Economic Opportunities and Structural Effects of Sustainable Energy Supply

by Jürgen Blazejczak, Frauke G. Braun, Dietmar Edler and Wolf-Peter Schill

Renewable energy sources and increased energy efficiency are not only crucial for reducing greenhouse gas emissions and other negative impacts of conventional energy supply; they also hold enormous economic opportunity. Significant and dynamically growing sectors have emerged in the area of renewable energy over the last several years. In 2010, 26.6 billion euros were invested in Germany alone in renewable energy facilities. Altogether, renewable energy sources created 35.5 billion euros in demand for the German economy. Gross employment in the area of renewable energy is estimated at 367,400 persons for 2010.

Likewise, the net economic balance for the expansion of renewables is positive. Model calculations conducted by DIW Berlin show that the gross domestic product is by 2.9 percent higher in 2030 in the "Expansion Scenario" than following a "Null Scenario" with no expansion. Depending on the labor market conditions, the net employment effects appear to be weak to moderate, but in any case positive. These scenario calculations also illustrate that the impact of the expansion differs across sectors. Furthermore, the transition from the current energy supply regime to one where renewable energy sources contribute a large share and energy efficiency has been substantially increased will require a structural change in business and the working world that will have to be followed closely in the future.

The German energy supply is currently primarily based on fossil energy sources. In the medium to long term, however, the aim is to switch to mainly renewable energy sources in all usage sectors (electricity, heat and fuel) and to abandon nuclear energy. Renewables lower the consumption of finite energy resources and reduce greenhouse gas emissions. The use of renewable energy sources available domestically also decreases the dependence on imported nuclear and fossil energy sources. Lastly, expanding the use of renewable energy sources is also hoped to have a positive economic impact by increasing value added in promising sectors of the future which is also supported by tapping new export markets.

Several studies have shown that a fundamental transformation of energy supply in Germany is technically possible. Particularly in the electricity sector, our demand could be mostly met by low-emission renewable energy sources by the middle of this century.[1]

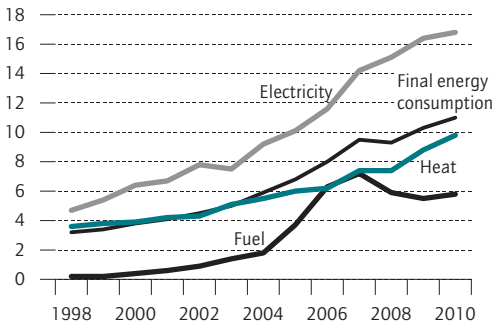
The contribution of renewables to total final energy consumption has been rising steadily since 1998 (Figure 1). It came to 11 percent in the year 2010. After shrinking in 2008 and 2009, it rose to a 5.8 percent share of fuel consumption. For heat, the proportion grew from 3.6 percent in 1998 to 9.8 percent in 2010. The share of renewable energy sources in gross electricity consumption even leaped during this period from 4.7 percent to 16.8 percent.

The importance of renewable energy is to increase further in Germany. The government's 2010 "Energy Concept" foresees that the share in gross electricity consumption will rise to 35 percent by 2020, 50 percent by

1 The German Advisory Council on the Environment (SRU): Wege zur 100 Prozent erneuerbaren Stromversorgung. Sondergutachten. January 2011. (Executive summary also available in English: SRU: Pathways towards a 100% renewable electricity system. Special report. January 2011.). Greenpeace International, European Renewable Energy Council: Energy [R]evolution. A sustainable world energy outlook. 3rd Edition World Energy Scenario. 2010; Öko-Institut, Prognos: Modell Deutschland Klimaschutz bis 2050: Vom Ziel her denken, Studie im Auftrag des WWF. Basel, Berlin 2009.

Figure 1

Share of renewable energy sources in final energy consumption in Germany between 1998 and 2010



Electricity generated from renewable energy sources compared to total gross electricity consumption. Heat generated from renewable energy sources compared to total energy consumption for heat. Fuel created from renewable energy sources compared to total fuel consumption (figures through 2002 refer to fuel consumption for road traffic; from 2003 on they refer to total consumption for all engine fuels except aircraft fuel).
Sources: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU): Erneuerbare Energien in Zahlen: Internet-Update ausgewählter Daten. Berlin, December 2010; and BMU: Erneuerbare Energien in 2010. Vorläufige Angaben, as of March 23, 2011. Berlin.

The share of renewable energy sources in total final energy consumption is steadily rising.

2030 and 80 percent by 2050.[2] Its contribution to the sectors heat and fuels should nearly double by 2020 and then continue to rise.

Improving the framework for the further expanding renewable energy sources

Several requirements need to be fulfilled to further adapt the energy system, especially in the electricity segment.[3] Funding through the Renewable Energy Sources Act (EEG), to be amended in 2011, will continue to be needed. Sufficient incentives for investment must be maintained so that the expansion of renewables does not slow to a halt. Deadweight effects should also be avoided wherever possible. Considering the growing share of fluctuating electricity generation, it is necessary to advance the support framework so that the feed-in better meets the needs.

The transmission and distribution systems need to be expanded to integrate renewables in a safer and more effective way.[4] Additional storage facilities will also be required and the necessary capacities will depend on integration measures such as load management. Furthermore, institutional and organizational provisions need to be taken that will also affect the design of the electricity market.[5]

The targeted, very high share of renewable energy will only be achieved if the energy efficiency (that is, the energy productivity) of the economy is significantly improved. Between 1995 and 2010, the (adjusted) primary energy consumption as measured relative to gross domestic product (GDP) fell annually by 1.3 percent on ave-

2 Federal Ministry of Economics and Technology (BMWi), Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU): Energiekonzept für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung. Berlin, September 28, 2010. (Also available in English: BMWi, BMU: Energy concept for an environmentally sound, reliable and affordable energy supply. Berlin, September 28, 2010.)

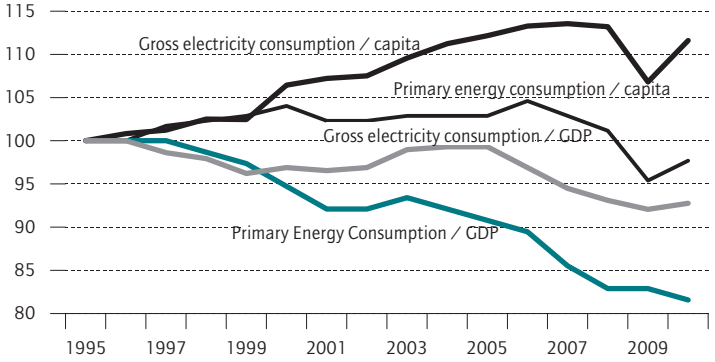
3 Traber, T., Kemfert, C.: Nachhaltige Energieversorgung: Beim Brückenschlag das Ziel nicht aus den Augen verlieren. Wochenbericht DIW Berlin No. 23/2010.

4 According to Dena's Grid Stuy II 3 600 kilometers will have to be added to Germany's transmission grid by the year 2020. German Energy Agency (Dena): Dena-Netzstudie II – Integration erneuerbarer Energien in die deutsche Stromversorgung im Zeitraum 2015-2020 mit Ausblick 2025. Berlin 2010. (For an executive summary of this study in English cf. Dena: Dena Grid Study II Integration of renewable energy sources into the German power supply system until 2020. Berlin 2010.)

5 Cf. the next article in this issue of the DIW Economic Bulletin for more information on this point.

Figure 2

Primary energy consumption and gross electricity consumption in Germany from 1995 to 2010
1995 = 100



Primary energy consumption adjusted for temperature and inventory effects. Gross domestic product (GDP) in real terms.
Source: AG Energiebilanzen: Ausgewählte Effizienzindikatoren zur Energiebilanz Deutschland. Berlin, March 2011.

Improving the efficiency of electricity consumption has been less successful than for primary energy consumption.

rage.[6] Gross electricity consumption in relation to GDP sank in the same period by only 0.5 percent, while electricity consumption per capita actually rose by 0.7 percent annually (Figure 2). If we are to switch electricity generation to mostly renewable energy sources by 2050, a substantial increase in energy efficiency will be needed in the future.

The expansion of renewable energy sources is already a driver of growth

The economic costs of the transformation of the energy supply, especially the use of funding for renewable energy and the costs of withdrawal from nuclear energy in the form of rising electricity prices has been subject of much debate as of late.[7] However, the picture is only complete if apart from costs also the economic opportunities are taken into consideration.

Using renewable energy sources helps to avoid a substantial part of the negative external effects of conventional energy supply.[8] Furthermore, expanding renewable energy offers significant opportunities for economic growth. This growth potential is especially large for the German economy, which already leads in renewable energy and efficiency technologies. In this regard, the associated need to restructure the economy represents a challenge to any forward-looking policy.

The increasing usage of renewable energy sources requires substantial investment. This has increased in Germany from 10.3 billion euros in 2005 to 26.6 billion euros in 2010 (Table 1).[9] Thus, the investment in renewable energy has grown by 158 percent in five years. Renewable energy facilities are therefore one of the fastest growing investment areas in the economy. Invest-

6 AG Energiebilanzen: Ausgewählte Effizienzindikatoren zur Energiebilanz Deutschland Daten für die Jahre von 1990 bis 2010. Berlin, March 2011.

7 Traber, T., Kemfert, C., Diekmann, J.: Strompreise: Künftig nur noch geringe Erhöhung durch erneuerbare Energie. Wochenbericht DIW Berlin No. 6/2011. (English version published as: Traber, T., Kemfert, C., Diekmann, J.: German Electricity Prices: Only Modest Increase Due to Renewable Energy expected. Weekly Report of DIW Berlin No. 6/2011.) Also see prior article in this issue.

8 Cf. Breitschopf, B., Diekmann, J.: Vermeidung externer Kosten durch Erneuerbare Energien – Methodischer Ansatz und Schätzung für 2009 (MEEEK). Study commissioned by BMU as part of its project "Einzel- und gesamtwirtschaftliche Analyse von Kosten- und Nutzenwirkungen des Ausbaus erneuerbarer Energien im deutschen Strom- und Wärmemarkt" – Arbeitspaket 3/2010.

9 The figures for the economic development of renewable energy are based on studies conducted by DIW Berlin in collaboration with other institutions. Cf. GWS, DIW, DLR, ISI, ZSW: Kurz- und langfristige Auswirkungen des Ausbaus erneuerbarer Energien auf den deutschen Arbeitsmarkt. Research project commissioned by the BMU, Osnabrück, Berlin, Karlsruhe, Stuttgart 2011, and O'Sullivan, M., Edler, D., van Mark, K., Nieder, T., Lehr, U.: Bruttobeschäftigung durch erneuerbare Energien in Deutschland im Jahre 2010 – eine erste Abschätzung. Research project commissioned by the BMU, March 2011. A summary report is made available in English: O'Sullivan, M., Edler, D., van Mark, K., Nieder, T., Lehr, U.: Gross employment from renewable energy in Germany in 2010 – a first estimate. Berlin, 18 March, 2011.

Table 1

Economic key indicators for the development of renewable energy sources (RES) in Germany

	2005	2006	2007	2008	2009	2010[4]	Difference 2010/2005 In percent	
							Total	Annual
	In billion euros (current prices)							
Investment in Germany	**10.3**	**11.1**	**11.6**	**16.8**	**20.2**	**26.6**	**158**	**21**
Sales of complete facilities[1]	7.9	10.6	11.8	15.5	16.8	19.7	149	20
Export of components[2]	0.7	0.7	3.4	4.1	4.6	5.6	67	52
Demand for operation and maintenance[3]	2.5	2.6	3.9	4.3	4.7	5.2	110	16
Demand for biomass and biofuels[3]	2.6	3.6	5.6	6.1	5.6	4.9	94	14
Total demand impulse from RES	**13.7**	**17.6**	**24.8**	**30.1**	**31.7**	**35.5**	**160**	**21**
	In 1,000 persons							
Employment	**194**	**236**	**277**	**322**	**340**	**367**	**89**	**14**

1 From manufacturers based in Germany, including the export of complete facilities.
2 Change in calculation basis in 2007, thus change shown for period 2007 to 2010.
3 Increase in demand in Germany.
4 Preliminary figures.
Sources: DIW Berlin; DLR; GSW; ZSW.

The economic significance of renewable energy sources has risen strongly.

ment in photovoltaic installations, in particular, has expanded strongly. Due to this boom, they made up nearly three quarters of total investment in renewable energy in Germany in 2010, while facilities using wind energy and biomass only accounted for around one-tenth each (Figure 3).

Companies in Germany have profited considerably over the last several years from the investment in Germany, mainly driven by the EEG, and from the rising demand for renewable energy facilities worldwide. These companies are now established as a strongly growing economic sector. Sales (including the export of components) have steeply increased from 8.6 billion euros in 2005 to 25.3 billion euros in 2010, which puts this in line with the growth seen for investment in renewable energy overall. Accounting for 48 percent of all sector sales in 2010, photovoltaic manufacturers were in the lead, followed by manufacturers of wind energy installations with 32 percent and those of biomass heat and power plants with 11 percent.

Thanks to Germany's lead position in the expansion of renewable energy, and the favorable sales conditions this provided, Germany has developed into a lead market for this field of technology. National support schemes, international climate protection policies and the rising price of fossil energy sources play an important role in foreign demand. Though demand has been volatile in some countries, the volume of global investment in renewable energy has nearly quadrupled within a few short years. Worldwide, 150 billion US dollars were invested in this segment in 2009. The amount estimated for 2005 was only 40 billion US dollars.[10]

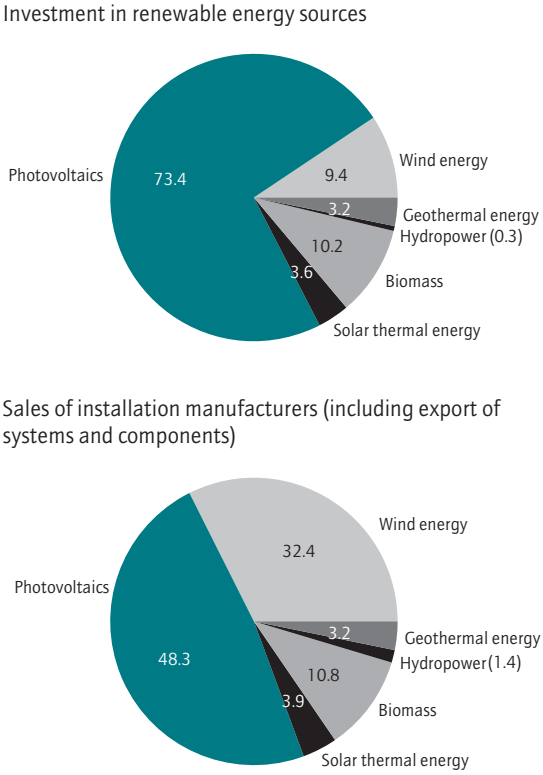
In Germany so far, it is the manufacturers of wind energy facilities and of specialized, high value-added system components that have succeeded in selling a noteworthy proportion of their production abroad. Companies specialized in equipment and in machinery and plant engineering that have managed to gain technological know-how in setting up production lines for facilities using renewable energy sources in Germany are increasingly achieving substantial sales on foreign markets.[11]

As the number of installations in Germany grows, operation and maintenance become more important, as well. While sales in this area were 2.5 billion euros in 2005, the volume of demand more than doubled by 2010 to 5.2 billion euros. The demand for biomass and biofuels has grown, too. The demand inducing production in Germany amounted to 2.6 billion euros in 2005 and rose to 4.9 billion euros in 2010. Altogether, the demand impulse associated with renewable energy sources accounts already for 35.5 billion euros for German industry.

The strong rise in total sales has also resulted in considerable employment in the area of renewable energy. In 2005 gross employment in the segment was 194,000 persons in Germany . It rose steadily over the following years. Thanks to the stable support conditions and robust foreign demand, the expansion also continued during the years of the global financial and economic crisis and had a stabilizing influence throughout this period.

Figure 3

Investment and manufacturer sales in the area of renewable energy sources in 2010
In percent



Source: O'Sullivan, M., Edler, D., van Mark, K., Nieder, T., Lehr, U.: Bruttobeschäftigung durch erneuerbare Energien in Deutschland im Jahre 2010 – eine erste Abschätzung. Research project commissioned by the German Federal Ministry of Environmental Protection, Natural Resources and Nuclear Safety (BMU), March 2011.

Photovoltaics dominated both sales and investment in 2010.

10 REN 21: Renewables 2010, Global Status Report. Paris 2010. In addition, 40 to 45 billion US dollars were invested in large hydropower projects. The countries with the greatest investment volumes were China and Germany.

11 For the photovoltaics area, cf. Grau, T., Huo, M., Neuhoff, K.: Survey of photovoltaic industry and policy in Germany and China. CPI Report. Berlin, March 2011, 15–17.

It is estimated that 367,400 persons were employed in this segment in 2010 (including research and development). This translates into a growth of 89 percent compared to 2005 and an average annual growth rate of nearly 14 percent. In 2010, the majority of employment was in the production of biomass (33 percent)[12] and solar energy (33 percent), followed by wind energy (26 percent) (Figure 4).

Economic effects in Germany also mostly positive in the future

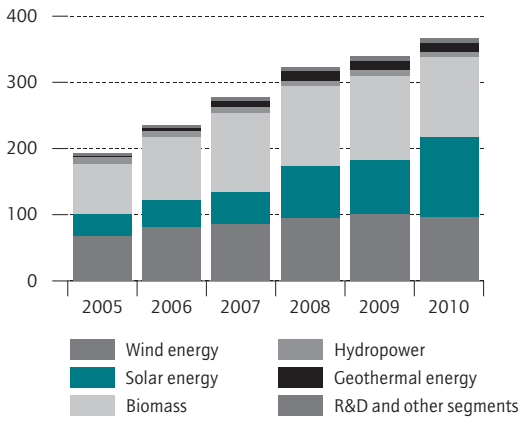
As part of a study, DIW Berlin recently calculated the net economic balance of expanding renewable energy sources in Germany through 2030.[13] A new model (the Sectoral Energy-Economic Econometric Model or SEEEM) was developed for this purpose and applied for the first time. It enables the calculation of dynamic impacts on the economy at an aggregate level as well as the effects on individual sectors.

12 The high employment in the biomass sector is due to the fact that the supply of biomass and biofuels is assigned to this category.

13 This study was conducted as part of the project "Gesamtwirtschaftliche und sektorale Auswirkungen des Ausbaus erneuerbarer Energien". Research project funded by the BMU. The project findings are summarized in Blazejczak, J., Braun, F. G., Edler, D., Schill, W.-P.: Ausbau erneuerbarer Energien erhöht Wirtschaftsleistung in Deutschland. Wochenbericht DIW Berlin No. 50/2010.

Figure 4

Gross employment from renewable energy sources in Germany from 2005 to 2010
In thousands



Sources: DIW Berlin; DLR; GSW; ZSW.

Gross employment in the area of renewable energy is estimated at 367,400 persons for 2010.

To determine the net economic balance, we compared an expansion scenario to a hypothetical null scenario, whereby renewable energy sources were not expanded after the year 2000. The expansion scenario is based on the BMU's reference scenario from 2009.[14] The expansion scenario contains positive stimuli such as additional investment, operating costs, displaced imported fossil energy carriers, and the export facilities and components. On the other hand, it also covers negative stimuli, such as displaced investment in the conventional energy business and additional costs (differential costs) (Figure 5).

The model calculations show that expanding renewable energy sources in Germany, together with the export of installations and components, will create higher economic growth. In the year 2030, GDP is by 2.9 percent higher in the expansion scenario than the respective GDP figure in the null scenario (Table 2). On the expenditure side, the greater GDP encompasses higher private capital investment (+6.7 percent in 2030) and higher real private consumption (+3.5 percent). Net employment increases only marginally in the base scenario.

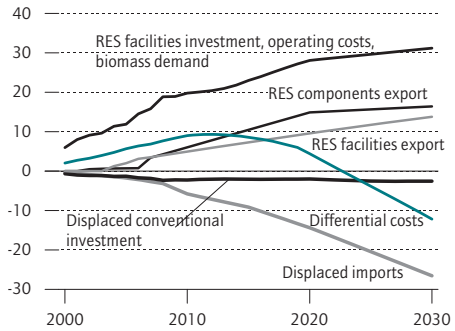
According to the model findings, the expansion would overall not have any economic disadvantages, but rather slight, positive effects. The results of a sensitivity analysis confirm this. One scenario version assumes that the increased costs of renewable energy (compared to conventional energy supply) will set off a spiral of rising wages and prices that will limit the ability of the German economy to compete internationally. The growth-enhancing effect of expanding renewable energy is less pronounced in this case, but still positive. Another version "ACTIV" assumes that additional labor forces will be activated from unemployment. In this case, the number of additional employed persons rises significantly through 2030. In the scenario calculations, the effects on employment depend substantially on assumptions regarding the concrete conditions on the job market, but they are all positive.

The study examined the sectoral effects through 2030. It shows that (even if the input-output matrix representing the interindustry linkages is kept unchanged) the changing structure of final demand will also alter employment in the sectors. The positive net employment effect found in this scenario version "ACTIV" is diffe-

14 BMU (ed.): Langfristszenarien und Strategien für den Ausbau erneuerbarer Energien in Deutschland: Leitszenario. Berlin 2009. The BMU has published an updated reference scenario that contains higher investment in photovoltaics and higher differential costs. It suggests that both the negative and positive growth stimuli would be stronger than assumed herein.

Figure 5

Economic stimuli in the expansion scenario for the period from 2000 to 2030
Price base 2000, in billion euros



RES = Renewable energy sources
Less import of conventional fuels
Investment, operating costs, and export from domestic production
Differential costs = Additional costs of energy supply from renewable energy

Source: Calculations of DIW Berlin based on BMU 2009, loc. cit.

Increasing economic stimuli from expansion of renewable energy sources.

Table 2

Effects from expanding renewable energy
Percentage of deviation between expansion scenario (base variation) and null scenario

	2010	2020	2030
Gross domestic product	1.7	2.6	2.9
Private consumption	1.0	2.3	3.5
Private investment in facilities	9.1	8.9	6.7
Exports	0.9	1.2	0.9
Imports	1.0	1.0	1.0
Productivity per worker	1.7	2.6	2.9
Employees	0.1	0.0	0.0

GDP and expenditure components in prices of 2000
investment in facilities ex housing construction.

Source: Calculations of DIW Berlin with SEEEM.

Higher growth and consumption from expanding renewable energy sources.

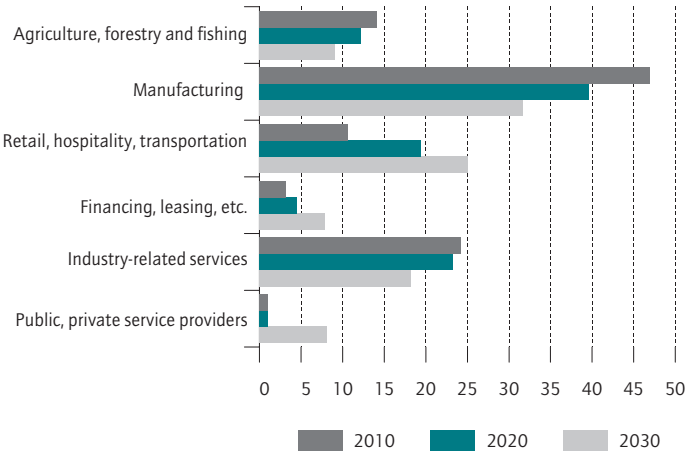
rently distributed from one sector to another.[15] Most are positive, but there are a few sectors where employment shrinks. Figure 6 shows the employment effects for the sectors aggregated into main groups. All of these main groups show positive net employment effects, though to different extents.

The structural change accompanying the expansion of renewables results in the greatest rise in employment in the manufacturing. Nearly 40 percent of the employment effect shows up here in 2020 and in 2030 it still accounts for 32 percent. This high proportion of the employment effect is due in part directly to the economic activities in the area of renewable energy (investment, operation and trade) and in part indirectly to interindustry linkages for intermediate goods and and aggregate second round effects. At 18 percent, industry-related services also account for a significant part of the net employment effect in 2030. Over the course of time, the share of employment effects in retail, hospitality and transportation grows: Starting at 19 percent in 2020, it rises to 25 percent in 2030. While the sectors that directly manufacture or operate renewable energy installations are

15 These calculations are based on the variant scenario "ACTIV" ("Aktivierung zusätzlicher Arbeitskräfte"). The scenario assumes that the unemployed can be successfully activated and that employment will increase instead of labor productivity. The net employment effects amount to 98,000 persons in 2010, 166,000 in 2020 and 270,000 in 2030 (cf. Blazejczak, J. et al., as shown above).

Figure 6

Breakdown of net employment effects by sector
In percent



Source: Calculations of DIW Berlin with SEEEM for scenario version reflecting the activation of additional workers.

The weight of net employment effects in the manufacturing industries decreases over time.

clearly winners of the structural change in employment, many other sectors also profit indirectly.

Sustainable energy supply implies structural change in business and the working world

Transforming the energy supply to one with a high contribution of renewable energy sources and better energy efficiency will be accompanied by a considerable structural change in business and the working world.[16] This change will affect more than the energy industries and energy-intensive sectors; the entire economy will feel its impact. Additional resources have to be mobilized through innovation, especially when the availability of labor diminishes. A forward-looking analysis of this structural change can help avoid some of the frictions. In addition, social hardships and inequalities can be lessened, making the transformation economically and socially sustainable.

A considerable strain on the labor market is expected in the future. This is also shown in the scenario calculations of DIW Berlin regarding long-term economic trends. Even if the population develops relatively favorably,[17] significantly increasing employment rates or working times will be necessary if real GDP is to grow 1.5 percent annually on average. If per capita productivity were to grow at the same rate as the GDP and the number of employed were to remain unchanged, the employment ratio (referring to the population aged 15 to 65) would have to increase from 75.2 percent in 2010 to 81.5 percent in 2025.[18] If we assume a longer employment phase in the future and use the population aged 15 to 67 as our reference, the employment rate will still have to rise to 77.7 percent in 2025. These relationships have to be kept in mind when evaluating the structural change related to the shift in energy supply.

Even if the net employment impacts of expanding renewable energy sources are moderate, the extent of structural change in employment will be considerable. The significant gross employment impacts shown above are an indication of this. If the net employment impacts are small, then roughly in the same dimension of the gross employment impacts new jobs will be created as are eliminated. For indirect gross employment this implies only moderate changes of occupations and structural change.

The transformation of energy supply will weigh especially on real estate activities, utilities, manufactures of transport equipment, transportation and a few energy-intensive sectors such as iron and steel manufacture and the chemicals industry. Sectors that might benefit by opening up new areas of business at home and abroad are construction, building technologies, electrical engineering, manufactures of machinery and equipment, agriculture and forestry, and some service sectors such as research and development and financial services. Some divisions in utilities, transport equipment and chemicals will feel a strain, others, however, will find new sales opportunities. Due to cross-sector interdependencies – especially from deliveries of intermediates and cost pass-through – as well as macroeconomic feedbacks, the structural effects are broadly distributed across all sectors of the economy.

The required qualifications will also change. This can already be anticipated because the sector composition of employment is changing and the required qualifications vary from one sector to another. Furthermore, the necessary qualifications within the sectors principally affected will change. Due alone to the high degree of innovation found in new energy technologies, it can be supposed that the required qualifications will increase. Looking at the occupations of workers employed in the use of renewable energy in 2007, the breakdown was 41 percent specialized labor, 27 percent commercial, 19 percent academics and 8 percent technicians and master technicians.[19] Jobs for workers with little qualification will also arise in some sectors, but the proportion of low-skilled workers in the aforementioned study was only 5 percent. The need for low-skilled labor in the area of heat insulation could increase. In general, there will likely continue to be a surplus of labor without professional training or education in the future.[20]

In addition to changes in the qualification required, it will frequently be necessary to supplement classic vocational training with sector-specific training. The impor-

16 de Serres, A., Murtin, F., Nicoletti, G.: A Framework for Assessing Green Growth Policies. OECD Economics Department Working Papers No.774. Paris 2010.

17 These scenario calculations assume the upper limit of the middle variant of the 12th coordinated population projection of the German Federal Statistical Office (Statistisches Bundesamt). Statistisches Bundesamt: Bevölkerung Deutschlands bis 2060. Ergebnisse der 12. Koordinierten Bevölkerungsvorausberechnung. Wiesbaden 2009. (English version: Federal Statistical Office: Germany's population by 2060. Results of the 12th coordinated population projection. Wiesbaden 2009).

18 Between 1991 and 2000 and between 2000 and 2010, per capita productivity rose more slowly than the real GDP. Cf. Statistisches Bundesamt: Volkswirtschaftliche Gesamtrechnungen. Inlandsproduktberechnung. Lange Reihen ab 1970. 2010. Fachserie 18, Series 1.5. Wiesbaden 2011.

19 Bühler, T., Klemisch, H., Ostenrath, K.: Ausbildung und Arbeit für Erneuerbare Energien. Statusbericht 2007. Bonn 2007. For more up-to-date figures, cf. Wissenschaftsladen 2010: Arbeitsmarktmonitoring Erneuerbare Energien 2010.

20 Helmrich, R., Zika, G. (ed.): Beruf und Qualifikation in der Zukunft – BIBB-IAB-Modellrechnungen zu den Entwicklungen in den Berufsfeldern und Qualifikationen bis 2025. Bonn 2010.

tance of cross-sector qualifications will rise at the same rate as innovative, quickly growing areas of business.

Little research has been conducted on the effects on the quality of jobs. The extent to which this reflects the structural change of sectors has yet to be examined because the incidence of atypical forms of employment, job security and remuneration can vary strongly by sector.

A sustainable energy supply with a high proportion of renewable energy sources and a significant increase in energy efficiency will also create structural change within sectors that – as measured by changes of job – might be more significant than the structural change between sectors, but is difficult to assess. From the social point of view, intrasector structural change is viewed as less serious because it generally requires less time and less need for retraining to change jobs within a sector.

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