stefan Bach: 'Sequestration of CO_2 in Geological Media: Criteria and Approach for Site Selection in Response to Climate Change'. *Energy Conversion and Management,* no. 41, 2000, pp. 953-970.

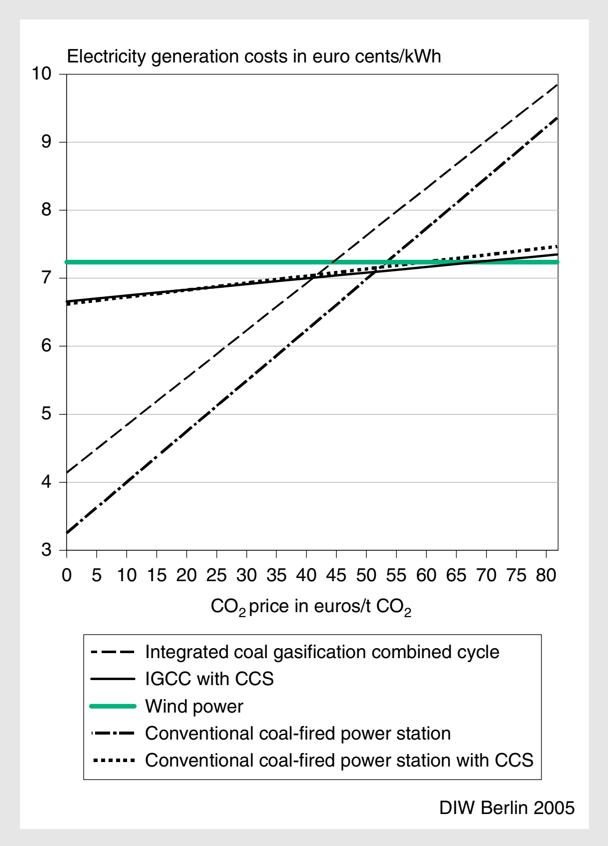
8 Wissenschaftlicher Beirat der Bundesregierung für globale Umweltveränderungen, loc. cit.

9 *www.powernews.org*, 17.12.2004.

10 Wissenschaftlicher Beirat der Bundesregierung für globale Umweltveränderungen, loc. cit.

Figure

Electricity Generation Costs of Selected Technologies as a Function of the CO_2 Price[1]



1 Interest rate 7%, coal price in 2010 1.76 euros/GJ, transport and storage costs 11 euros/tonne CO_2. CO_2 capture in conventional coal-fired power station using subsequent chemical absorption. Offshore wind power plant, 30 km from the coast. Sources: Fachinformationszentrum Karlsruhe 2003; IEA 2004.

developing low-CO_2 power stations are the reduction in efficiency, the higher electricity generation costs and the long-term storage of CO_2. Only after these problems are satisfactorily solved will it be possible to more precisely assess when CO_2-reduced coal-fired power stations might become an important part in Germany. Experts believe this could be between 2015 and 2020.[11]

The possibilities for CO_2 capture and storage in Germany

In view of the liberalization of the electricity market and the climate protection objectives, CO_2 capture and storage power stations (CCS) will in future be competing with both conventional fossil fuel power stations and the use of renewable energy sources. The replacement investments that will soon be needed could offer a window of opportunity to invest in low-emission electricity generation technologies. It is important which technologies offer the option for long-term CO_2 reduction. In the long term, renewable energy sources offer the possibility of generating electricity without emission, although this may be limited by availability (wind speed, amount of sunshine, etc.) and by grid integration. The capture and storage of CO_2 from power stations, however, is only possible as long as sufficient storage capacities are available. Leakages also diminish this option's potential for avoiding emissions.

Three main factors determine the assessment of CCS and renewable energies: 1st the interest rate on which the investment calculation is based, 2nd the prices of gas and coal and 3rd the cost of an emission certificate. As 'green' electricity is generally more capital-intensive than fossil electricity, a low interest rate is relatively advantageous for the costs of producing green electricity. Similarly, higher fuel prices and a higher emission certificate price also give renewable energy sources a relative advantage. The same is true when comparing fossil fuel power stations with and without CO_2 capture and storage. Power stations that retain CO_2 are more capital-intensive, but lower in emission. So a higher emission certificate price improves the economic viability of these technologies.

The figure shows the dependence of electricity generation costs on the certificate price (with a given interest rate and fuel price). The costs of generating electricity from wind power are independent of the certificate price, as there are no CO_2 emissions.[12] In the data base[13] chosen (cf. table) the costs of generating electricity using integrated coal gasification with CO_2 capture and storage (process 3) are about as high as those for traditional coal-fired power stations with subsequent CO_2 capture and storage (process 1). These costs are also about as high as the costs of wind power. In this comparison the differences in availability and the back-up costs for wind power are not included.

[11] Cf. Dolf Gielen and Jacek Podkanski: 'The Future Role of CO_2 Capture in the Electricity Sector', 7th Conference of Greenhouse Gas Control Technologies, Vancouver 2004 (*www.ghgt7.ca*).

[12] Reference here is to a modern offshore wind power plant, 30 km from the coast, that will come on stream in 2010. Cf. Fachinformationszentrum Karlsruhe (ed.): IKARUS Datenbank, Version 4.1 (CD-ROM), Karlsruhe 2003.

[13] International Energy Agency (IEA): Prospects for CO_2 Capture and Storage, Paris 2004, pp. 56-57. It should be observed that there is a wide range of assumptions on costs and efficiency. The sources chosen give an overview, and for CO_2 retention see also Edward S. Rubin, Anand B. Rao and Chao Chen: 'Comparative Assessments of Fossil Fuel Power Plants with CO_2 Capture and Storage', 7th Conference of Greenhouse Gas Control Technologies, Vancouver 2004 (www.ghgt7.ca).

Table

Cost and Performance Assumptions for Wind and Coal Technologies[1]

	Wind power plant	Conventional coal-fired power station	IGCC[2]
Without CO_2 capture and storage (CCS)			
Conversion of efficiency (%)		43	46
Utilization (%)	36	75	75
Emission coefficient (kg CO_2 /kWh)		0.746	0.697
Specific investment costs (euros/KW)	1908	1075	1455
Capital costs (euro cents/kWh)	5.71	1.26	1.78
Operating costs (euro cents/kWh)	1.52	0.52	0.98
Fuel costs (euro cents/kWh)		1.47	1.38
Electricity generating costs (euro cents/kWh)	7.23	3.26	4.14
With CO_2 capture and storage (CCS)			
Conversion of efficiency (%)		31	38
Emission coefficient (kg CO_2 /kWh)		0.103	0.084
Specific investment costs (euros/kWh)		1850	2100
Capital costs (euro cents/kWh)		2.17	2.58
Operating costs (euro cents/kWh)		1.39	1.59
Fuel costs (euro cents/kWh)		2.04	1.67
Transport and storage costs (euro cents/kWh)		1.02	0.83
Electricity generating costs (euro cents/kWh)		6.62	6.66
Cost difference (euro cents/kWh)		3.36	2.52
Emission difference (kg CO_2 /kWh)		0.64	0.61
Cost per t/CO_2 avoided (euros/tonne CO_2)		52	41

1 Interest rate 7%, coal price in 2010 1.76 euros/GJ, transport and storage costs 11 euros/tonne CO_2. CO_2 capture in conventional coal-fired power station using subsequent chemical absorption. Offshore wind power plant, 30 km from the coast. — 2 Integrated coal gasification combined cycle.
Sources: Fachinformationszentrum Karlsruhe 2003; IEA 2004.

They show the break-even, or crossover, carbon price for each fossil technology, where the levelized cost is the same with or without CCS. Furthermore, they show the carbon price for wind and the fossil technologies to break-even in terms of levelized cost of electricity production.

To illustrate this consider the costs of electricity production from wind power and from integrated coal gasification with CO_2 capture and storage. The break-even point is 68 euros per tonne CO_2. This means that with a given interest rate and coal price a CO_2-price of around 68 euros would render electricity generated from wind

Box

Research method

The SGM Germany simulation model is a general equilibrium model for the German economy focussing on energy and climate policy issues. It is a version of the Second Generation Model developed by the Pacific Northwest Laboratory for the United States and here applied to Germany.[1] The model is especially designed to analyze the costs of climate protection and the effects of different policy measures, like emission trading. It examines the economic development over a period of 50 years.

A specific feature of the model is that concrete electricity generation technologies can be evaluated within the framework of a macroeconomic model. SGM calculates future shares of various electricity generation technologies and fuels in total electricity generation together with the costs involved. The model also analyzes economic growth effects and structural changes, as well as marginal abatement costs.

[1] Ronald Sands: 'Dynamics of Carbon Abatement in the Second Generation Model', in: *Energy Economics,* vol. 26, 2004, pp. 721-738.

power less expensive than electricity generated in integrated coal gasification combined cycle (IGCC) plants with CO_2 capture and storage. For conventional coal firing and post-combustion CO_2 capture and storage and advanced wind power the break-even CO_2-price is even lower, at around 60 euros per tonne of CO_2.

A comparison of coal-fired electricity generation with and without CO_2 capture and storage shows that CCS can prove economically viable from a certificate price of slightly more than 40 euros per tonne of CO_2 (integrated coal gasification using process 3). For the slightly more expensive post-combustion process 1 the profitability threshold is a certificate price of just under 52 euros/tonne CO_2.[14]

Model calculations using the SGM Germany simulation model show that – assuming appropriate availability – advanced wind power and coal-fired electricity generation with CO_2 capture and storage could come into use from 2015 on at a CO_2-price of about 30 euros/tonne CO_2.[15] As the certificate price rises this share also increases, so that by the middle of the century about 50% of German electricity generation could be based on these technologies if the CO_2 certificate price is about 50 euros per tonne. The use of CO_2 capture and storage would then be economically competitive and could make a considerable contribution to reducing emissions in Germany. It is also clear that wind power plants and coal-fired power stations with CCS need not necessarily be competing with each other, they can well be complementary.[16]

Conclusion

The German electricity market is currently characterized by larger competition and growing requirements for climate protection. The large amount of replacement investment in power stations raises the challenge to make supply more secure, while at the same time to improve the economic efficiency and environmental compatibility of energy supply. In this context, CO_2 capture and storage (CCS) could become very important in the future, as it could enable fossil fuels like coal to be used in power stations without substantial damage to the climate. The development of CCS is very promising, if the problems of reducing the conversion efficiency of power plants and of long-term storage of carbon dioxide can be satisfactorily solved. CCS technologies will be economically viable from a certificate price of about 30 to 60 euros/tonne CO_2. However, they are not yet marketable; they are expected to be available for use on a competitive market from 2015 to 2020.

In regard to a sustainable energy supply the possibilities for generating electricity from coal using CO_2 capture and storage on the one side and greater use of renewable energies on the other could be complementary, ensuring climate-compatible electricity generation on a permanent basis.

[14] Cf. Ottmar Edenhofer, Hermann Held and Nico Bauer: 'A Regulatory Framework for Carbon Capturing and Sequestration within the Post-Kyoto Process', accepted for publication in E.S. Rubin, D.W. Keith and C.F. Gilboy (ed.): 'Proceedings of 7th International Conference on Greenhouse Gas Control Technologies, Vol. 1: Peer-Reviewed Papers and Plenary Presentations, IEA Greenhouse Gas Programme', Cheltenham, UK 2005.

[15] In comparison to the figure please note that the costs of these technologies are not uniform, so some use is worthwhile even at a lower certificate price.

[16] Cf. Ottmar Edenhofer: 'Strategien und Instrumente einer nachhaltigen Klima- und Energiepolitik', in: *Aus Politik und Zeitgeschichte,* B27/2003.

Supplement: Economic Indicators
Weekly Report No. 16/2005
(data as of 9 June 2005)

Germany – Selected Seasonally Adjusted Economic Indicators[1]

		Unemployment		Vacancies		Orders in manufacturing (volume)[2]											
						Manufacturing						Intermediate goods industry		Capital goods industry		Durable consumer goods industry		Non-durable consumer goods industry (incl. semi-durable goods industry)	
						Total		Domestic		Abroad									
		in 000s				2000 = 100													
		month	quarter	month	quarter	month	quarter	month	quarter	month	quarter	month	quarter	month	quarter	month	quarter	month	quarter
2003	J	4 317		391		98.1		93.3		104.2		97.6		99.4		89.0		98.5	
	F	4 363	4 333	379	385	98.4	97.1	94.7	92.9	103.0	102.3	96.8	96.5	100.3	98.3	88.0	87.6	100.0	97.6
	M	4 389		372		94.6		90.7		99.6		95.0		95.3		85.7		94.4	
	A	4 406		365		96.9		92.7		102.0		96.1		98.4		86.8		96.6	
	M	4 401	4 398	352	359	93.1	95.7	91.6	92.4	94.8	99.9	93.6	95.2	93.1	97.0	83.8	84.6	95.6	96.6
	J	4 385		345		97.3		93.0		102.7		96.0		99.5		83.1		97.8	
	J	4 390		346		97.4		93.0		102.8		97.6		98.1		88.3		96.5	
	A	4 395	4 392	341	342	97.4	97.8	92.3	93.2	103.7	103.6	97.2	97.8	98.5	99.0	85.7	87.3	97.7	96.7
	S	4 397		337		98.8		94.3		104.4		98.7		100.3		88.1		95.9	
	O	4 399		332		99.7		94.8		105.9		100.2		100.5		89.1		98.5	
	N	4 397	4 395	330	331	100.1	100.1	95.7	94.8	105.7	106.7	100.8	100.9	101.5	100.9	87.3	88.2	95.7	97.5
	D	4 379		324		100.3		93.8		108.6		101.7		100.7		88.3		98.3	
2004	J	4 302		313		99.6		94.8		105.5		100.5		100.6		87.6		95.1	
	F	4 282	4 306	302	307	100.5	100.9	95.1	95.7	107.3	107.3	102.2	102.0	101.3	102.1	87.6	87.8	94.4	95.4
	M	4 291		287		102.6		97.3		109.0		103.2		104.3		88.3		96.8	
	A	4 334		276		103.3		97.0		111.2		104.2		104.7		87.7		98.9	
	M	4 355	4 339	279	280	106.8	104.2	98.4	97.2	117.5	113.0	107.1	105.2	109.1	105.7	90.2	88.9	100.3	98.6
	J	4 365		280		102.4		96.2		110.4		104.2		103.3		88.8		96.5	
	J	4 392		275		103.4		96.4		112.1		103.3		105.7		87.2		98.6	
	A	4 417	4 404	273	275	103.5	103.4	97.2	96.3	111.3	112.2	104.7	103.8	105.0	105.5	87.7	86.6	97.1	97.7
	S	4 440		275		103.3		95.3		113.3		103.3		105.8		85.0		97.5	
	O	4 457		279		102.8		95.7		111.8		102.0		106.3		83.7		96.9	
	N	4 487	4 479	282	281	102.0	103.6	94.5	96.2	111.4	112.8	101.5	101.4	104.2	107.9	85.4	84.3	100.2	98.6
	D	4 549		291		105.9		98.4		115.3		100.7		113.3		84.0		98.6	
2005	J	4 734		306		104.8		96.0		115.6		103.5		107.8		85.6		103.0	
	F	4 833	4 763	327	319	103.4	104.3	94.1	95.3	115.0	115.7	100.8	102.0	107.0	108.0	85.9	85.9	103.5	103.5
	M	4 893		355		104.8		95.6		116.4		101.7		109.2		86.1		104.0	
	A	4 864		381		102.5		94.8		112.1		100.2		105.9		87.2		101.6	
	M	4 891		395															
	J																		
	J																		
	A																		
	S																		
	O																		
	N																		
	D																		

1 Seasonally adjusted by the Berlin Method (BV4). With this method, the addition of new data can change previous seasonal adjustment patterns even if the original, unadjusted, figures remained unchanged. Quarterly figures are calculated from seasonally adjusted monthly figures. — 2 Also adjusted for working days.
Sources: Federal Labour Office; Federal Statistical Office; DIW Berlin calculations.

Germany – Selected Seasonally Adjusted Economic Indicators[1] (continued)

		Employment in mining and manufacturing		Manufacturing output[2]: Manufacturing		Capital goods industry		Durable consumer goods industry		Non-durable consumer goods industry (incl. semi-durable goods industry)		Construction industries		Retail trade turnover		Foreign trade (Special trade)[2]: Exports		Imports	
		in 000s		2000 = 100												Euro billion			
		month	quarter	month	quarter	month	quarter	month	quarter	month	quarter	month	quarter	month	quarter	month	quarter	month	quarter
2003	J	6 190		99.6		102.4		88.1		97.5		85.6		100.9		55.5		45.7	
	F	6 182	6 177	100.1	99.2	104.1	102.3	89.1	87.7	97.5	97.0	81.1	83.8	100.9	100.2	55.5	165.1	44.8	135.6
	M	6 173		98.0		100.4		85.8		96.1		84.8		98.7		54.0		45.1	
	A	6 161		99.7		101.6		87.5		98.9		86.8		100.6		54.3		44.5	
	M	6 152	6 157	97.7	98.5	100.2	100.2	85.5	85.6	95.8	97.6	84.9	85.7	101.3	100.2	54.1	163.3	44.1	133.2
	J	6 140		97.9		98.7		83.8		97.9		85.5		98.7		54.9		44.6	
	J	6 130		99.6		102.2		88.7		97.8		86.5		99.4		55.7		44.1	
	A	6 116	6 123	98.3	98.8	99.9	100.9	85.6	87.0	97.4	97.2	83.7	84.9	98.1	99.2	55.7	168.2	44.2	132.2
	S	6 106		98.5		100.7		86.8		96.3		84.5		100.1		56.8		43.9	
	O	6 096		100.3		102.2		88.0		97.8		84.5		100.4		55.7		44.3	
	N	6 088	6 092	101.1	101.0	104.5	103.9	87.9	88.2	97.0	97.7	83.8	84.4	97.8	99.6	56.9	170.8	45.7	135.4
	D	6 081		101.7		105.0		88.9		98.2		84.8		100.5		58.2		45.4	
2004	J	6 048		100.7		103.0		88.1		97.5		81.4		98.5		58.1		45.0	
	F	6 039	6 048	101.2	101.3	103.0	103.8	87.5	88.4	97.3	97.3	85.9	83.3	98.0	98.8	58.4	175.9	46.0	136.2
	M	6 035		102.1		105.4		89.6		97.1		82.7		99.7		59.4		45.2	
	A	6 030		102.5		105.4		88.8		97.8		80.2		98.7		61.3		46.8	
	M	6 022	6 026	105.3	103.8	108.8	107.4	92.0	90.3	100.0	98.3	82.4	81.2	95.9	98.2	63.0	184.5	48.7	141.9
	J	6 018		103.6		107.9		90.2		97.2		81.0		100.1		60.2		46.4	
	J	6 010		102.8		105.9		87.4		97.9		78.8		98.4		61.0		48.9	
	A	6 011	6 011	104.2	103.8	108.1	107.4	88.6	87.6	98.1	98.3	81.0	79.6	98.3	98.1	60.6	181.8	48.2	146.2
	S	6 008		104.3		108.4		87.0		98.8		79.0		97.8		60.2		49.1	
	O	6 003		103.5		107.9		85.6		97.9		77.8		96.3		62.7		49.3	
	N	5 993	5 998	102.2	102.4	104.1	105.2	85.0	85.3	98.6	98.1	77.4	77.6	98.9	97.5	61.9	184.9	48.8	146.0
	D	5 986		101.7		103.7		85.3		97.7		77.4		97.4		60.4		47.9	
2005	J	5 969		105.3		108.0		88.3		100.6		80.0		98.4		63.1		49.6	
	F	5 959	5 965	104.3	104.9	107.2	108.0	88.5	88.2	100.9	101.0	72.1	73.5	98.8	98.6	62.4	188.7	48.6	147.6
	M	5 950		105.1		108.9		87.9		101.5		68.3		98.7		63.2		49.4	
	A			105.0		109.5		88.9		99.7		74.5		97.1		61.8		49.7	
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1 Seasonally adjusted by the Berlin Method (BV4). With this method, the addition of new data can change previous seasonal adjustment patterns even if the original, unadjusted, figures remained unchanged. Quarterly figures are calculated from seasonally adjusted monthly figures. — 2 Also adjusted for working days.
Sources: Federal Labour Office; Federal Statistical Office; DIW Berlin calculations.

Germany's Quarterly National Accounts Data

Unadjusted figures

	2002	2003	2004	2002				2003				2004				2005
				I	II	III	IV	I	II	III	IV	I	II	III	IV	I
GDP by type of expenditure at current prices, euro billion																
Private consumption	1266.7	1286.3	1304.2	304.0	313.9	319.0	329.9	310.3	319.7	322.9	333.4	314.1	322.8	326.9	340.4	315.7
Government consumption	411.8	414.6	412.9	97.6	98.2	99.8	116.2	98.3	99.1	102.2	115.1	98.3	99.3	100.9	114.4	98.9
Fixed capital formation	392.9	380.7	379.5	88.2	101.8	102.4	100.6	83.7	97.5	100.1	99.5	82.7	97.0	99.7	100.0	79.5
Machinery and equipment	151.9	146.9	148.4	34.6	38.6	36.8	42.0	33.6	36.4	35.8	41.1	32.3	36.5	37.1	42.6	32.9
Construction	216.5	209.2	206.3	47.6	57.3	59.5	52.1	44.1	55.1	58.2	51.8	44.4	54.5	56.5	50.9	40.5
Other	24.6	24.6	24.7	6.0	6.0	6.1	6.5	6.0	6.0	6.1	6.5	6.0	6.0	6.2	6.5	6.1
Change in stocks	–18.8	–3.4	1.7	6.0	–5.7	2.5	–21.6	13.0	–2.4	1.8	–15.8	11.3	–4.7	9.5	–14.3	12.2
External surplus or deficit	96.2	86.6	108.9	23.5	23.5	22.3	26.9	19.1	19.7	23.8	24.0	31.0	33.4	20.2	24.3	33.5
Exports	767.3	768.8	838.6	181.0	192.3	193.1	201.0	188.6	187.5	193.4	199.3	200.0	212.4	207.4	218.9	210.0
Imports	671.1	682.2	729.7	157.5	168.8	170.8	174.1	169.5	167.8	169.6	175.3	169.0	179.0	187.2	194.6	176.5
Gross domestic product	2148.8	2164.9	2207.2	519.2	531.7	546.1	551.9	524.4	533.6	550.8	556.1	537.4	547.9	557.2	564.8	539.8
Change (%) on the previous year																
Private consumption	0.7	1.5	1.4	0.6	0.2	1.0	1.1	2.1	1.9	1.2	1.1	1.2	1.0	1.2	2.1	0.5
Government consumption	2.9	0.7	–0.4	2.5	3.4	3.4	2.4	0.7	0.8	2.3	–0.9	0.0	0.3	–1.2	–0.6	0.6
Fixed capital formation	–7.1	–3.1	–0.3	–9.8	–7.0	–5.6	–6.2	–5.1	–4.3	–2.2	–1.1	–1.1	–0.5	–0.4	0.6	–4.0
Machinery and equipment	–9.3	–3.2	1.0	–14.6	–9.4	–7.5	–5.8	–2.7	–5.6	–2.6	–2.0	–3.9	0.2	3.6	3.5	1.8
Construction	–6.1	–3.4	–1.4	–7.1	–5.8	–4.8	–7.0	–7.4	–3.8	–2.2	–0.5	0.8	–1.0	–3.0	–1.8	–8.9
Other	–1.4	0.0	0.8	–0.5	–2.1	–1.9	–1.2	–1.0	0.2	0.7	0.2	0.3	0.7	1.1	0.9	1.8
Exports	4.4	0.2	9.1	–0.2	4.4	7.5	5.7	4.2	–2.5	0.2	–0.8	6.1	13.3	7.2	9.8	5.0
Imports	–3.2	1.6	7.0	–8.7	–3.7	–2.1	1.8	7.6	–0.6	–0.7	0.7	–0.3	6.7	10.4	11.0	4.4
Gross domestic product	1.7	0.7	2.0	0.9	1.7	2.7	1.3	1.0	0.4	0.9	0.8	2.5	2.7	1.2	1.6	0.5
GDP by type of expenditure as price-adjusted chain-linked index (2000 = 100)																
Private consumption	101.3	101.6	101.6	97.3	100.6	102.1	105.4	98.0	101.5	102.0	105.1	98.2	100.7	101.6	105.7	97.4
Government consumption	102.6	102.1	101.4	100.5	100.2	101.0	108.5	98.9	99.2	100.5	109.9	98.5	98.3	100.0	108.9	99.0
Fixed capital formation	90.5	89.0	88.5	80.8	93.4	94.5	93.4	78.2	90.4	93.4	93.8	77.6	90.1	92.7	93.7	74.5
Machinery and equipment	89.1	88.9	91.0	80.2	89.5	86.8	99.8	81.3	86.7	86.5	101.3	79.2	88.4	90.7	105.6	82.2
Construction	89.8	86.8	84.6	78.9	95.1	98.7	86.6	73.1	91.5	96.6	86.1	73.6	89.4	92.2	83.1	65.7
Other	107.7	111.5	112.7	103.9	104.2	107.6	115.1	107.4	107.4	111.4	120.0	109.2	109.0	112.9	119.6	112.0
Exports	111.2	113.2	123.4	105.3	111.5	111.8	116.2	110.6	110.3	114.0	117.9	118.5	125.0	121.6	128.4	123.9
Imports	100.2	104.4	111.5	93.8	99.7	102.4	104.9	101.9	102.5	104.4	109.0	104.8	109.7	113.7	117.8	107.2
Gross domestic product	101.3	101.4	102.9	98.4	101.2	103.2	102.5	98.9	100.7	102.8	103.0	100.7	102.7	104.1	104.3	100.7
Change (%) on the previous year																
Private consumption	–0.4	0.3	–0.1	–0.9	–1.0	–0.1	0.2	0.7	0.9	–0.1	–0.3	0.2	–0.7	–0.4	0.5	–0.8
Government consumption	1.7	–0.4	–0.7	1.0	1.7	2.2	1.8	–1.6	–1.0	–0.5	1.3	–0.4	–0.9	–0.4	–0.9	0.4
Fixed capital formation	–6.1	–1.7	–0.5	–9.2	–6.1	–4.3	–5.0	–3.2	–3.1	–1.1	0.5	–0.7	–0.4	–0.7	–0.2	–4.1
Machinery and equipment	–7.5	–0.2	2.3	–13.7	–8.1	–5.0	–3.6	1.3	–3.2	–0.3	1.4	–2.6	2.0	4.9	4.2	3.9
Construction	–5.8	–3.3	–2.6	–6.7	–5.5	–4.6	–6.9	–7.3	–3.8	–2.1	–0.6	0.6	–2.2	–4.6	–3.5	–10.7
Other	1.4	3.6	1.0	0.8	0.8	1.8	2.1	3.4	3.1	3.5	4.3	1.7	1.6	1.3	–0.4	2.6
Exports	4.6	1.8	9.0	0.3	5.1	7.7	5.3	5.0	–1.1	2.0	1.4	7.1	13.3	6.6	8.9	4.6
Imports	–1.0	4.2	6.7	–6.4	–1.6	0.7	3.3	8.7	2.8	1.9	4.0	2.8	7.1	8.9	8.0	2.3
Gross domestic product	0.2	0.0	1.6	–1.1	0.3	1.1	0.2	0.4	–0.5	–0.4	0.4	1.8	1.9	1.2	1.3	0.0

Sources: Federal Statistical Office; DIW Berlin calculations.