Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

Renewably employed!

Short and long-term impacts of the expansion of renewable energy on the German labour market

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FOREWORD

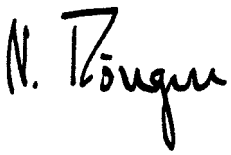
Dear reader,

The expansion of renewable energy (RE) in Germany has made a crucial contribution to our environmental, climate and energy policy. However, over and above that, it has also had a significant impact on economic growth and jobs, as was shown by the findings of a multi-year study commissioned in 2008 by the Federal Environment Ministry (BMU) and carried out by a team of renowned research institutions, with the Institute of Economic Structures Research (GWS) as the leading agency.

Based on a broad survey of over 1,200 companies in the renewable energy sector, including their suppliers, and on sophisticated model calculations, the latest study confirms the basic conclusions of earlier studies. In parallel with the steady expansion of renewables, which now meet about 10 % of our total energy demand, their contribution to employment rose to about 340,000 jobs in 2009. This is more than twice as much as the 2004 figure (about 160,000 jobs) and is significantly higher than earlier estimates.

By 2030, gross employment could rise to over half a million jobs. Extensive model calculations show that in the same period renewable energy's impact on net employment in Germany is positive in virtually all the scenarios analysed. They indicate that, apart from the trend in energy prices, one of the key factors in stimulating employment in Germany is the future export success of our renewables sector. Against this backdrop, the study examines in detail the future trends on the global RE markets and identifies the international markets that are likely to be of particular strategic importance in the next few decades.

This brochure summarises the key findings of the study; over the next few months, a comprehensive main report will be published to accompany it. It highlights the opportunities that the expansion of renewable energy holds – including opportunities for the economy.



Dr. Norbert Röttgen
Federal Minister for the Environment,
Nature Conservation and Nuclear Safety

1 OVERVIEW OF THE KEY FINDINGS

1. In 2009 almost 340,000 people were employed in manufacturing, operation and maintenance of renewable energy facilities, in the supply of biogenic fuels, and from the use of public and common use funds. The number of people employed has thus more than doubled since the first systematic estimate for 2004 (160,500).

2. The expansion of renewable energy to just below 32 % of final energy consumption by 2030 leads to positive net employment throughout the entire observation period in almost all the scenarios analysed. Only in a few years, under particularly unfavourable assumptions, does employment fall below the fossil-based reference scenario.

1.1 Methodological findings

3. The survey of 1,200 companies in the renewables sector in Germany, which was carried out as part of this study, is the most comprehensive of its kind to date. The survey made it possible to acquire important information about the interindustry flows of goods and services, which is crucial for a detailed analysis of employment. It also provided an understanding of foreign trade that surpassed any information available elsewhere.

4. Export opportunities for German companies depend on how international trade in the renewable energy sector develops. This in turn is influenced by national and international policies and trends in the respective domestic industry. For the first time, German exports were consistently depicted as a function of share in world trade by regions, systematically improving the quality of future export estimates.

5. Net employment impacts can only be calculated with sufficient accuracy in a complex macroeconomic model. To implement this an additional comparative analysis of a number of consistent future scenarios is needed. Uncertainty about future energy prices and international expansion of renewable energy can be reduced by examining a range of export opportunities in combination with a higher and a lower energy or electricity price path (A or B).

6. Uncertainty regarding the export opportunities of German companies on international markets is countered by using four scenarios. The lower limit of export activity is set to be equal in terms of volume of exports during the calibration year (2007), i.e. exports remain at the 2007 level. The upper limit equates to the share in world trade remaining constant, as observed in 2007. Growing markets lead to an expectation of declining share in world trade and increasing export volumes; the two options in the centre of the range reflect this expectation.

1.2 Findings of short-term analyses

7. In 2007, gross employment, which was determined on the basis of updated data from the company survey amounted to 277,300 people, putting it at 11 % above the previously estimated value. Updating the estimates for 2008 and 2009 generates values of 322,100 (2008) and 339,500 employees, which is 16 % (2008) and 13 % (2009) above the initial estimates, which were deliberately cautious.

8. The strongest growth spurts from 2004 onwards were shown in the field of geothermal energy (706 %). In absolute figures, developments in solar energy (221 %) and biomass (125 %) were significantly more relevant. Wind energy, which had already achieved a higher level of maturity in 2004, recorded an increase of just under 60 %.

9. Similarly, the number of people employed from the use of public and common use funds almost doubled. This is particularly a result of the rise in federal funding from € 117 million in 2004 to € 297 million in 2009.

1.3 Findings of long-term analyses

10. There are no variations in investments in renewable energy facilities across the whole set of scenarios with differing energy price paths. However, the additional costs (calculated on the basis of systems analysis) of renewable energy differ as a function of the price assumptions made for fossil energy sources. How favourable the expansion of renewable energy is thus depends on the prices of fossil energy sources at a given time.

11. Worldwide investments in renewable energy quintupled during the observation period, rising from $€_{2005}$ 122 billion to $€_{2005}$ 589.7 billion in 2030. The regions driving this development most are Europe and North America until 2020, followed by emerging countries and Africa up to 2030. This development also assumes that worldwide efforts to mitigate climate change will be stepped up.

12. The total turnover of German companies will be increasingly export-based. Depending on the export trend assumed, exports account for 50 – 80 % of the total turnover. The actual export share varies greatly from one technology to another.

13. The lower limit for export activity is set as a constant at the level of the calibration year 2007 ($€_{2005}$ 8.6 billion); the upper limit is calculated by maintaining the share in world trade at its 2007 level (2030: $€_{2005}$ 59 billion). The two options in the centre of the range reflect the expectation of a decreasing share in world trade and an increase in export volumes (2030: $€_{2005}$ 33 and 48 billion respectively).

14. The intensity of labour in the different renewable energy sectors drops in line with the intensity of labour in comparable non-renewable sectors. Thus, by 2030 only 70 % of the number of people employed in this sector today will be needed to produce the same output.

15. Under cautious export assumptions, with low prices for fossil energy sources and an expansion of photovoltaics assumed to continue at its present rate, gross employment rises by 2030 to 500,000 and to 600,000 jobs under optimistic assumptions. In 2020, over 450,000 and possibly as many as 580,000 people are employed as a result of domestic expansion of renewable energy, including operation of facilities, export of renewable energy facilities and components, preliminary services for these sectors and supply of biomass.

16. Gross employment experiences a long-term drop from today's level as a result of increased productivity only under minimal export assumptions and a relatively constant domestic trend. That would imply that 325,000 people would still be employed in the field of renewable energy in 2020 and 291,000 in 2030.

17. Stabilisation of sales by the domestic market is crucial if further opportunities for technological leadership in the majority of renewable energy technologies are to be maintained on the world market and the continued establishment of export markets is to be successfully taken forward. This is the only way to profit from the considerable growth in foreign markets to an appropriate extent in future.

18. The scenarios with maximum, optimistic or cautious export expectations also show a positive impact throughout the entire observation period if a low price level for fossil energy sources is assumed. Net employment in 2030 amounts to between 150,000 and 280,000 additional people, given average export assumptions across all domestic expansion scenarios.

19. Lower price assumptions for conventional energy sources in combination with the lowest export expectation, which assumes no growth in exports on a dynamically developing world market, in some cases lead to slightly negative short-term effects of up to 40,000 jobs. However, from 2025 on, positive effects prevail also in this scenario and net employment is positive.

20. It is apparent that the scenarios that envisage a moderate continuation of photovoltaic expansion from 2009 and 2010 (PV1 in Tables 1 and 2) have the most positive net effect on the economy as a whole. In this case lower exports, which took off slowly at the beginning of the observation period, are offset by domestic production.

21. In addition to direct effects, exports also trigger significant indirect employment effects through manufacturers' demand for preliminary services.

22. If the German renewables sector, which, including its exports, currently accounts for about 13 % of global investments in renewable energy, wants to participate to a similar extent in the global renewable energy market which in future will undergo considerable growth, it must turn its attention to those regional markets which will experience above-average growth in the decades to come. Since the domestic market, following its rapid growth in recent years, will grow at a slower rate in future, successes in these markets and the ability to take advantage of export opportunities will be of special significance for the continued growth of Germany's renewables sector.

23. The main report on this project, which is scheduled for submission at the end of the year, will contain a far more detailed exploration of this entire area.

		Preispfad A											
		Referenz	PV1				PV2						
	Jahre		Max	Optimistisch	Verhalten	Min	Max	Optimistisch	Verhalten	Min	Max	Optimistisch	Verhalten	Min
Deutschland														
Endenergieverbrauch (PJ/a)	2009[1]	8.713												
	2020	8.129	8.127	8.123	8.118	8.112	8.111	8.112	8.107	8.102	8.101	8.092	8.089	8.087
	2030	7.650	7.704	7.700	7.696	7.688	7.696	7.693	7.689	7.681	7.683	7.678	7.675	7.667
Investitionen in EE-Neuanlagen (Mrd. € 2005)	2009[2]	20,4												
	2020	–	15,4				16,0				16,6			
	2030	–	15,1				14,1				14,0			
Arbeitsintensität (Index, %, 2008 = 100)	2009	über alle Szenarien gleich: 106												
	2020	über alle Szenarien gleich: 81												
	2030	über alle Szenarien gleich: 65												
Importpreise – Öl (US$ 2005/bbl)	2009[3]	über alle Szenarien gleich: 58												
	2020	über alle Szenarien gleich: 96												
	2030	über alle Szenarien gleich: 118												
Importpreise – Gas (€ 2005/TJ)	2009[3]	über alle Szenarien gleich: 5.794												
	2020	über alle Szenarien gleich: 10.700												
	2030	über alle Szenarien gleich: 13.800												
Importpreise – Steinkohle (€ 2005/t)	2009[3]	über alle Szenarien gleich: 79												
	2020	über alle Szenarien gleich: 155												
	2030	über alle Szenarien gleich: 202												
Systemanalytische Differenzkosten zum Nullszenario (Mrd. € 2005)	2009[4]	7,0												
	2020	–	3,9				6,7				10,8			
	2030	–	-13,0				-10,7				-4,6			
Welt														
Investitionen in EE-Neuanlagen weltweit (Mrd. € 2005)	2009[5]	102,7												
	2020	–	418,9											
	2030	–	589,7											
Gesamtumsatz deutscher Hersteller von Anlagen zur Nutzung erneuerbarer Energien (Mrd. € 2005)	2009	16,4												
	2020	–	51,3	42,4	28,6	15,1	51,8	43,3	29,5	16,0	52,5	43,6	29,8	16,3
	2030	–	73,2	60,4	43,5	14,6	72,9	60,5	43,6	14,7	73,2	60,5	43,5	14,7
Exporte von Strom- und wärmeerzeugenden Anlagen (Mrd. € 2005)	2009	8,6												
	2020	–	41,3	32,9	19,9	7,1	41,3	32,9	19,9	7,1	41,3	32,9	19,9	7,1
	2030	–	59,1	47,8	32,7	7,1	59,1	47,8	32,7	7,1	59,1	47,8	32,7	7,1
Beschäftigung														
Bruttobeschäftigung (1000)	2009	339,5												
	2020	5	645	570	445	326	654	580	455	336	658	583	459	340
	2030	5	697	607	496	293	703	613	502	299	703	612	502	299
Nettobeschäftigung (1000)	2009	70 – 90												
	2020	–	157,0	116,7	56,4	-3,8	119,4	144,0	82,6	26,0	136,3	105,6	40,0	-25,1
	2030	–	277,3	241,2	202,5	118,9	304,5	287,6	252,4	170,3	247,7	221,0	184,7	91,4

Tabelle 1: Die wichtigsten Größen im Überblick für deutlichen Energie- und Strompreisanstieg (Preispfad A)

1. AG Energiebilanzen (2010). Auswertungstabellen zur Energiebilanz für die Bundesrepublik Deutschland 1990 bis 2009.
2. BMU (2010b). Erneuerbare Energien in Zahlen.
3. BMWi (2010). Zahlen und Fakten. Energiedaten.
4. BMU (2010c). Breitschopf, B. (ISI), Klobasa, F. (ISI), Sensfuß, F. (ISI), Steinbach, J. (ISI), Ragwitz, M. (ISI), Lehr, U. (GWS), Horst, J. (IZES), Leprich, U. (IZES), Diekmann, J. (DIW), Braun, F. (DIW), Horn, M. (DIW): Einzel- und gesamtwirtschaftliche Analyse von Kosten- und Nutzenwirkungen des Ausbaus Erneuerbarer Energien im deutschen Strom- und Wärmemarkt.
5. UNEP (2010). Global Trends in Green Energy 2009: New Power Capacity from Renewable Source Tops Fossil Fuels Again in US, Europe.

		Price path B												
			Refer-ence	PV1								PV2			
	Year			Max.	Opti-mistic	Cautious	Min.	Max.	Opti-mistic	Cautious	Min.	Max.	Opti-mistic	Cautious	Min.
Germany															
Final energy consumption (PJ/a)	2009 [1]	8,713													
	2020	8,248	8,226	8,222	8,217	8,211	8,212	8,208	8,203	8,197	8,203	8,199	8,194	8,188
	2030	7,814	7,828	7,824	7,820	7,812	7,815	7,812	7,807	7,799	7,811	7,808	7,803	7,795
Investment in new RE facilities ($€_{2005}$ billion)	2009 [2]	20.4												
	2020	–	15.4				16.0				16.6			
	2030	–	15.1				14.1				14.0			
Intensity of labour (index, %, 2008 = 100)	2009	the same for all scenarios: 106												
	2020	the same for all scenarios: 81												
	2030	the same for all scenarios: 65												
Import prices – Oil (US_{2005}$/bbl)	2009 [3]	the same for all scenarios: 58												
	2020	the same for all scenarios: 79												
	2030	the same for all scenarios: 94												
Import prices – Gas ($€_{2005}$/TJ)	2009 [3]	the same for all scenarios: 5,794												
	2020	the same for all scenarios: 8,400												
	2030	the same for all scenarios: 10,000												
Import prices – Coal ($€_{2005}$/t)	2009 [3]	the same for all scenarios: 79												
	2020	the same for all scenarios: 123												
	2030	the same for all scenarios: 147												
Additional costs compared with the zero scenario, calculated using systems analysis ($€_{2005}$ billion)	2009 [4]	7.1												
	2020	–	8.6				11.8				13.6			
	2030	–	-0.2				2.9				3.7			
Worldwide															
Investment in new RE facilities worldwide ($€_{2005}$ billion)	2009 [5]	102.7												
	2020	–	418.9											
	2030	–	589.7											
Total turnover of German manufacturers of renewable energy facilities ($€_{2005}$ billion)	2009	16.4												
	2020	–	51.1	42.2	28.5	15.1	52.0	43.2	29.4	16.0	52.3	43.5	29.7	16.3
	2030	–	72.7	60.1	43.2	14.6	72.8	60.2	43.3	14.7	72.8	60.1	43.3	14.7
Exports of electricity and heat generation facilities ($€_{2005}$ billion)	2009	8.6												
	2020	–	41.3	32.9	19.9	7.1	41.3	32.9	19.9	7.1	41.3	32.9	19.9	7.1
	2030	–	59.1	47.8	32.7	7.1	59.1	47.8	32.7	7.1	59.1	47.8	32.7	7.1
Employment															
Gross employment (1000)	2009	339.5												
	2020	6	642	568	444	325	651	577	453	334	656	582	458	339
	2030	5	693	604	493	291	699	610	499	297	699	610	500	298
Net employment (1000)	2009	70 – 90												
	2020	–	125.7	89.9	27.9	-31.2	154.0	118.4	56.3	-2.9	141.0	104.9	42.7	-16.6
	2030	–	180.9	146.4	107.2	24.3	224.6	190.7	151.7	68.9	220.0	185.6	146.3	63.2

Table 2: An overview of the most important factors in a moderate increase in energy and electricity prices price path B)

1. AG Energiebilanzen (2010). Auswertungstabellen zur Energiebilanz für die Bundesrepublik Deutschland 1990 bis 2009.
2. BMU (2010b). Renewable Energy Sources in Figures.
3. BMWi (2010). Zahlen und Fakten. Energiedaten.
4. BMU (2010c). Breitschopf, B. (ISI), Klobasa, F. (ISI), Sensfuß, F. (ISI), Steinbach, J. (ISI), Ragwitz, M. (ISI), Lehr, U. (GWS), Horst, J. (IZES), Leprich, U. (IZES), Diekmann, J. (DIW), Braun, F. (DIW), Horn, M. (DIW): Einzel- und gesamtwirtschaftliche Analyse von Kosten- und Nutzenwirkungen des Ausbaus Erneuerbarer Energien im deutschen Strom- und Wärmemarkt.
5. UNEP (2010). Global Trends in Green Energy 2009: New Power Capacity from Renewable Sources Tops Fossil Fuels Again in US, Europe.

2 BACKGROUND

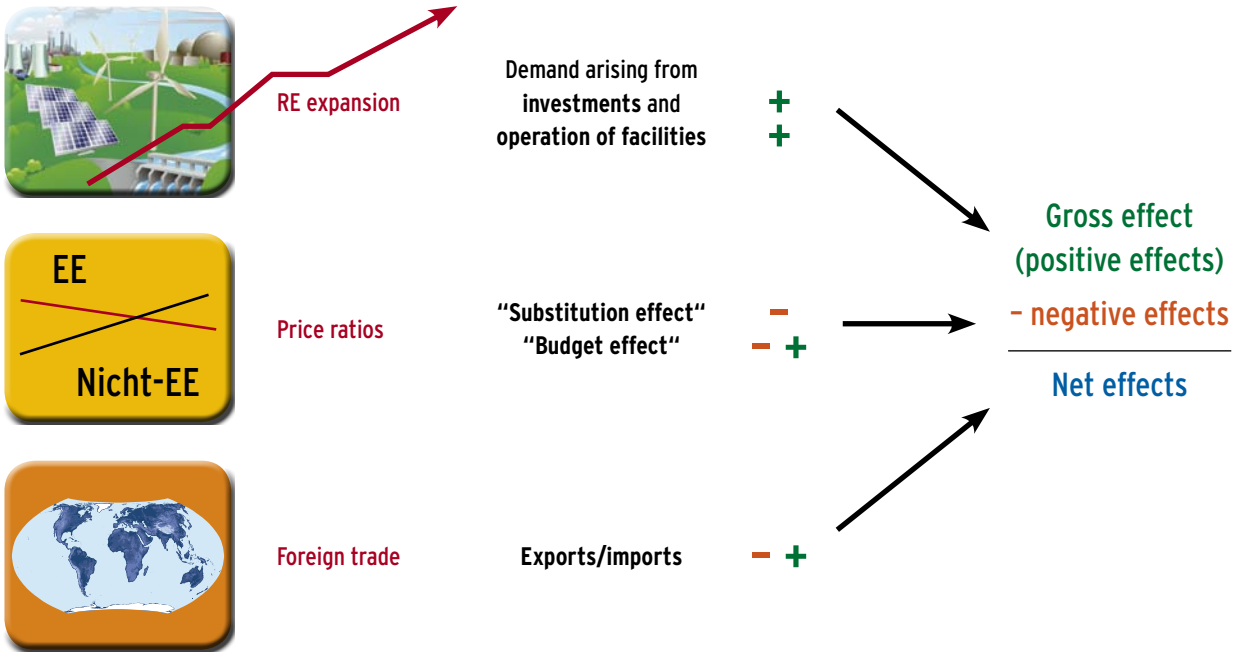
2.1 Looking at the gross and net effects

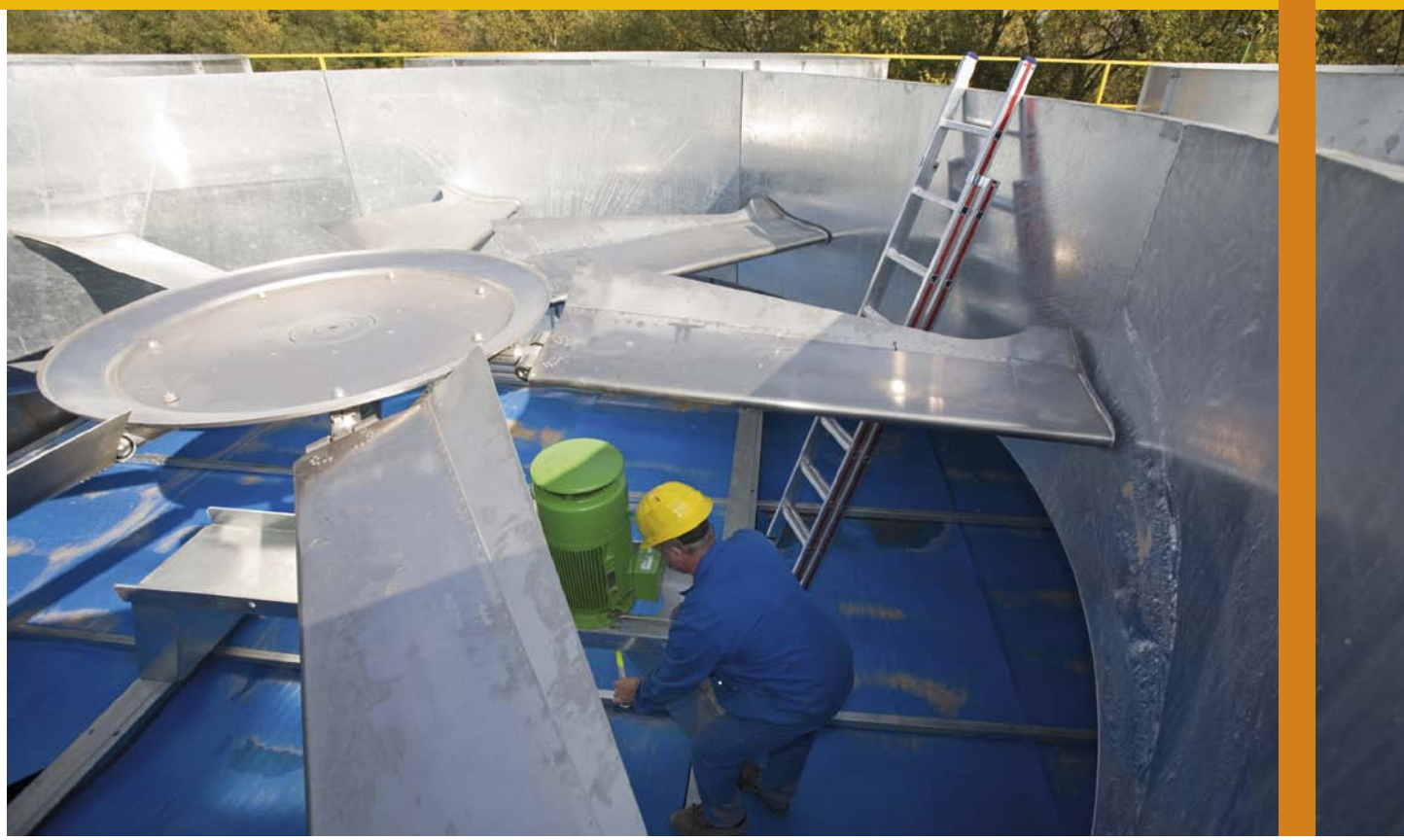
The impacts of the expansion of renewable energy on the German labour market is an intensively discussed topic (cf. for example, Frondel [2007, 2010], Erdmann [2008], Blankart [2008], Alvarez [2009]). The question is whether – from a macroeconomic point of view – promoting renewable energy ultimately produces an increase in employment or leads to job losses. Assumptions about future trends in key variables – i.e. prices, investments and exports – play a crucial role for these developments. Depending on the timescale, they influence the scope for interpretation.

Against this backdrop, it is especially important to study the different effects in a consistent framework. First of all, investments in facilities and operation and maintenance create direct employment for manufacturers, operators and service companies. They in turn demand goods from other sectors of the economy, thus creating indirect employment by backward-linked suppliers of intermediate inputs.

The total of direct and indirect employment creates what is known as gross employment (cf. BMU 2008, 2009a, 2010a). Whereas this is always positive, a sound macroeconomic analysis also has to take into account possible negative employment effects, such as the additional costs of renewable energy or substitution of investment in conventional power plants. What is known as the net employment impact represents the result of all effects and can therefore be either positive or negative. Whereas gross employment can be determined for any given scenario, the net employment impact is calculated as the difference between two consistent future scenarios. If it is positive, it represents the actual rise in employment as a result of increased expansion of renewable energy. To determine this effect, a model-based analysis is used and a comparison between the results of two calculated model simulations is drawn.

The expansion of renewable energy triggers many demand, substitution and budget effects. The net result of these effects can only be determined using integrated models.





2.2 Previous findings

The economic impacts of the expansion of renewable energy, particularly in terms of employment, have been monitored since 2004 by a research project commissioned by the BMU. In these studies (BMU 2006, 2007, 2008, 2009a, 2010a), attention was first directed to an analysis of current employment in the sectors of the economy concerned with manufacturing and operating renewable energy facilities and with supplying biomass and biofuels for transport. Since the initial survey carried out in 2004, when gross employment was at 160,500 people, conservative and provisional estimates have been submitted annually; the latest showed a rise in employment to 300,500 in 2009.

Secondly, the macroeconomic effects of a future expansion of renewable energy were studied, with the focus lying on an analysis of trends in employment (net effects). The BMU (2006) compared a scenario with increased expansion to one of markedly lower expansion. The comparison of employment developments under these two scenarios clearly showed that the increased expansion scenario had positive effects for the economy as a whole. Net effects on employment trends of up to 180,000 employees by 2030 were shown (BMU 2006). Since the possible increase in domestic production depends to a great extent on how international demand is expected to develop and on the export opportunities seized by German industry on the world markets, BMU (2006) also tested the sensitivity of the findings to different export assumptions. The positive net employment impact remained intact, even under cautious export assumptions.

The follow-up study (BMU 2007) looked at particular aspects of gross employment in more detail. For example, the number of jobs created by public funding was surveyed in detail and the employment effects of expanding production capacities, which are otherwise only implicit in the calculations, were estimated to be 23,500 (2006). This study also compared an increased expansion of renewable energy with a development in which the expansion of renewable energy is not promoted and therefore no capacity is added (zero scenario). The comparison with a development of this kind made it possible to estimate the overall impact of expanding renewable energy. The result was that under the expansion scenario the number of gainfully employed people in 2030 was – depending on the export assumptions – around 80,000 – 120,000 higher than in this new reference development and thus showed the same tendency as in the study published in 2006.

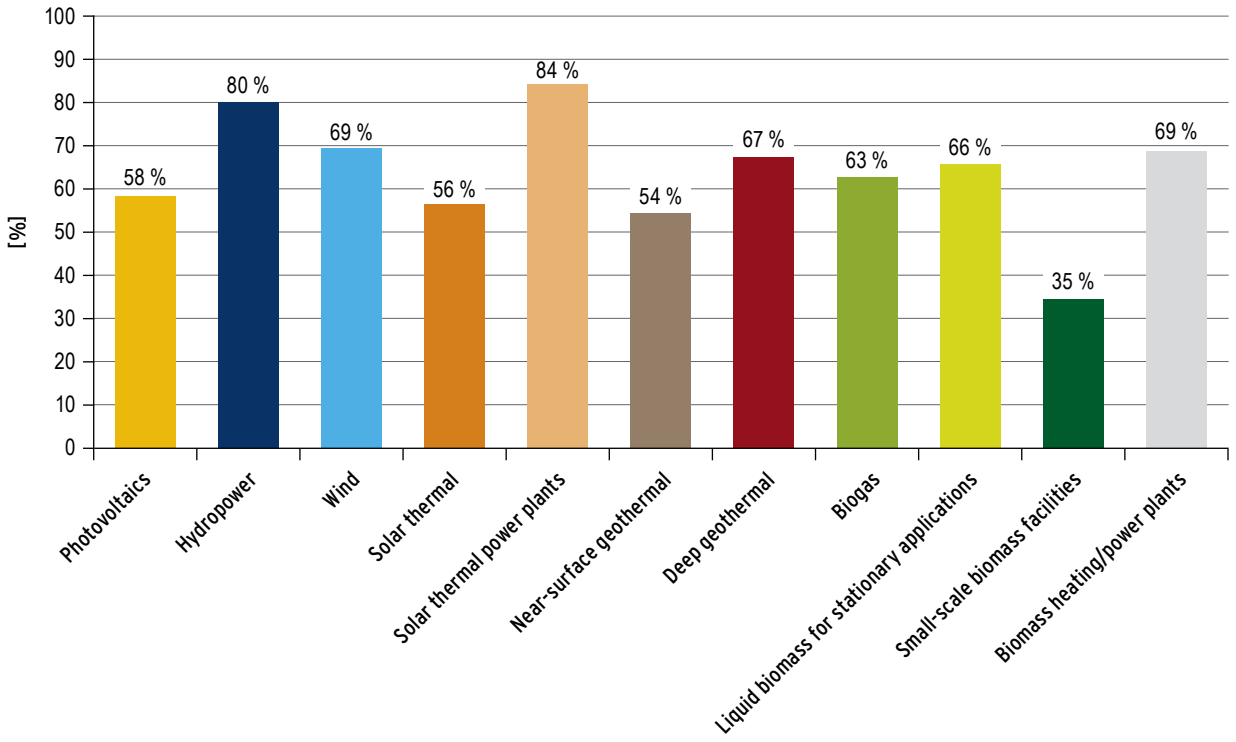
3 GROSS EMPLOYMENT YESTERDAY AND TODAY

3.1 Survey of companies

The empirical basis of the studies of the employment effects of expanding renewable energy is a broad-based survey of companies. The aim of this survey was to acquire reliable primary data for 2007 on the German renewables sector's flows of goods, intermediate goods and input structures. These data form the key empirical foundation for an analytical description of the renewables sector in the context of input-output analysis and make it possible to update and work out further details for the input-output vector (IO vector) of the sector "manufacturing of renewable energy facilities" (BMU 2006), which was calculated for the first time for 2004. The information acquired on foreign trade is also indispensable for ascertaining turnover for German companies. The survey was conducted by telephone by the Bielefeld Institut für Sozialforschung und Kommunikation (SOKO) from April to September 2008. As a rule, gathering all the necessary information entailed several telephone calls, faxes and emails for each of the companies that responded. With a total of 1,200 companies, representing almost 60,000 jobs in Germany, this is the most comprehensive survey of the renewables sector in Germany to date.

Apart from detailed information on 2007, the companies were also interviewed on their export strategies. Developing foreign trade scenarios for renewable energy elicits the question of whether there was an upper limit to export shares in the view of RE companies. The results showed that the estimates are predominantly in the 50-70 % range. This estimate will have an impact on the long-term expansion of production locations and is therefore significant for developing foreign trade scenarios. Furthermore, the industry regards the domestic market as being of continued importance. Key innovative products are installed first on the domestic market, which also acts as an important showcase for German products.

The companies surveyed believed that, depending on the sector, the strategically most beneficial export share from Germany is between 35 % and 84 %.



The survey of companies also provided some interesting findings on the type of employment in these relatively new industrial sectors (cf. for a first analysis: Lehr/O'Sullivan [2009]; further information will be published in the project's final report).

On average, 82 % of people employed in the renewables sector have completed vocational training; nearly 40 % of these have a university degree. The average for all industrial sectors is just below 70 % people with vocational qualifications and just below 10 % with a university degree.

A prominent feature of companies in the renewable energy sector is their high proportion of skilled employees.

	Without vocational qualifications	With vocational qualifications	With a university degree
Photovoltaics	5.8 %	81.7 %	34.7 %
Hydro	1.7 %	93.8 %	57.0 %
Wind	0.9 %	79.7 %	27.1 %
Solar thermal	9.5 %	80.3 %	24.4 %
Solar thermal power plants	6.7 %	84.8 %	44.1 %
Deep geothermal	2.1 %	85.6 %	50.4 %
Near-surface geothermal	6.6 %	81.1 %	15.3 %
Biogas	2.5 %	82.5 %	33.1 %
Liquid biomass	0.0 %	92.2 %	57.3 %
Solid biomass	3.1 %	86.5 %	29.7 %
RE overall	**4.1 %**	**82.1 %**	**32.1 %**
Manufacturing jobs	22.7 %	63.2 %	0.6 %
Technical jobs	4.0 %	88.3 %	37.7 %
Total	**15.0 %**	**69.5 %**	**9.9 %**

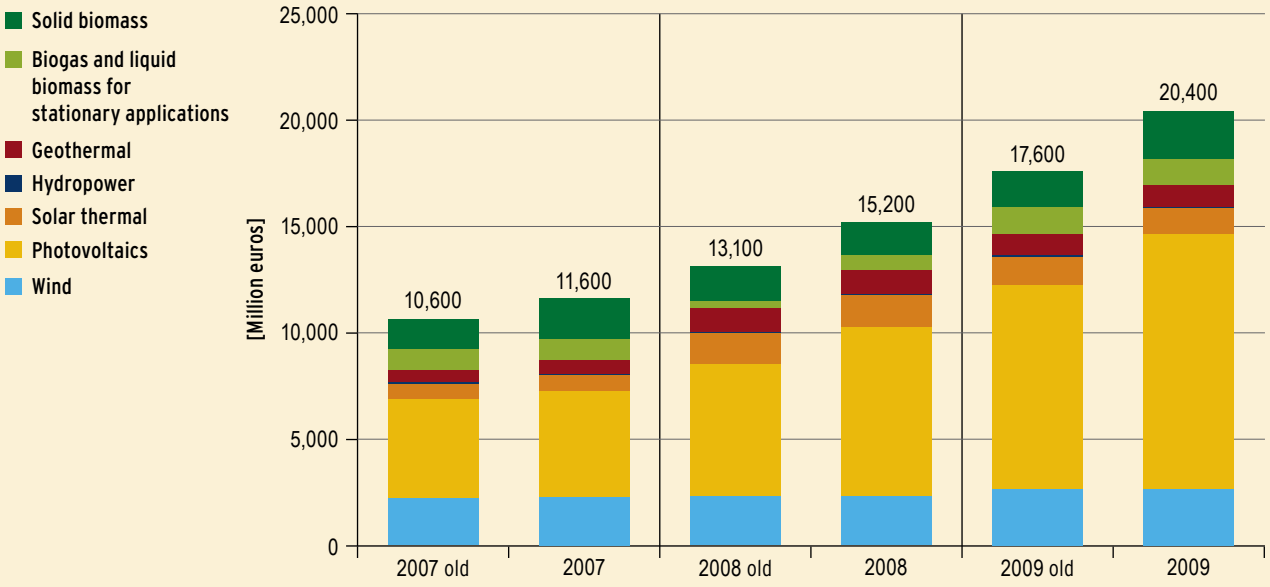
3.2 Results for 2007, 2008 and 2009

As part of this project, gross employment in the renewable energy sector in Germany was provisionally estimated for the period from 2007 to 2009 at the beginning of each subsequent year on the basis of the data available and the IO vector calculated in the predecessor study (BMU 2008, 2009a, 2010a). On the basis of the updated IO vector and improved data, a revised estimate of gross employment for this period can now be presented. Some of the findings of the revised estimate deviate significantly from the provisional results. Below is a description of the procedure used for the revised estimate, pointing out the differences in the individual stages of the calculation.

The gross employment shown here for the renewable energy sector comprises all individuals directly employed in manufacturing renewable energy facilities, operating and maintaining facilities, supply of biomass and biofuels for transport, those indirectly employed as a result of the demand of these sectors for intermediate inputs, and people employed in relevant areas that are financed by public funding. For the indirect effects, jobs resulting from expansion of production capacity are taken into account to the extent that the costs incurred are incorporated into pricing by the manufacturers of RE facilities.

The starting point for ascertaining direct and indirect gross employment effects for the manufacture of renewable energy facilities is the investment in the sector in Germany as determined by the interministerial Working Group on Renewable Energy Statistics (AGEE-Stat). As the level of knowledge about the expansion figures and the costs per installed unit consolidates over the course of each year, the investment data is adjusted to reflect that level of knowledge and published several times a year. Figure 1 provides an overview of investments which were used as the basis for the preliminary estimates made at the beginning of each year (marked as "old") and the investments which reflect the level of knowledge in July/August 2010 (cf. BMU 2010d). The latter are the basis for the new calculations. For all the years, the updated values are higher than the initial estimates. Overall, in 2007 there was a rise of 9 % and in 2008 and 2009 investments were about 16 % higher than initially assumed.

Figure 1: Investments in renewable energy facilities in Germany between 2007 and 2009 (AGEE Stat, as at: 7/2010).



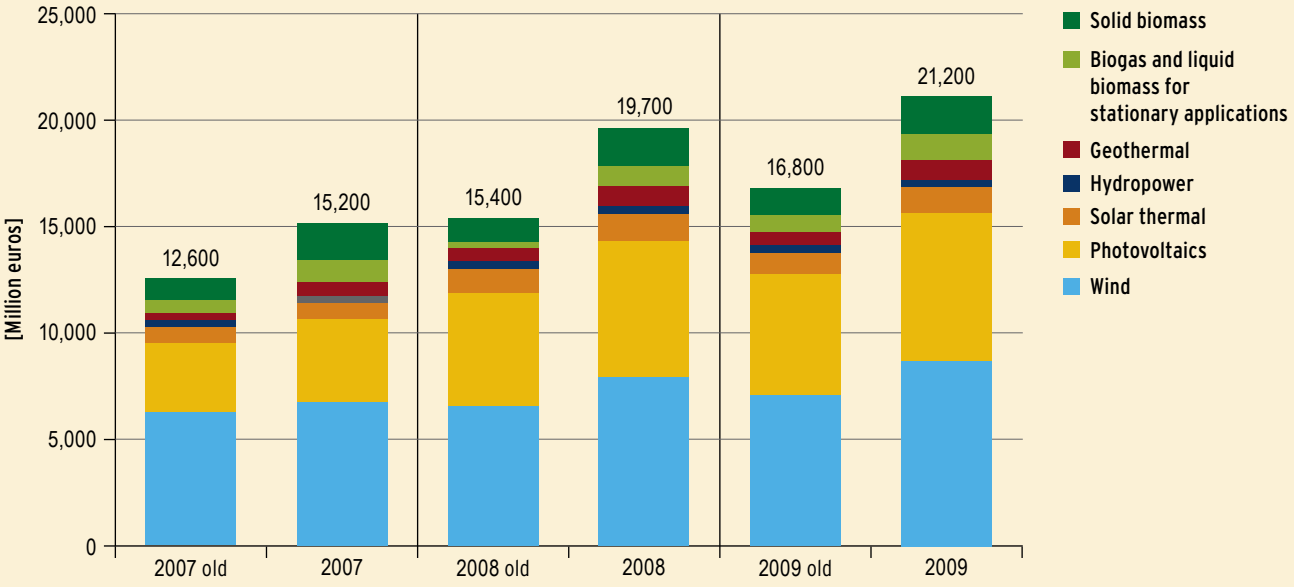
The changes are essentially confined to a handful of areas. The most distinct change is in photovoltaics. Here, new information meant that the installed capacity had to be revised upwards by a significant amount for all three years. In the area of biomass (heating) and power plants, it was possible to use the results of new up-to-date studies, which meant that both the installed capacity and the investment per MW were corrected upwards by an appreciable amount. Other changes are of less consequence. They include the expansion of liquid biomass facilities, which – contrary to initial estimates – came to a standstill as early as 2008, and installed biogas capacity in 2008, which did not decline as strongly as was originally assumed. Furthermore, slight adjustments in the area of solar thermal will have to be made each year, as soon as the final analysis of funding under the market incentive programme becomes available.

The turnover of German-based manufacturers of renewable energy facilities was determined on the basis of investments in Germany as a starting point. For the further steps of calculation the findings of the survey on foreign trade were decisive. In the estimates published annually, these values were adjusted wherever information was available, but in many sections of the provisional estimates the results of the survey for 2004 were decisive. This is particularly true of imports of facilities, which to date had sel-

dom, if ever, been included in any studies. The updated turnover figures are based on new survey results for 2007, which means that there are sometimes significant changes in turnover.

Figure 2 provides an overview of trends in turnover of German-based manufacturers of renewable energy facilities, including exports by component manufacturers.

Figure 2: Trends in turnover from 2007 to 2009 of German-based manufacturers of renewable energy facilities, including exports by component manufacturers



Component manufacturers' exports form an area that studies to date have not analysed in great depth. This is partly due to the fact that before the results of the new survey were known, a conservative approach had fixed these exports at the 2004 level. The results now available have shown that component manufacturers' export turnover in 2007 was about € 3.4 billion, making it over four times (almost 360 %) higher than in 2004. When the figures for 2008 and 2009 were updated, the component exports were adjusted to correspond to manufacturers' turnover. This is justified first by the fact that this approach is in line with the generation of the export scenarios in which component exports were also included. Second, it is based on the realisation that fixing component exports led to turnover and thus employment being significantly underestimated. For 2008 this meant that € 4.1 billion from export of components were added to the manufacturers' turnover relevant to employment. For 2009 that figure is € 4.4 billion.

This implies that, in the new calculations for 2007, turnover relevant to employment rose by just below 21 %. Although manufacturers' total turnover remained the same, there was a shift within the different technologies. For example, exports by wind turbine manufacturers had been overestimated in recent years. The exports by component manufacturers offset this since, at € 2.5 billion, by far the larg-

est share of export turnover for components was in the wind energy sector, followed by photovoltaics at over € 0.5 billion and hydropower at around € 0.1 billion. Another area in which manufacturers' exports had been overestimated was solar thermal, which, in combination with slightly higher imports, resulted in lower turnover. Areas in which exports were underestimated were biogas and small-scale biomass facilities. However, the recently acquired information about imports has a greater influence on turnover. Here, both near-surface geothermal and biogas have seen a significant shift toward domestic value added since 2004. Finally, offshore wind energy and solar thermal power plants have recently been taken into consideration. Up to now, these two areas have not been covered by AGEE Stat. The estimate of turnover here is based on a study of individual current projects, taking into account the participation of German-based companies.

In 2008, turnover relevant to employment was almost 28 % higher than initial estimates, although manufacturers' turnover witnessed a rise of only 6 %. In the areas of biogas and (heat) and power plants (CHP), a decline in newly installed capacity by comparison with 2007 was identified. By contrast, significantly more capacity was installed in 2009 than in 2007, which confirms the presumption that some companies deliberately deferred completing manufacture of renewable energy facilities until 2009 in order to take advantage of changes in the Renewable Energy Sources Act. This aspect was taken into consideration when turnover was recalculated. Overall, turnover relevant to employment for 2009 was almost 26 % higher than had been assumed, with manufacturers' turnover rising by 4 %.

Resulting gross employment in 2007 amounted to 277,300 people, which is a 73 % rise from 2004 (160,500). In 2009, employment was estimated to be as high as 339,500, in other words more than twice as much as its 2004 level. Table 3 provides a precise breakdown of this employment. The new survey of companies has provided far more detailed results than was achieved in previous studies. This will be explained in greater depth in the final report on the research project.

In addition to the changes already described, biomass and the supply of biofuels for transport were also the subject of a detailed study, which ensured a substantial improvement in basic data. One aspect that could be included in the calculations for the first time was foreign trade in biomass supply. Another improvement could be achieved in the field of biofuels for transport. Here, more detailed and reliable data on volumes produced in Germany are now available. This is particularly true for the agricultural sector. Agricultural statistics were used to achieve a more differentiated picture of the intensity of labour as a factor of specific products.

Employment in maintenance and operation is also higher than initially estimated. This is primarily due to the fact that the number of facilities was corrected upwards.

Jobs resulting from public and common use funding include those in the ministries responsible for renewable energy, along with the research and demonstra-

tion projects that are supported by this funding. Detailed data on this area was collected for the period from 2004 to 2006 (BMU 2007) and assumed to be constant in the initial estimates for 2007 and 2008. For the 2009 estimate, the federal government's research funding, which had risen considerably, was taken into account for the first time. In the new figures shown here both federal and EU funding was recalculated. It was not possible to conduct a new survey of ministry employees; a conservative approach was therefore adopted and employment kept at the 2006 level. The total employment resulting from this for 2009 aggregates 6,500 people, which is almost double the 2004 level.

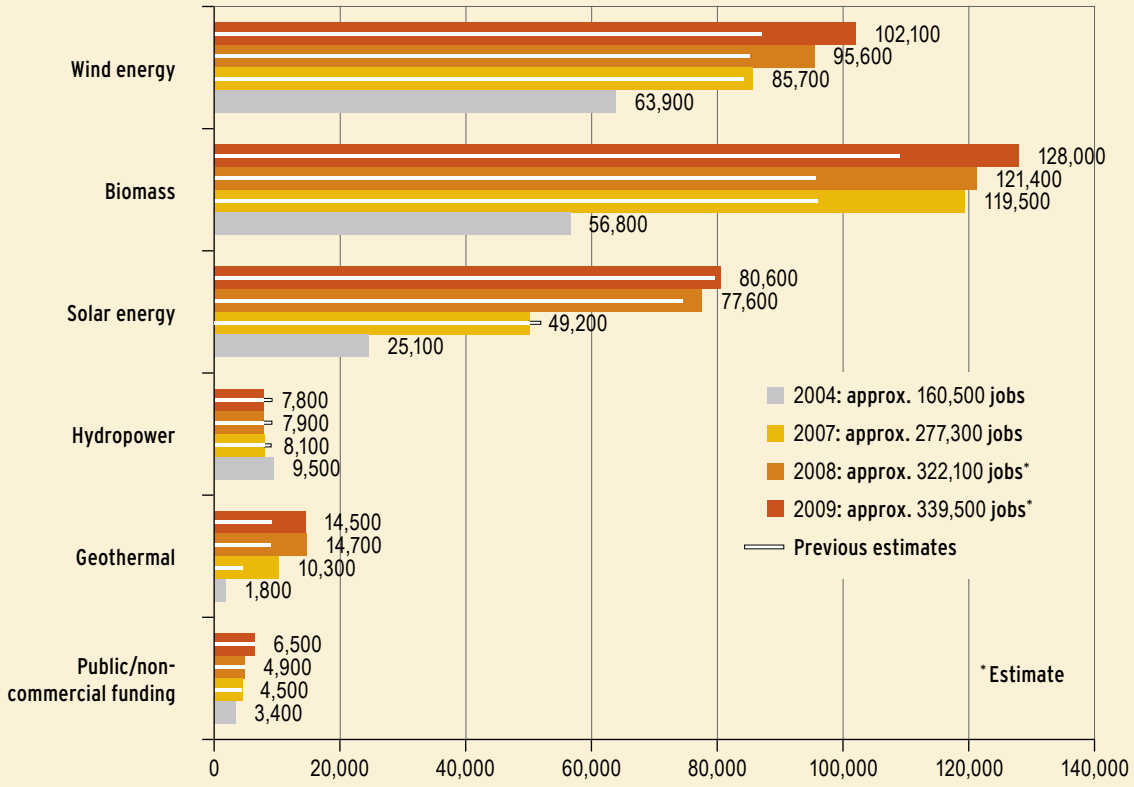
	Jobs created by investments (including export)	Jobs created in maintenance and operation	Jobs created by supply of biomasst	Total jobs in 2009	Total jobs in 2008	Total jobs in 2007
Wind [1]	84,800	17,300		102,100	95,600	85,700
Photovoltaics	60,700	4,000		64,700	60,300	38,300
Solar thermal [2]	13,700	2,200		15,900	17,300	10,900
Hydropower	3,400	4,400		7,800	7,900	8,100
Geothermal	11,800	2,700		14,500	14,700	10,300
Solid biomass	21,000	26,600		47,600	47,800	48,300
Biogas and liquid biomass	13,600	9,200		22,800	19,300	19,100
Biomass fuels			31,500	31,500	30,800	28,200
Biofuels for transport			26,100	26,100	23,500	23,900
Total	**209,000**	**66,400**	**57,600**	**333,000**	**317,200**	**272,800**
Employment provided by public/common use funding				6,500	4,900	4,500
Total				**339,500**	**322,100**	**277,300**

Table 3:Jobs created by renewable energy in Germany in 2009, 2008, 2007

1) Including offshore and onshore wind
2) Including solar thermal heat-generation plants and solar thermal power plants

Figure 3 compares the latest calculated values with the former provisional results. The updated values are in total significantly higher than the previous. The difference for 2007 is 11 %, for 2008 just below 16 % and for 2009 about 13 %. The sectors with the greatest differences from the previous are wind energy (17 % in 2009), biomass (27 % in 2008) and geothermal, which in relative terms underwent the highest correction (129 % in 2007). However, in a handful of sectors the provisional figures were adjusted downwards. This was true primarily for hydropower (22 % in 2008) and solar energy, where employment in 2007 had been overestimated (3 %). Essentially this is due to exports of solar thermal plants and equipment which have been overestimated. The figures were corrected following the new survey.

Figure 3: Trends in gross employment from renewable energy in Germany



In 2009, on the basis of this new information, employment was calculated as being 339,500 people in Germany's renewable energy sector, which equates to more than double the 2004 level. At almost 38 %, biomass had the largest share in employment, followed by wind energy at about 30 % and solar energy at 24 %. The geothermal share was just over 4 %, followed by hydropower at about 2 %. Jobs that were created by public and non-commercial funding also had a share of almost 2 %.

4 FUTURE OPPORTUNITIES FOR GERMAN COMPANIES – WORLDWIDE EXPANSION OF RENEWABLE ENERGY

In order to describe the influence of international developments on the turnover of German companies, the international expansion of renewable energy must first be estimated and the development of trade between the different regions of the world derived by drawing conclusions by analogy with other hi-tech products. It will ultimately be the volume of trade that determines the market opportunities for German companies and not a system manufactured in a region of the world for domestic installation.

4.1 National and international development of markets based on different scenarios

Robust information about assumptions concerning the future global expansion of renewable energy can be found in the global energy scenarios that various institutions have produced in recent years. They indicate that a considerably more efficient use of energy (EFF), combined with a massive expansion of renewable energy (RE), can make a major contribution, and probably even the most significant contribution, to solving the problem of how to reduce greenhouse gas emissions worldwide (WBGU [2003], Krewitt [2008], IEA [2008, 2009]). It is expected that by 2050 renewable sources will be able to supply the quantities of energy needed to match the current world energy consumption.

National development of renewable energy

For Germany, the Lead Scenario 2009 generated for the BMU specifies a possible consistent future development on which the following studies are based. The Lead Scenario describes how the key national and EU-wide targets can be achieved. It is the latest version of a family of scenarios that has been elaborated for the BMU since 2004 and which was also used for the predecessor to this study.

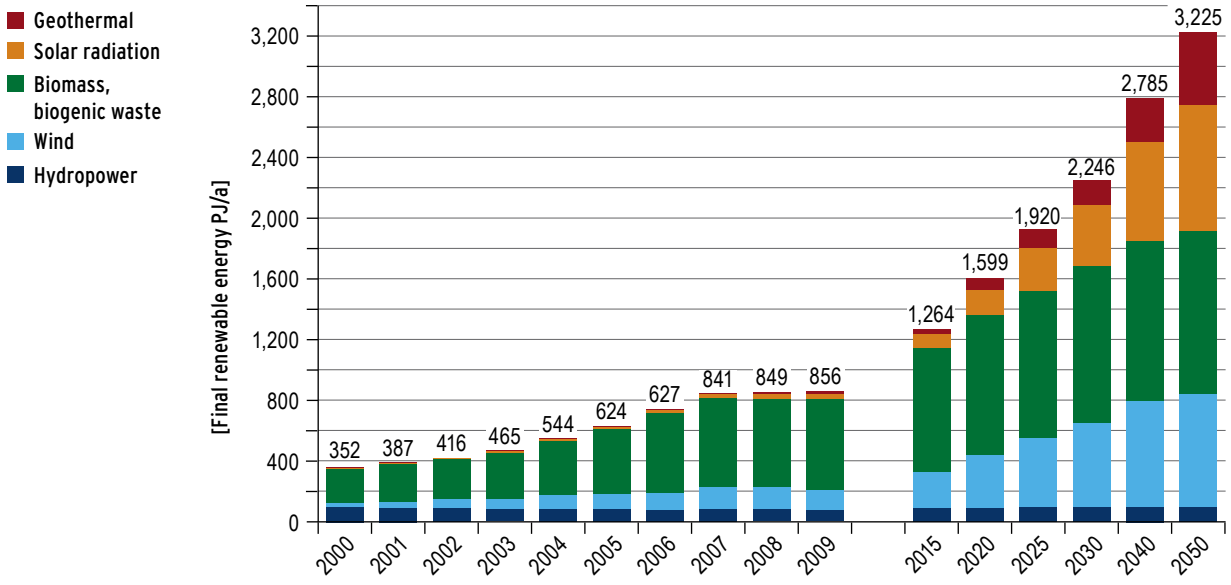
According to this, the volume of investments for technologies to supply electricity and heat from renewable sources in Germany has more than tripled in the last ten years and in 2008 totalled €$_{2005}$ 15 billion p.a. A total of €$_{2005}$ 95 billion was invested up to 2008 in facilities for producing electricity and heat from renewable sources. Between 2009 and 2020, a further €$_{2005}$ 175 billion will be invested (cf. Lead Scenario 2009).

The growth dynamic assumed in Lead Scenario 2009 is crucial if the domestic market is to maintain its ability to stabilise turnover in the renewables sector. That in turn is essential to retain opportunities for technological leadership on the world market in the majority of RE technologies and to be able to successfully advance the expansion of export markets. This is the only way to benefit appropriately from the considerable growth on international markets in future.

Scenarios are internally consistent views of how the future might turn out. In dealing with the inherent uncertainty of future developments, a range of different scenarios is typically developed. The question of the macroeconomic impact of a policy instrument can then be answered using an if-then analysis.

[1] The lead scenario is scheduled to be updated in the immediate future. With regard to renewable energy's expansion path, it essentially continues the development described in the Lead Scenario 2009. As well as a number of other adjustments, the Lead Scenario 2010 primarily describes the latest developments on the PV market. In anticipation of this, this study includes two additional scenarios on the future development of photovoltaics.

The Lead Scenario 2009 describes a target-oriented development, which aims for renewable energy to achieve a 31.7 % share in final energy consumption by 2030 through a combination of energy efficiency and expansion of renewables.

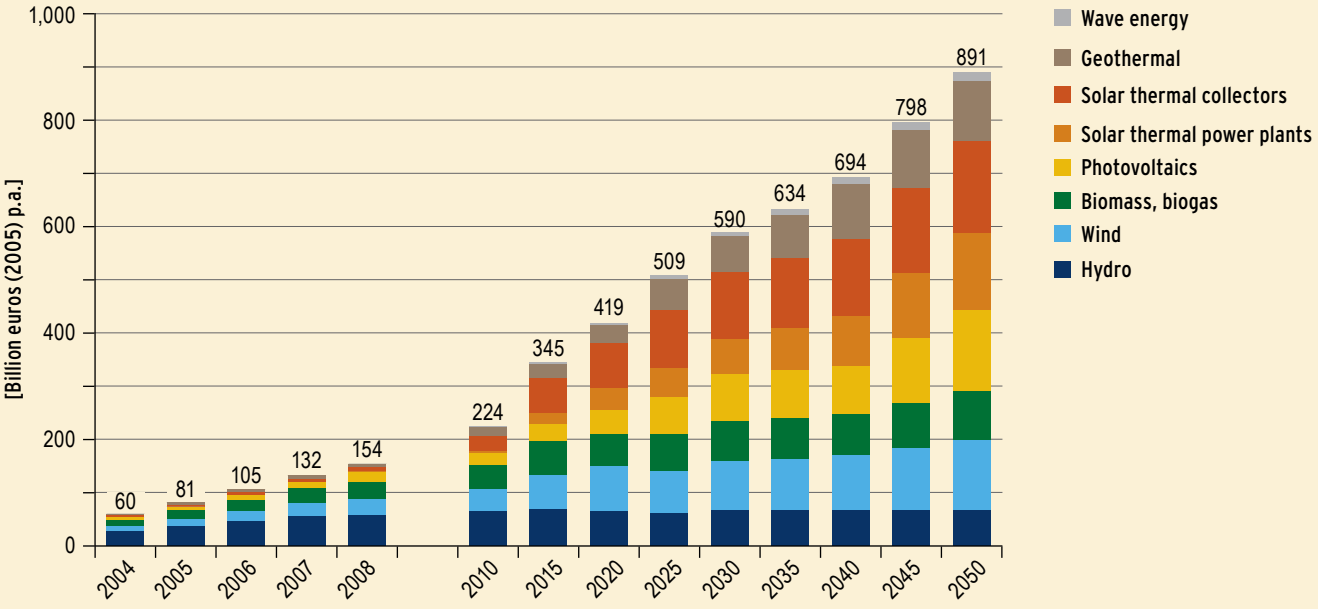


Global growth in renewable energy

This study uses the Energy (R)evolution (Krewitt 2008) scenario as a data framework for the future global expansion of renewable energy. This scenario describes a consistent development differentiated by world regions and RE technologies. It builds on the economic potential of renewable energy worldwide. With a primary renewable energy consumption of 271 EJ/a in 2050 it is of a similar magnitude to IEA's BLUE Map Scenario (2010), which assumes roughly 268 EJ/a RE PEV in 2050. It surpasses the renewable energy shares achieved in the World Energy Outlook's 450-ppm scenario published by IEA (2009), which is predominantly based on nuclear energy and CCS, but lags behind the 2010 Energy (R)evolution Advanced scenario (Krewitt 2010). A description of the quantified framework underpinning the scenarios used and the worldwide investments associated with it can be found below. In terms of systematics, the scenarios are consistent with current considerations in Germany focusing on investments in renewable energy facilities. For reasons of sustainability, biomass and supply of bio fuel for transport – reported in Germany for information purposes only – takes place locally in the regions of the world.

The quantitative developments on the market can be used to derive the volumes of investments that can be expected on a growing global renewable energy market. Even now, around €$_{2005}$ 150 billion p.a. are invested in RE technologies. Thereof, approximately €$_{2005}$ 60 billion p.a. go into (large-scale) hydropower, which is often regarded as not belonging to the new RE technologies. The wind industry accounts for a further €$_{2005}$ 30 billion p.a. If investments in hydropower remain constant, the annual volume of investment will raise to almost €$_{2005}$ 600 billion p.a. in 2030 and to just under €$_{2005}$ 900 billion p.a. by 2050. Solar technologies will by far account for the greatest share of 55 %, followed by wind energy (cf. Figure 4).

Figure 4: Annual global volume of investment for electricity and heat provision from renewable energy (electricity and heat)



The substantial growth in the volume of investment in renewable energy (fivefold or eightfold if hydropower is not included) marks a departure from today's raw-material-dependent energy provision. In the electricity sector, 50 % of a total investment volume of €$_{2005}$ 260 billion p.a. has been invested in renewable energy. In 2030 these technologies will dominate the market with almost 60 % of investments (€$_{2005}$ 337 billion p.a.). The three most important pillars of renewable electricity supply are wind energy, photovoltaics and solar thermal power plants. Since in 2050 electricity production will already be 80 % renewable, only low-level investments in fossil power plants will be made under the E[R] scenario. The heat market is currently clearly dominated by investments in fossil-based heat supply. At a level of €$_{2005}$ 26 billion p.a. (not including the costs of traditional use of biomass), only 14 % is currently being invested in the renewables sector. With investments of €$_{2005}$ 128 billion p.a., the renewables share under the E[R] scenario will have reached 58 % in 2020. In 2050, RE investments will also predominate in the heat market with a share of 86 %.

The regional structure of global investments in renewable energy

The regional structure of investments is an important starting point for estimating international trade in RE facilities and thus Germany's export opportunities in this sector. Through geographical proximity, established trade relations and political closeness, Germany has established favourable relationships in certain regions of the world. Currently, RE investments are primarily being made in three regions: OECD Europe, with Germany being of particular significance, OECD North America, and China. In 2008, around 87 % of wind energy capacity, 86 % of photovoltaics capacity and 93 % of solar collector capacity was installed in these three regions. Around two-thirds of total investments (including large-scale hydropower) occur in these regions. However, the individual markets have considerable structural differences.

To achieve significant additional annual RE capacity, a rapid expansion of RE investments to those regional world markets that are still "underdeveloped" is vital, while at the same time securing the high level of capacity being added in the above-mentioned regions. Figure 5 shows the development of the future RE market as envisaged under the E[R] scenario.

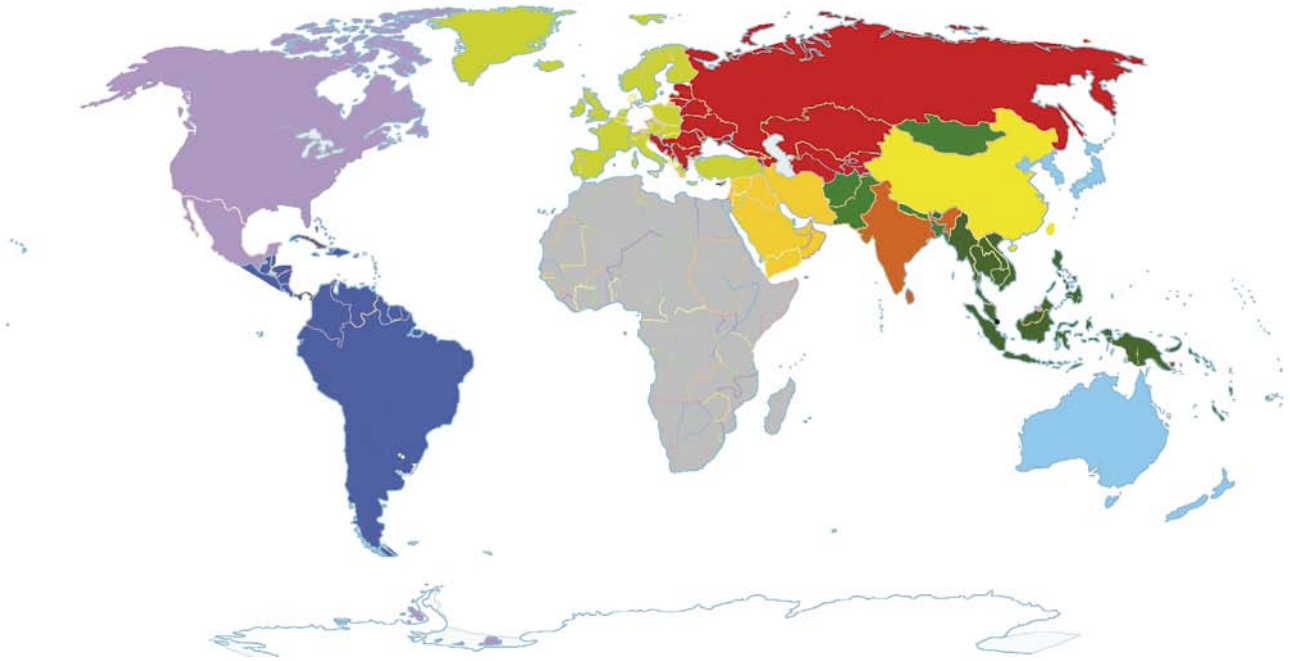


Figure 5: RE capacity added (year) by groups of countries (including large-scale hydropower) for generating electricity and heat under the E[R]scenario

North America	RE capacity added (year)	in GW/a
Electricity	2020 2030	55.2 50.9
Heat	2020 2030	70.2 144.3

Rest of Asia	RE capacity added (year)	in GW/a
Electricity	2020 2030	9.2 19.0
Heat	2020 2030	46.6 56.1

Europe (excluding Germany)	RE capacity added (year)	in GW/a
Electricity	2020 2030	33.0 36.9
Heat	2020 2030	50.8 117.4

Pacific	RE capacity added (year)	in GW/a
Electricity	2020 2030	9.9 15.6
Heat	2020 2030	25.9 32.3

Transition countries	RE capacity added (year)	in GW/a
Electricity	2020 2030	8.5 16.6
Heat	2020 2030	52.8 62.5

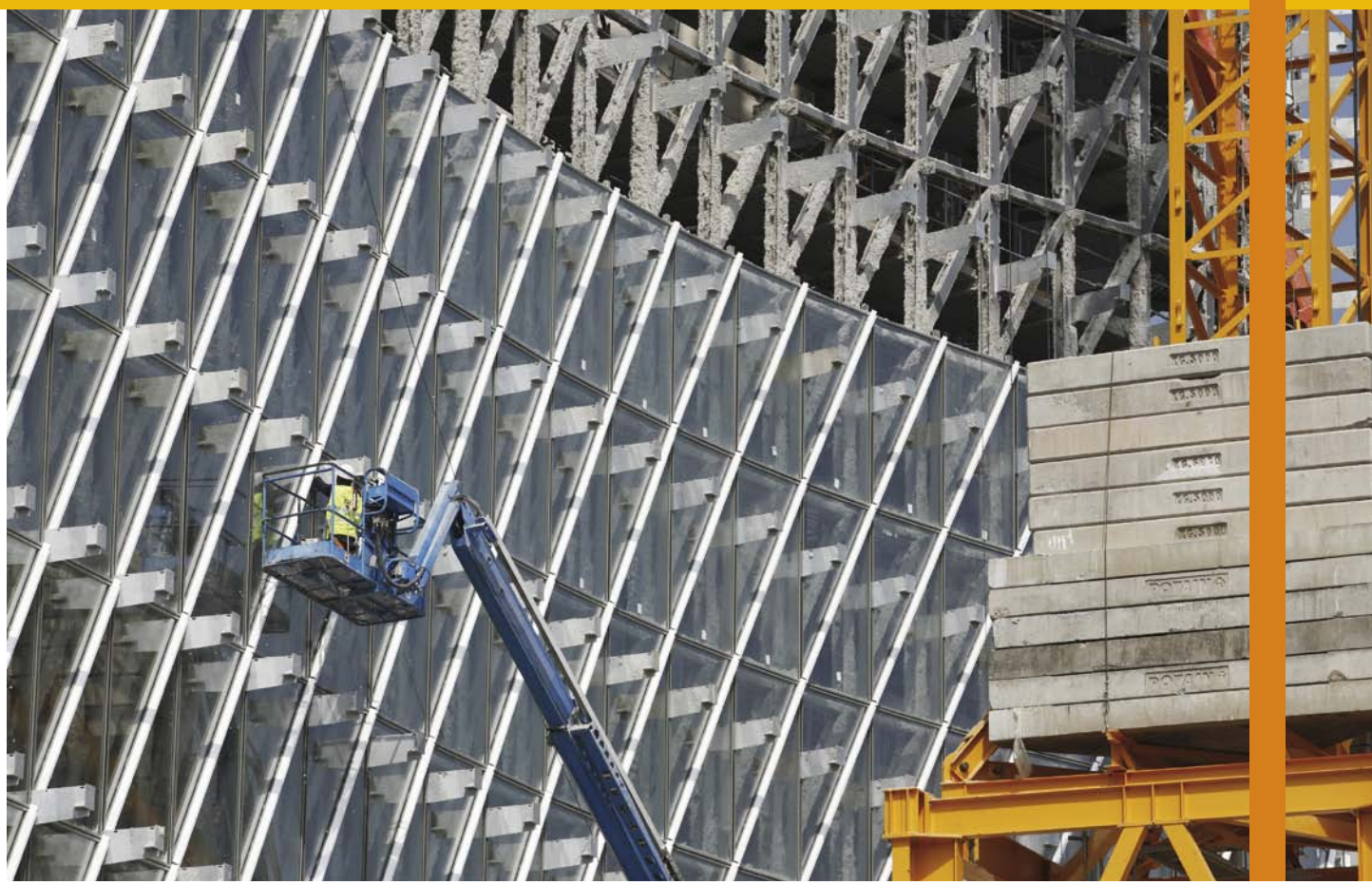
Middle East	RE capacity added (year)	in GW/a
Electricity	2020 2030	5.2 15.9
Heat	2020 2030	33.8 47.5

China	RE capacity added (year)	in GW/a
Electricity	2020 2030	29.7 55.0
Heat	2020 2030	44.6 68.0

Africa	RE capacity added (year)	in GW/a
Electricity	2020 2030	3.9 11.4
Heat	2020 2030	31.1 39.8

India	RE capacity added (year)	in GW/a
Electricity	2020 2030	12.8 21.3
Heat	2020 2030	32.8 65.4

Latin America	RE capacity added (year)	in GW/a
Electricity	2020 2030	11.8 20.5
Heat	2020 2030	32.1 32.6



The classification of groups of countries/regions shown in Figure 5 is based on the definition used in the World Energy Outlook (IEA 2008; Krewitt 2008).

In all groups of countries, the capacity added each year is growing substantially, but average growth rates differ greatly so that shares adjust to the expected future energy consumption of the individual regions. In 2007, 30 % of renewable electricity generating facilities and 26 % of renewable heat generating facilities were installed in OECD Europe. In 2030, the market shares are still 14 % and 17 % respectively and in 2050 10 % and 12 % respectively. By contrast, China and India increase their share significantly. In the electricity sector, the share of annual facilities rises from 21 % at present to 29 % in 2030 and 31 % in 2050. The Middle East and Africa also increase their market shares in future renewable energy facilities. The shifts are even more marked if RE facilities are considered without large-scale hydropower.

The regional breakdown of global investments in renewable electricity and heat generation shown in Figure 6 is based on these assumptions about the development of regional RE markets. By 2020, annual RE investments will grow on average by 8.8 % p.a. globally. Above-average growth rates will be seen particularly on the markets in Africa and the Middle East at 12.5 % p.a, in North America, the Eastern European countries in transition at 11 % p.a. and the rest of Asia (including India) at 10 % p.a. The European market experiences a growth rate of 4 % p.a, the German market 2.3 % p.a. In terms of overall volume, the North American market is the largest market up to 2020, totalling €$_{2005}$ 110 billion p.a., followed by China and OECD Europe at about €$_{2005}$ 65 billion p.a. each. After 2020, the European and North American markets are largely saturated, whereas the world market continues to grow at an average rate of 2.5 % p.a. The markets in Africa and the Middle East will see significant above-average growth of 4.6 % p.a. during this period. The average growth rates of the Asian markets (China, India, the rest of Asia) are also relatively high at 3.3 % p.a. In 2050, China will be the single largest market at just under €$_{2005}$ 170 billion p.a; India and the rest of Asia together reach the €$_{2005}$ 160 billion p.a. mark, followed by OECD North America at €$_{2005}$ 150 billion p.a. By the middle of the century, the African market (including the Middle East) will equal it. In OECD Europe, investments in renewables will only reach less than €$_{2005}$ 90 billion p.a.

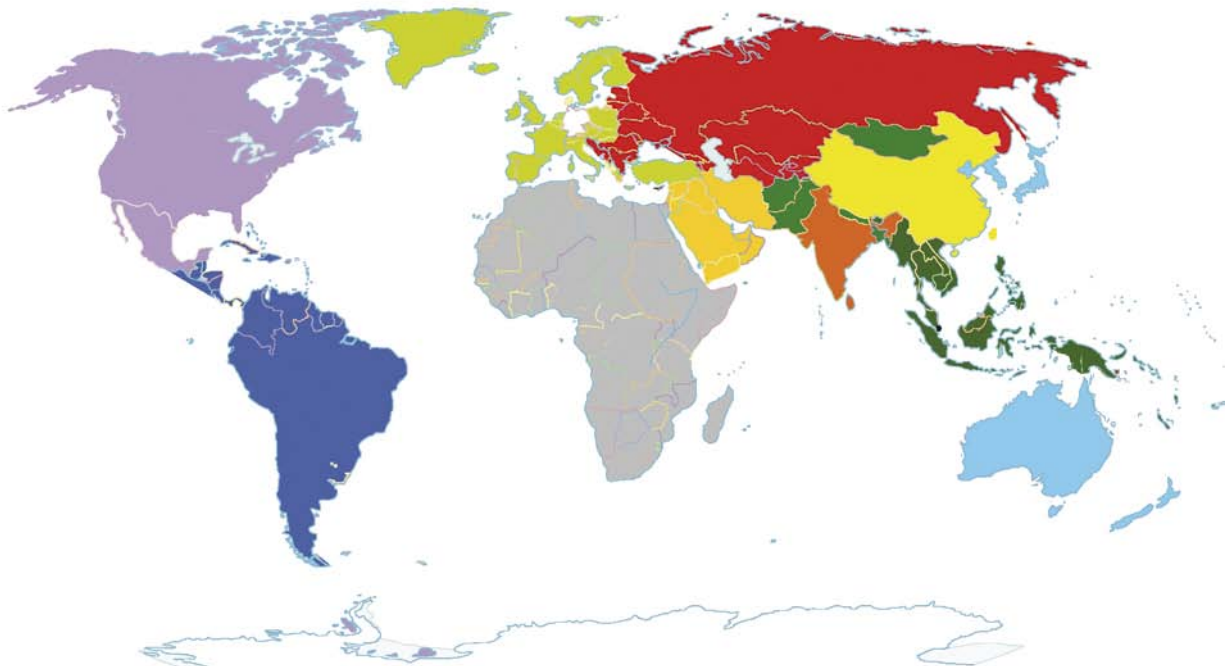


Figure 6: Global investments in technologies for generating electricity and heat from renewable sources, by groups of countries, in €$_{2005}$ billion

North America	Investments in renewable energy	in € billion
Electricity	2020 2030	87.92 85.41
Heat	2020 2030	21.57 40.12

The rest of Asia	Investments in renewable energy	in € billion
Electricity	2020 2030	15.34 26.25
Heat	2020 2030	14.18 15.53

Europe not including Germany	Investments in renewable energy	in € billion
Electricity	2020 2030	39.87 42.71
Heat	2020 2030	10.03 28.04

Pacific	Investments in renewable energy	in € billion
Electricity	2020 2030	14.74 21.07
Heat	2020 2030	8.16 8.99

Transition countries	Investments in renewable energy	in € billion
Strom	2020 2030	17.01 24.69
Wärme	2020 2030	16.10 17.76

Middle East	Investments in renewable energy	in € billion
Electricity	2020 2030	9.22 29.12
Heat	2020 2030	10.70 13.45

China	Investments in renewable energy	in € billion
Electricity	2020 2030	48.25 81.41
Heat	2020 2030	13.49 18.83

Africa	Investments in renewable energy	in € billion
Electricity	2020 2030	8.33 21.29
Heat	2020 2030	9.12 10.59

India	Investments in renewable energy	in € billion
Electricity	2020 2030	19.76 33.95
Heat	2020 2030	10.01 18.31

Latin America	Investments in renewable energy	in € billion
Electricity	2020 2030	20.99 30.53
Heat	2020 2030	9.74 8.91

The regional breakdown of growth rates described here and the total volumes on the future global energy market clearly illustrate the major importance of the German and European renewables markets. In 2007, 8 % of global investments in renewables was made in Germany, almost 30 % in OECD Europe. Given the aim to expand renewable energy worldwide, these shares will drop as early as 2020 to 3.5 % (Germany) and 15 % (OECD Europe) and in 2050 will be at 1.9 % (Germany) and 10 % (OECD Europe). If the German renewables sector, which – including its exports – currently accounts for 13 % of global investments in renewables, wishes to participate to a similar or at least only slightly lesser extent in the global RE market, which in future will undergo considerable growth, it must direct its attention to the regional markets that are set to experience above-average growth in the next few decades. Since the domestic market, after its rapid growth of recent years, will grow at a slower rate in the future, it is particularly important for the continued growth of the domestic renewables sector to achieve successes in these markets and to grasp export opportunities.

4.2 From the world market to world trade

The methodological challenge posed by trying to estimate export opportunities involves as a first step a differentiation of worldwide demand between the part serviced by local manufacturers (local content) and that which is traded internationally. Only the volume traded internationally determines export opportunities. The second step is then to estimate what share of this volume of world trade German exports account for - by region and by technology.

Data is available for 2007 for all world regions, which can be used to calibrate world trade and German shares. Overall, in 2007 capital goods worth €$_{2005}$ 23.5 billion were traded in the renewable electricity and heat generation technology sector. This is just 17.8 % of the total investment volume of €$_{2005}$ 132 billion. However, if hydropower is taken out of the equation, this share rises to about 30 %. This underlines the importance of a technologically differentiated analysis for the export potential.

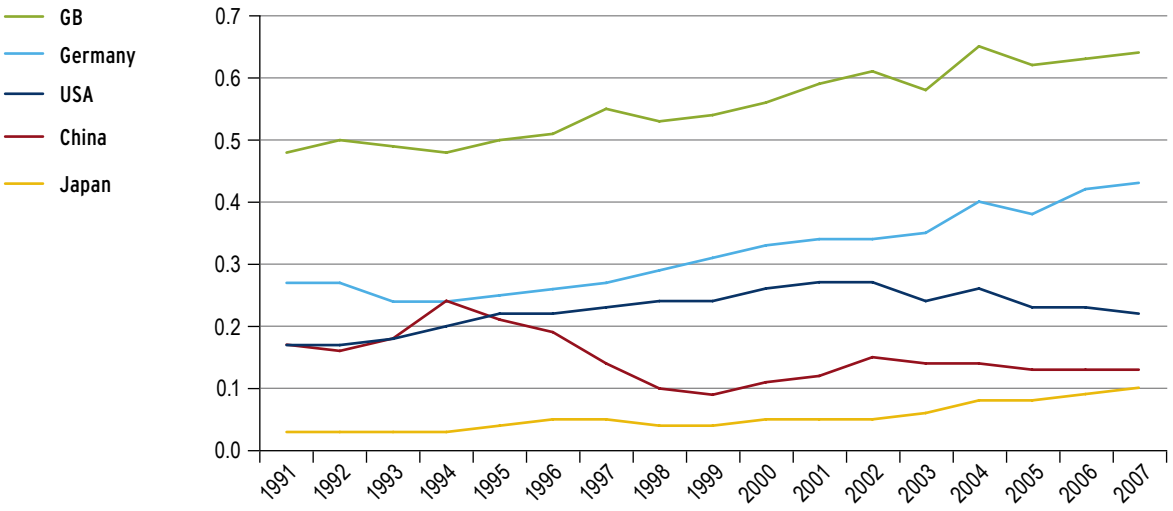
Although over 20 % of total investment is spent for heat generating technologies, they are traded to a significantly lesser degree. Heat generation from biomass or using solar collectors has been established for years in many regions of the world and domestic industries have developed that are tailored to the needs of their particular regional market.

In 2007, Germany was able to serve considerable shares of world trade. Overall, German exports accounted for € 7.17 billion (€$_{2005}$ 8.6 billion in 2009, cf. Table 1). This corresponds to a 30 % share in world trade. Germany achieved the greatest shares in trade in wind turbines, solar thermal power plants and photovoltaics in the electricity generation sector and with solid biomass facilities in the heat generation sector. Wind energy has the largest export turnover.

To deal with the uncertainty regarding future developments, four different scenarios for the possible opportunities of German RE companies on the world markets were developed. Two of these are for information only character and represent maximum and minimum export expectations.

A plausible minimum level of future exports would be that German exports remain constant until 2030. This would mean that Germany does not manage to participate at all in the growth in volume of world trade in RE technologies. Whereas the volume of world trade will already have increased more than fivefold by 2020, in terms of volume German exports in this scenario remain constant. In other words, this entails considerable losses in world trade share for Germany. For wind energy, biomass and photovoltaics technologies, this extreme case would cause a decrease in world trade share of over 50 %. Exports in this scenario would lag significantly behind domestic investments in 2020 (below 50 % of domestic investments). Since in the scenario (Lead Scenario 2009), the assumed decreasing costs mean that domestic investments in Germany between 2020 and 2030 also decrease, domestic manufacturers – assuming imports remained constant – would have to scale back their production capacities. For our further considerations, the share in world trade that arises in this scenario thus represents a lower limit, which all signs indicate will be significantly surpassed.

Countries differ greatly in terms of share of demand for capital goods that is met by imports. This chart shows mechanical engineering as an example.



Estimating how shares in trade will develop in the future is also taken from the historical development of other mature industrial sectors. For example, for mechanical engineering the shares in trade are between 20 and 50 % depending on the target region. The EU countries are currently the predominant trading partner. Long-term shifts typically take place between the target regions; here growth in excess of ten percentage points has been witnessed.

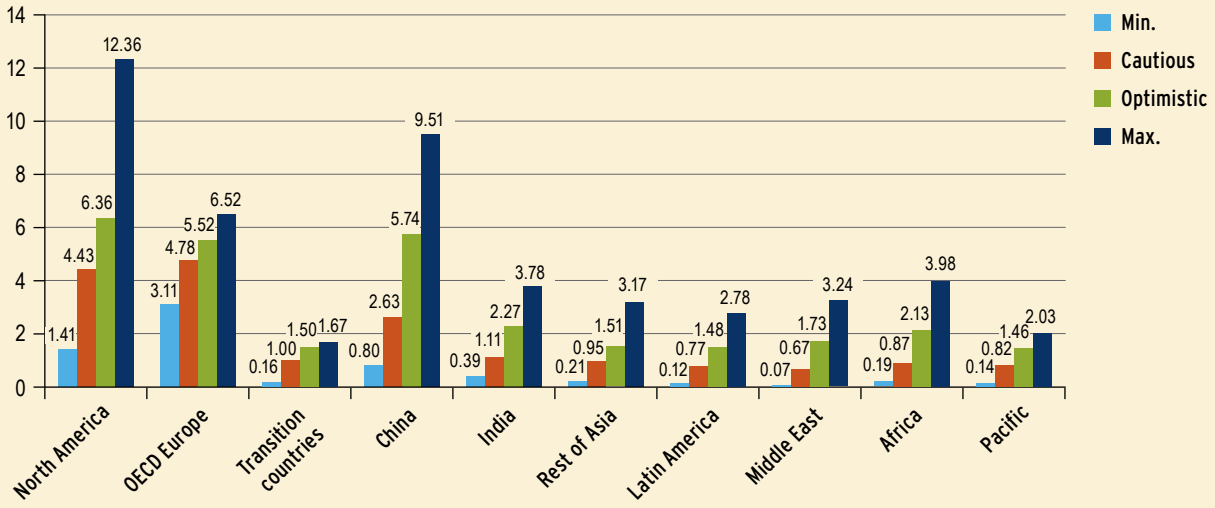
An upper limit (maximum) for German exports – which we also believe to be unrealistic – emerges if we assume the exact opposite: if, as a result of its pioneering role, Germany's currently high shares in world trade remain unchanged in the long run, the growth in world trade would translate into a fivefold increase in exports.

Within the area framed by these two boundaries, a cautious view of how German exports will develop assumes a significant decline in export opportunities for the German industry. This can be interpreted as a loss of technological leadership along with greater significance of manufacturers in other regions. German companies producing their goods abroad would still have the same effect, because this scenario would also lead to lower exports and a decline in employment induced by exports.

The optimistic option assumes that markets in the transition countries, Africa, and the Middle East will open up more by 2020 and that China and India will follow up to 2030. A gentler drop in trade shares by comparison with the cautious scenario is expected for wind energy up to 2020 and for heat generation technologies. Up to 2030, solar thermal power plants increase their trade share with China and India. It is assumed that North America will see an increase in domestic production, making it an exception in our systematisation, since an increase in trading activity has been assumed for the other regions and technologies. However, since there has already been significant growth in RE technologies in North America since 2007, the two middle-of-the-range options assume constant to decreasing trading activity.

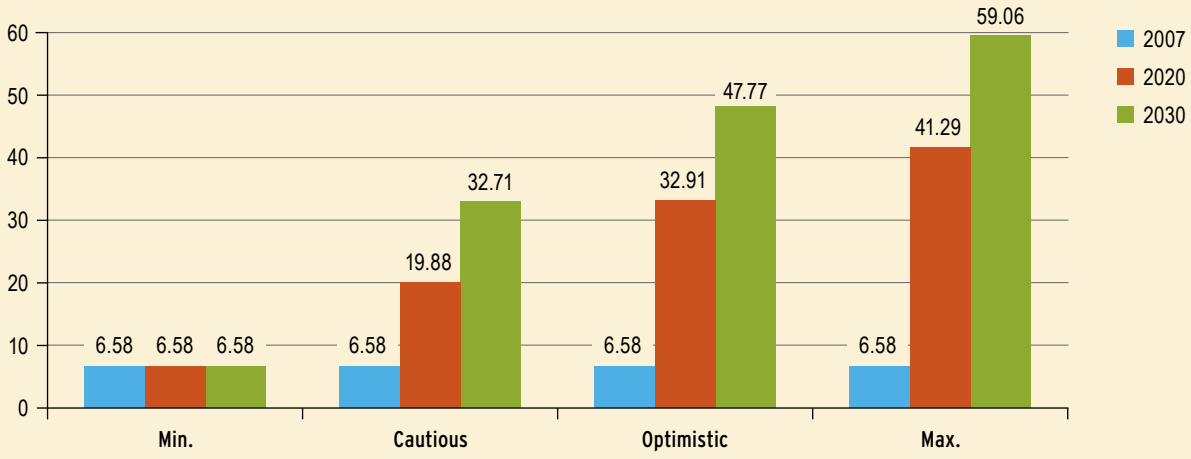
The best overview is achieved by looking at these scenarios by technology and region for specific years and following the development of exports over time. Figure 7 shows the exports in different regions for the four scenarios in 2020 in $€_{2005}$ billion.

Figure 7: Exports of RE facilities by region in 2020, in €$_{2005}$ billion



It becomes clear which regions drive the differences among the scenarios. Due to the close economic interrelations in Europe, there is a smaller difference in the export estimates for Europe across all scenarios than, for example, for China or North America. There are similarly no major differences among scenarios in countries where expansion is lower.

Figure 8: RE technology exports over time, in €$_{2005}$ billion



Comparing worldwide exports over time in the different scenarios reveals the range of fluctuation produced by the different assumptions. In 2020, there was a difference of about € 35 billion between the lower limit and upper limit. The cautious scenario differs by about € 10 billion from the optimistic scenario for 2020. In 2030 these differences are far greater. At almost €$_{2005}$ 50 billion, the optimistic variant is about € 15 billion higher than the cautious variant. The optimistic variant represents more than a sevenfold rise in the 2007 export level, assuming a ninefold growth in world trade.

5 LONG-TERM EMPLOYMENT TRENDS AS A RESULT OF EXPANSION OF RENEWABLE ENERGY

5.1 Trend in gross employment up to 2030

Worldwide demand for renewable energy technologies, which can be seen as an export opportunity for German RE companies, has a growing influence on domestic employment in the sector. Whereas domestic investment rises sharply to 2020 and then flattens out, the spurt in demand in some regions of the world does not begin until after 2020 and thus, given the corresponding export assumptions, offsets these trends. Domestic production of renewable energy facilities will, however, increasingly concentrate on high-tech products that are made in highly automated, technology-based manufacturing processes. A starting point for looking at how productivity might develop is again provided by the mature industrial sectors. Here, depending on the industrial sector, annual increases in productivity of between 1.5 and 2.5 % are not uncommon.

Overall, if RE companies continue to be successful on world markets, gross employment will be between 500,000 and 600,000 jobs in 2030 (Figure 9). The rise in gross employment is steepest between now and 2020. In this period, gross employment rises from just under 340,000 to 450,000 – 580,000 jobs. This shows that the national and international market for RE technologies is still very dynamic, even if a repeat of the rapid doubling of employment within 5 years that was seen between 2004 and 2009 is not anticipated in the future.

Overall, growth flattens out due to increased automation and a general increase in productivity in all sectors. Growth in jobs also shifts to production, because exports are not expected or not possible, in the areas of operation or supply of biomass and biofuel for transport.

Figure 9: Jobs (in 1000) under different domestic investment paths and export scenarios assuming a low price path

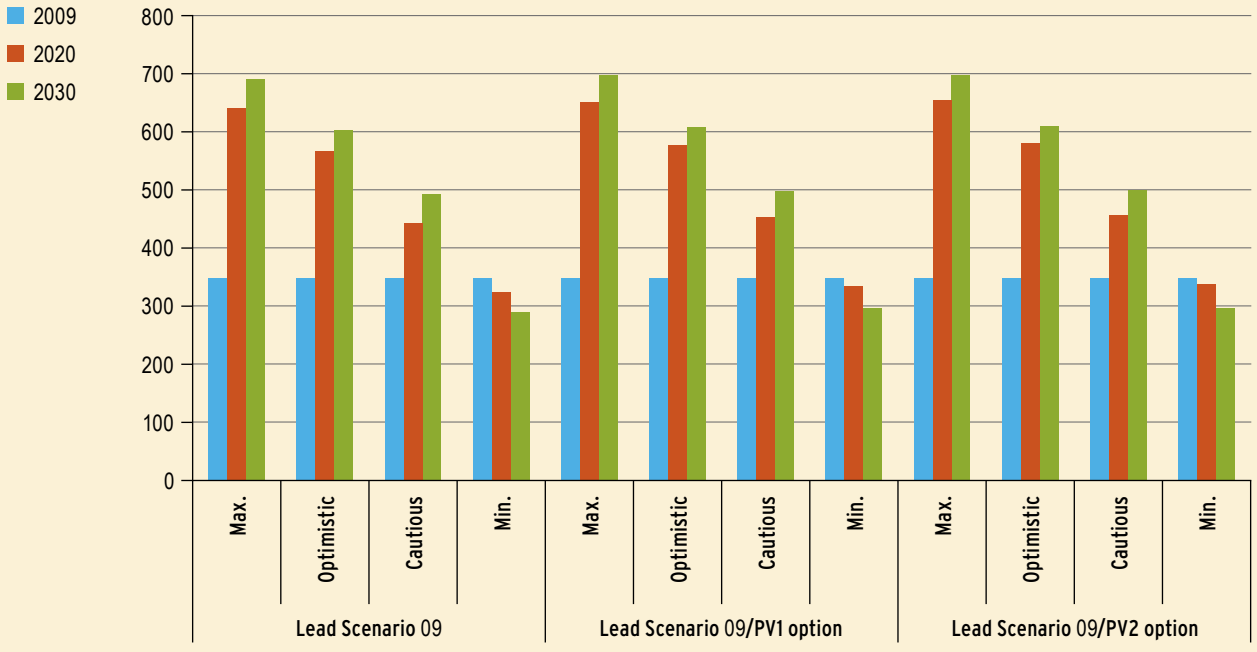
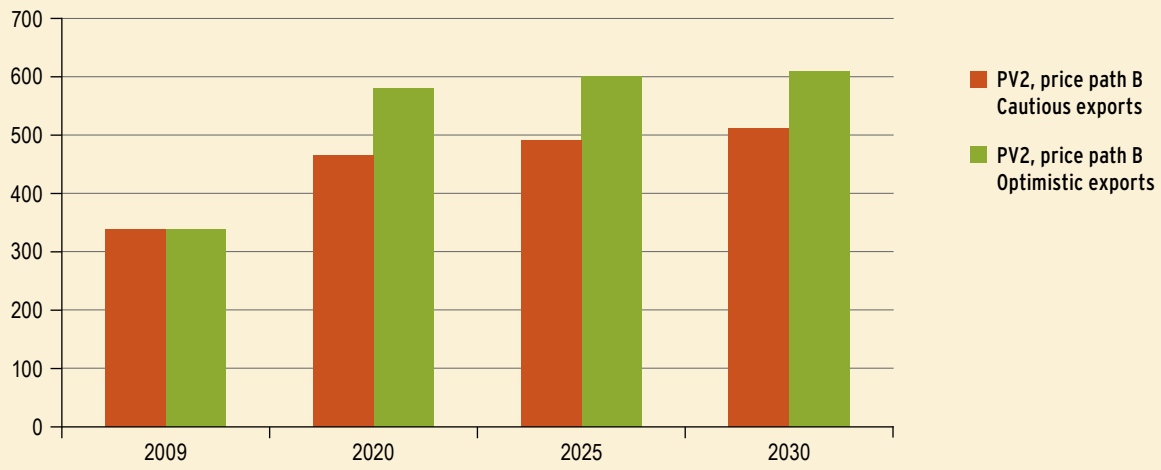


Figure 10 considers the PV2 scenario with a strong expansion in photovoltaics and compares the impact of different export assumptions on trends in gross employment. It can be clearly seen that, depending on the extent to which export opportunities are seized, the worldwide demand for RE facilities will lead to a significant number of additional jobs. In the case of cautious export assumptions, gross employment is just below 500,000 in 2020 and just above that figure in 2030. More optimistic export assumptions lead to 100,000 additional jobs, so that gross employment in 2030 may total over 600,000.

Figure 10: trends in gross employment up to 2030



5.2 Net employment

5.2.1 Comparison of scenarios

The economic impact of an activity such as the expansion of renewable energy is assessed by comparing a simulation without the activity or economic policy measure with a simulation that includes the activity. To do so, consistent scenarios are developed in which energy prices, energy volumes and energy consumption are set at different levels, thus exerting different influences on the economy.

This study is based on national scenarios, which – as outlined above – are to a great extent derived from the RE Lead Study 2009 (BMU 2009b).[2] Below is a brief comparison of the scenarios and their principal assumptions. A more detailed summary of the scenarios and the assumptions they are based on will be given in the comprehensive report on this project, expected to be available at the end of 2010.

[2] The Lead Study 2009 is based on the assumption of Germany's nuclear phase-out having begun. The Lead Study 2010, which is currently being drafted, integrates the planned extended operating lives for nuclear power plants. For the findings on renewable energy net employment documented below the extended operating lives are, however, of no consequence since the price effects calculated in Prognos/EWI/GWS (2010) have been included both in the reference scenario and in the expansion and export scenarios. Since in the analysis of net effects only deviations from the reference scenario at the same energy prices can be taken into account, the effects cannot fundamentally change.

1. **Price level for fossil energy sources/electricity prices**: price path A shows a marked rise in prices for imported oil, natural gas and hard coal. Price path B assumes the same relation between the import prices for these energy sources, albeit with a less steep rise.[3] Electricity prices differ as a result of the price level for fossil energy sources. Each price path thus influences the additional costs of renewable energy: high prices for fossil energy sources reduce the additional costs for renewable energy.

2. **Expansion of renewable energy**: the RE increase follows the Lead Scenario 2009. To take account of the high degree of expansion of photovoltaics in 2009 and the high degree expected for 2010, two sensitivities for photovoltaics were also added in the course of the project: PV1 assumes a growth of 3 GW/a up to 2020, after which growth up to 2030 drops to 2.5 GW/a. PV2, which is in line with the target set under current legislation, assumes additional capacity of 6 GW for 2010, 4.5 GW in 2011 and then 3.5 GW/a up to 2020.[4] After that, additional capacity is set at 2.4 GW/a. The additional costs for all quantified frameworks were based on both price paths.

3. **Export activity of manufacturers of renewable energy facilities**:[5] The upper limit (maximum) is characterised by constant trade shares on strongly expanding world markets; at the lower limit (minimum), export volumes remain constant at today's level. What we have called an optimistic and a cautious export path run between these two limits.

Instead of a business-as-usual reference run, which in many studies describes a development under which no further measures are taken (cf. Prognos/EWI 2005, ISI 2009), this study uses a zero scenario (cf. also BMU 2007). It describes a consistent hypothetical development in energy generation without renewable energy from 2000 onwards and includes the additional fossil power plants and heat generation plants that would then be necessary along with the associated investment. In this scenario, renewable energy makes only a very limited contribution to the heat and electricity supply, for the latter predominantly from large-scale hydropower, which was already competitive even before the Renewable Energy Sources Act came into force.

The zero scenario based on price path A or B is now compared to a development with differing degrees of domestic expansion and differing export trends based on the same price path. This makes it possible to identify the macroeconomic effects of different turnover trends by looking at the difference in outcome of the simulations. Net employment effects can only be calculated with adequate accuracy in a complex macroeconomic model. The simulations in this study used the PANTA RHEI model.

PANTA RHEI is a version of the macroeconometric simulation and prognosis model INFORGE developed by GWS mbH, which has been expanded to include an analysis of environmental economic issues.

The PANTA RHEI model tracks the long-term structural change in economic development and in environmental economic interdependences. As well as comprehensive economic modelling, energy use – and in particular use of renewable energy – is also recorded in detail. All parts of the model are consistently interconnected.

[3] Overall in the low price scenario (B), the price of oil at 79 $\$_{2005}$/bbl (94 $\$_{2005}$/bbl) 2020 (2030) is clearly below the framework assumptions of Prognos/EWI/GWS (2010) at 97.5 $\$_{2008}$/bbl (110 $\$_{2008}$/bbl).

[4] The latest reports (September 2010) indicate that PV expansion in 2010 is probably above this mark. Important drivers for long-term employment effects are, however, the long-term development paths of renewable energy expansion.

[5] Including component manufacturers.

5.2.2 Net effects

To gain an overview of selected results in all the simulations run, the charts below show the results for net employment over time. Absolute deviations from the zero scenario of the particular price path are shown. Positive values should be seen as positive net employment by comparison with a development without expansion of renewable energy. Negative values indicate that employment lags behind the value it would have had without the expansion of renewable energy.

In **price path A** (Figure 11) the increase of renewable energy leads in virtually all the scenarios studied to positive net employment, rising steadily, particularly from 2020 onwards. The net effects are lowest in the scenarios with minimal exports (i.e. remaining constant at today's level), although this should be seen here more as a notional lower limit. In this case, for the two expansion paths (Lead Scenario 2009 and PV2) only slightly lower values for employment are produced by comparison with the zero scenario. However, at the end of the observation period there is a reversal in these cases: the net employment effects become positive (around 100,000 jobs). The influence of exports on the domestic employment level also becomes very evident in the scenarios studied: using the optimistic expectations, the positive net employment effect rises by 2030 to values in excess of 200,000. In combination with cautious export expectations, there are only slightly less positive deviations from the zero scenario up to 2015. After that the positive employment effects of exports become apparent.

By comparison with the different renewable energy expansion scenarios, the moderately higher PV expansion (PV1) produces the best net employment effects under virtually all other conditions.

Figure 11: Jobs (in 1000s), deviation from the zero scenario for price path A

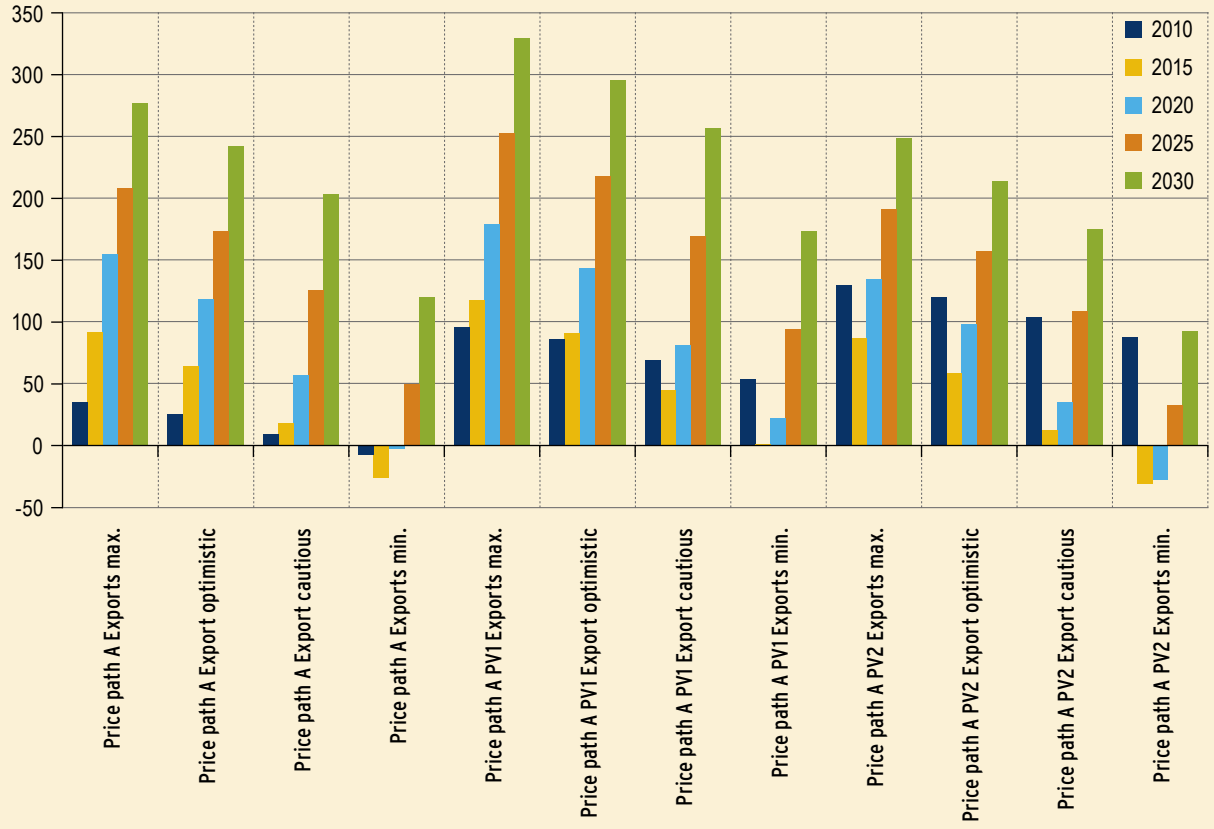
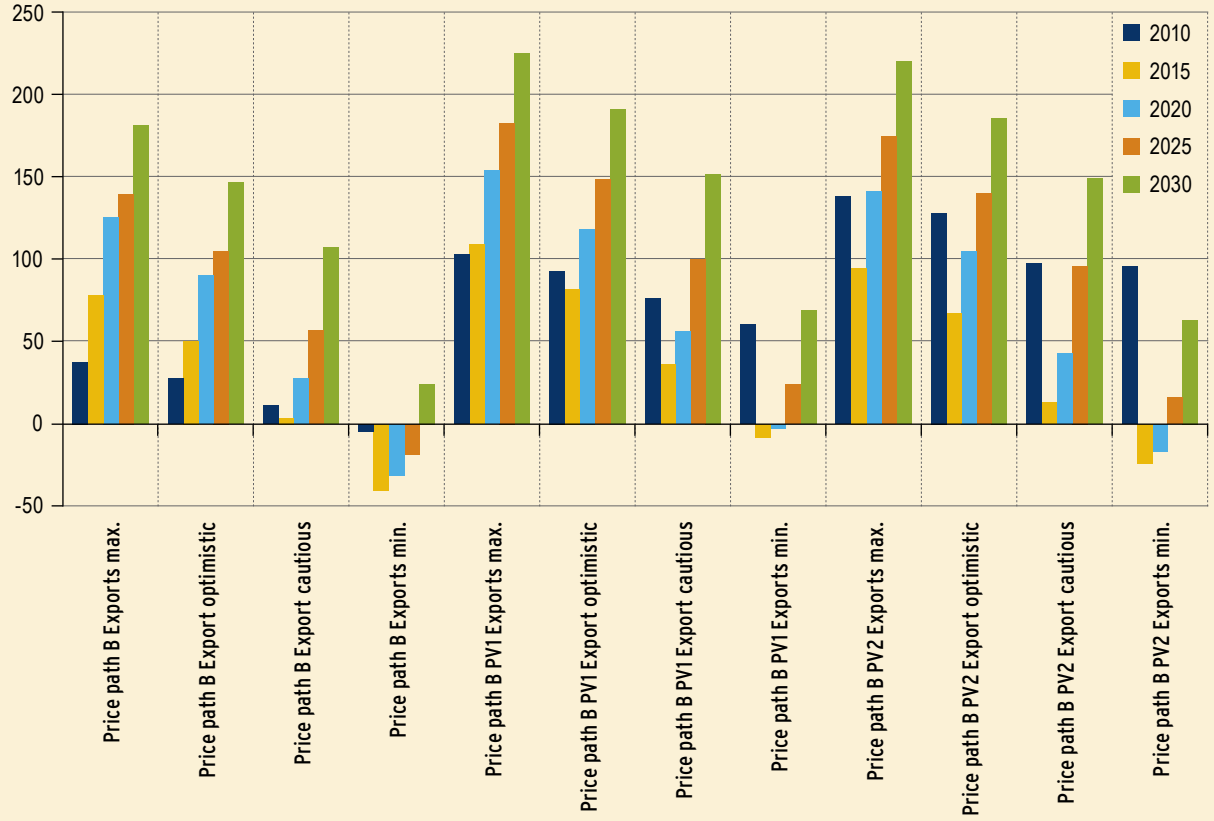


Figure 12: Jobs (in 1000s), deviation from the zero scenario for price path B



Using **price path B** the higher additional costs, brought about by low prices for fossil energy sources, slightly attenuate the positive net employment effects described above. However, the basic pattern described for price path A remains: negative net employment effects occur, sometimes at the notional lower export limit.

Overall, the highest net employment for price path A is at the upper export limit in combination with PV1 expansion. Here net employment in 2030 is 300,000 people higher than it would have been without expansion of renewable energy in Germany.

5.2.3 Net effects for 2009 and 2010

Identifying net effects for 2009 and 2010 is difficult for reasons of methodology and because of the high degree of uncertainty connected with the economic crisis. Some data for 2009, such as installed renewable energy capacity, is available in the form of statistics; other data is based on model results. The two types of data cannot readily be combined. An example is data on the energy balance: details are available up to 2007, marginal totals up to 2008, and data on primary energy consumption up to 2009. 2009 was also an exceptional year due to the economic crisis and therefore cannot simply be updated. This particularly complicates an interpretation by comparison with the zero scenario. The price level for energy in 2009 and 2010 is on the low side; additional PV capacity in 2010 will clearly surpass that of 2009. Overall, there seems to have been no slump in exports and the net effect of the current renewable energy expansion compared with the zero scenario can therefore be estimated at 70,000 – 90,000 jobs.

6 SUMMARISING ASSESSMENT

A comparison of the macroeconomic development under different expansion scenarios with the respective development without renewable energy expansion shows overall positive effects on growth and employment. The current study is thus in agreement with the findings of previous studies (BMU 2006, 2007). In summary, the following points can be noted:

- The number of jobs connected with the manufacture of renewable energy facilities, the operation and maintenance of facilities and the supply of biogenic fuels or jobs which were financed from public and common use funding designed to promote renewable energy, has more than doubled to almost 340,000 since the first systematic estimate was made for 2004.

- The most comprehensive survey to date of 1,200 companies in the renewables sector in Germany made it possible to significantly improve the data situation for flows of goods and production connections among manufacturers of renewable energy facilities. Furthermore, the survey acquired information on foreign trade, which for many sectors goes far beyond the data available elsewhere.

- For the vast majority of scenarios studied, the expansion of renewable energy clearly produced positive net employment effects.

- Consistent with previous studies, the survey proved that the development of export rates is significant for employment trends. Middle-of-the-range export assumptions produce a net increase in employment by 2030 of 107,000 to 288,000 people, depending on the other framework conditions.

- The import price paths for fossil energy sources impact in the first place on economic growth in general and secondly on the employment stimulus provided by the expansion of renewable energy. The economic benefits of renewable energy increase as prices for fossil fuels rise.

- The curbing effects of higher additional costs can be more than offset by rises in export. However, this is only the case if production capacities are expanded to the same degree, so that demand on the domestic market is not met to a greater extent by imports, which would also have an attenuating effect.

- In the PV2 sensitivity, the attenuating influences in the low price path for fossil energy sources have a greater effect in the medium term due to the high additional costs and even additional exports generate a maximum of 170,000 additional jobs. However, in the long term (by 2030) these effects will recede into the background.

- Overall, the renewable energy industry is characterised by significant growth in productivity, which has been reflected in lower costs but also in lower levels of employment per unit produced. Nevertheless, this progress in production facilities will increasingly translate into additional export opportunities for these facilities. These effects have not been taken into account in any depth to date, but will gain significance in the future.

- If the German renewables sector, which – including its exports – currently accounts for about 13 % of global investments in renewables, wishes to participate to a similar extent in the global RE market, which in future will undergo significant growth, it must direct its attention to the regional markets that are set to experience above-average growth in the next few decades. Since the domestic market, after its rapid growth of recent years, will grow at a slower rate in the future, it is particularly important for the continued growth of the domestic renewables sector to achieve successes in these markets and to grasp export opportunities. As a result of a stable political framework in recent years, the domestic renewables sector has matured into an industry that can produce considerable positive macroeconomic stimuli in the future through active participation in world trade.

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