Energy Transition Calls for High Investment

by Jürgen Blazejczak, Jochen Diekmann, Dietmar Edler, Claudia Kemfert, Karsten Neuhoff, and Wolf-Peter Schill

Achieving the objectives of the German governments 2010 Energy Concept and the accelerated phase-out of nuclear energy will require significant investment in restructuring energy supply. In particular, this includes investment in installations for the use of renewable energy sources in the power and heating sector, as well as in the infrastructure, such as power grids. In addition, substantial investment is needed to improve energy efficiency, for example, by insulating buildings.

Model calculations by DIW Berlin show that the transformation of the energy sector is likely to have a sustained positive effect on added value in Germany. Furthermore, this investment will lead to substantial savings of primary fossil energy sources. This is also accompanied by a reduction in energy-related greenhouse gas emissions. The existing framework for investment in renewable power generation and electricity grids is largely appropriate and should, in principle, be maintained in the near future. Accelerating the rate of the energy-efficient building refurbishment, however, will require additional incentives.

The German government's 2010 Energy Concept outlines the country's long-term strategy for future energy supply.[1] The Concept proposes to increase the share of renewables in gross final energy consumption from 11 percent in 2010 to at least 18 percent by 2020. This target is in line with the EU Directive 2009/28/EC and Germany's obligations on the promotion of the use of energy from renewable sources in Europe.[2] The Directive requires the proportion of energy consumption produced by renewable sources to reach 60 percent by 2050.[3] The Energy Concept envisages a share of renewables in gross electricity consumption of at least 35 percent by 2020 and the target for 2050 is 80 percent. In 2012, the corresponding figure was almost 23 percent. At the same time, energy consumption should be significantly reduced in the long term. By 2050, primary energy consumption should be 50 percent lower than 2008 levels. In the buildings sector, the aim is to reduce primary energy needs by 20 percent by 2020 and 80 percent by 2050.

In order to meet these targets, significant investment is needed in various areas. In particular, this includes investment in installations for the use of renewables in the power and heating sector, and in other parts of the energy infrastructure. In addition, substantial investment is necessary for energy-efficient building refurbishment. The present article discusses future investment needs and the potential macroeconomic effects of this investment, as well as the framework required.

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1 German Federal Ministry of Economics and Technology (Bundesministerium für Wirtschaft und Technologie), Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit), Energiekonzept für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung (September 28, 2010). The Energy Concept was supplemented with resolutions from the Energy Package of June 6, 2011. A particularly important element of this was a complete nuclear phase-out by 2022.

2 J. Diekmann, "Renewable Energy in Europe: Strong Political Will Required for Ambitious Goals". DIW Berlin Weekly Report 5 (2009), 36, 242-250.

3 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Erneuerbare Energien in Zahlen. Internet-Update ausgewählter Daten (December 2012).

Energy Transition Investment Needs Until 2020

Against the backdrop of previous investment activity, the following outlines investment needs until 2020, in order to implement the Energy Concept. The article distinguishes between different sectors: installations for the use of renewables in electricity and heat generation, power grids, energy storage systems and other installations for the system integration of renewable energy, and also energy-efficient building refurbishment.

Electricity and Heat Generation from Renewables

Table 1 shows the development of investment in installations for using renewables in electricity and heat generation until 2012. Starting at a low level in 2000, investment increased dramatically to 27 billion euros in 2010.[4] Since then, installation volume has remained virtually constant but a slight decrease in investment has been observed as a result of falling prices, particularly of solar power (photovoltaics).[5]

According to data from the Federal Environment Ministry's (BMU) "2011 Lead Study,"[6] from 2013 to 2020, annual investment of between 17 and almost 19 billion eu-

4 Here and throughout the text, only real investment figures are given based on 2012 prices. This means that it is not necessary to forecast general future price developments.

5 J. Diekmann, C. Kemfert, and K. Neuhoff, "The Proposed Adjustment of Germany's Renewable Energy Law: A Critical Assessment". DIW Economic Bulletin 2 (2012), 6, 3-9. T. Grau, "Targeted Support for New Photovoltaic Installations Requires Flexible and Regular Adjustments" DIW Economic Bulletin, 6 / 2012, 11-15.

6 German Aeronautics and Space Research Center(Deutsches Zentrum für Luft- und Raumfahrt, DLR), Fraunhofer Institute for Wind Energy and Energy System Technology (Fraunhofer Institut für Windenergie und Energiesystemtechnik, IWES), Ingenieurbüro für neue Energien (IfnE), Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global. Final Report (March 29, 2012). The study which is often referred to as the "2011 Lead Study"maps a development path that is consistent with the German government's resolutions on the implementation of the energy transition. Here, the scenario being referred to is "2011A".

Table 1

Investment in Renewables and Their Share of Macroeconomic Investment

Year	Investment in renewable energy	Share of equipment investment	Share of capital investment
	In billion euros	In percent	In percent
2012	19.5	11.1	4.2
2011	23.5	12.8	5.0
2010	27.0	15.8	6.2
2009	22.7	14.6	5.5
2008	17.2	8.6	3.7
2007	14.4	7.4	3.2
2006	13.6	7.6	3.2
2005	11.6	7.2	3.0
2004	9.5	6.2	2.5

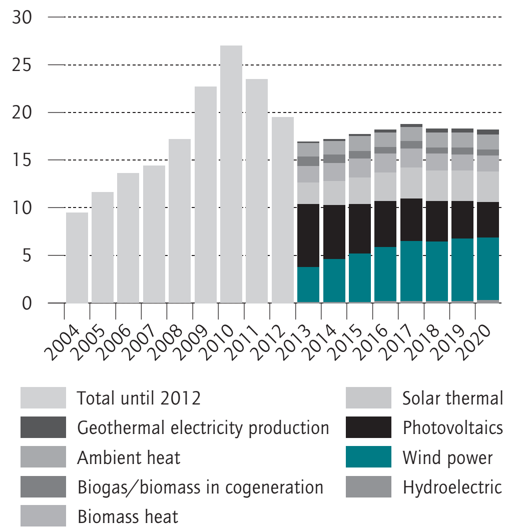
Based on 2012 prices.
Sources: Federal Statistical Office, Working Group on Renewable Energy Statistics (AGEE-Stat); calculations by DIW Berlin.

Up until 2010, investment in renewable energy steadily increased but has slightly declined since then.

Figure 1

Annual Investment in Power and Heat Generation from Renewables Until 2020

In billion euros



Based on 2012 prices. Excluding investment in local heat networks and energy imports.
Sources: German Federal Statistical Office, Working Group on Renewable Energy Statistics (AGEE-Stat), German Aeronautics and Space Research Center (DLR), Fraunhofer Institute for Wind Energy and Energy System Technology (IWES), Ingenieurbüro für neue Energien (IfnE), Langfristszenarien und Strategien (2012); calculations by DIW Berlin.

Investment plateaus at a high level.

Table 2

Investment in Power Grids, 2007 to 2012
In billion euros

	Transmission grids			Distribution grids			Overall total
	New construction / upgrade / expansion	Maintenance/ renewal	Total transmission grids	New construction / upgrade / expansion	Maintenance/ renewal	Total distribution grids	
2007	0.4	0.1	0.5	1.2	1.0	2.2	2.8
2008	0.6	0.2	0.8	1.3	1.2	2.5	3.3
2009	0.4	0.1	0.5	1.3	1.3	2.6	3.2
2010	0.5	0.1	0.6	1.6	1.7	3.3	3.9
2011	0.5	0.1	0.6	1.6	1.4	3.1	3.7
2012	0.6	0.2	0.7	1.6	1.4	3.0	3.8

Based on 2012 prices. 2012 values are planned figures.
Source: German Federal Network Agency (Bundesnetzagentur) and German Competition Authority (Bundeskartellamt); calculations by DIW Berlin.

Recent annual investment in power grids has amounted to almost four billion euros.

ros will be necessary (based on 2012 prices).[7] The data shows an increase in the significance of investment in wind energy as well as heat generation from renewables by 2020 (see Figure 1). According to the study, the expansion of renewables requires that the high level of investment of recent years largely be sustained up until 2020. However, investment in photovoltaics is likely to fall since the cost per installation has plummeted and the total output of subsidized photovoltaic plants has been capped. At the same time, however, it can be assumed that investment in other technologies will increase. To a certain extent, the aforementioned investment substitutes replacement and new investment in conventional power and heat generation.[8]

Power Grids

The German electricity networks can be distinguished according to their voltage levels. The distribution grids comprise low, medium, and high voltage levels (0.4, 10–30, and 110 kilovolt), and the transmission networks have the highest voltage levels (220 to 380 kilovolt). Table 2 shows annual investment in power grids since 2007. Total investment over the last few years was between just under three and almost four billion euros and has recently followed an upward trend.

Table 3

Additional Annual Investment in Power Grids Until 2020
In billion euros

Transmission grids		Distribution grids			Total
Onshore	Offshore	Low voltage	Medium voltage	High voltage	
2.1	2.2	0.3	0.5	1.0	6.1

Based on 2012 prices. Distribution grid investment needs according to the dena Distribution Grid Study, NEP B 2012 Scenario. Transmission network investment needs according to current Network Development Plan drafted by network operators, Scenario B 2023, including starter network. Investment for whole period evenly distributed across individual years.
Sources: German Energy Agency (dena), Ausbau und Investitionsbedarf (2012), 50Hertz et al., Netzentwicklungsplan Strom (2013) (2013a and b); calculations by DIW Berlin.

Additional expansion needs amount to a total annual investment sum of six billion euros.

The power generation capacity of renewable energy is geographically dispersed and the power supply from wind energy and photovoltaics is subject to significant fluctuations. Therefore, alongside adjustments to power supply operation, the expansion of renewables increasingly also needs to include expanding and upgrading transmission and distribution grids. The lion's share of power from renewable sources is fed into the distribution grids while the transmission grids facilitate long-distance electricity transmission.

7 In 2012, actual investment was higher than the figures used in the 2011 Lead Study, particularly for photovoltaics.

8 The specific investment costs for renewable energy technologies are, however, generally considerably higher than those of conventional power plants; at the same time, renewables usually only clock up a minimal number of full load hours. Thus, power and heat generation using renewable sources requires significantly more investment than conventional supply.

According to calculations by the German Energy Agency (Deutsche Energie-Agentur, dena), between 2010 and 2020, the distribution grids will require a total investment of 18.4 billion euros.[9] If this investment is more or less equally distributed over the individual years, it becomes apparent that an additional almost two billion euros a year will be needed to fund network expansion (see Table 3).

A multistage process was recently implemented by the transmission network operators to calculate the expansion requirements of the transmission grids and this information was then formalized by the legislature in the form of a Federal Requirements Plan (Bundesbedarfsplan).[10] Including network expansion projects that are already underway (five billion euros), onshore investment needs are expected to be 21 billion euros through 2023.[11] An equivalent offshore network development plan is being created for the grid connection of offshore wind farms. Including investment for starter grid lines that are already in the planning or construction stages (12 billion euros), additional annual investment needs of 22 billion euros up until 2023 are anticipated.[12] This corresponds to an average annual investment of 2.1 billion euros onshore and 2.2 billion euros offshore.

The expansion needs calculated by the transmission network operators should largely be viewed as additional investment requirements generated by the energy transition. However, it is not yet apparent whether all planned projects will actually be implemented within the envisaged timeframe. Delays will result in investment being postponed.[13] In this respect, the figures for expected investment are likely to be liberal estimates.

System Integration of Renewable Energy

Due to the variable power generation of wind energy and photovoltaics in Germany, and the fact that the shares of these technologies in total energy production are increasing, additional measures will be required for the system integration of these energy sources. These include the flexibilization of thermal power plants, energy storage systems, demand-side measures, and active feed-in management for power generators using renewable energy sources. Measures such as this usually have investment implications which can vary dramatically depending on technology and field of application. However, in recent years, there has been no significant investment in the construction of power storage systems or other installations for the system integration of renewables in Germany.

According to forecasts for up to 2020, estimated investment needs for the aforementioned measures are generally much lower than requirements for electricity generation and grids.[14] With regard to power storage, a series of large pump storage projects are currently in the planning stages with investment of over five billion euros. The developers of all these projects have substantiated their investment with the need to integrate renewables (see Table 4). In the light of current price developments on the electricity exchange and long approval processes, from today’s perspective it appears unlikely that these projects will actually be completed by 2020.

For the period after 2020, energy storage systems—not only electricity, but also heat and gas storage—will be needed. In addition, other measures for the system integration of renewables will be necessary with the aim of improving the flexibility of thermal power plants or for the system integration of future electric vehicle fleets, the scale of which cannot yet be accurately quantified. Therefore, even prior to 2020, relevant research, development, and demonstration projects are needed. These are also likely to have certain investment implications. Overall, annual investment of approximately one billion euros should be anticipated for this purpose.

Energy-Efficient Building Refurbishment

Based on definitions used in the system of national accounts, in 2011, gross investment in the residential cons-

9 German Energy Agency (Deutsche Energie-Agentur, dena), dena-Verteilnetzstudie: Ausbau und Innovationsbedarf der Stromverteilnetze in Deutschland bis 2030 (Berlin: December 11, 2012). Information is based on framework data from the middle scenario B in the 2012 Network Development Plan compiled by the transmission grid operators. An additional scenario implies significantly higher investment needs of almost 27 billion euros.

10 For details on this process, see C. Gerbaulet, F. Kunz, C. von Hirschhausen, and A. Zerrahn, “German Electricity Tranismission Grid Remains Robust,” DIW Economic Bulletin, no. 20/21 (2013): 3–12.

11 50Hertz, Amprion, TenneT, TransnetBW, Netzentwicklungsplan Strom 2013. Erster Entwurf der Übertragungsnetzbetreiber (March 2, 2013), Figures from B 2023 Scenario (2013a).

12 50Hertz, Amprion, TenneT, TransnetBW, Offshore-Netzentwicklungsplan 2013. Erster Entwurf der Übertragungsnetzbetreiber (March 2, 2013) (2013b).

13 A recently published study by DIW Berlin discusses the methodology used by the government for requirement planning and comes to the conclusion that actual expansion needs until 2020 have been overestimated. Delays in grid expansion would not in fact jeopardize the energy transition. Gerbaulet et al. “German Electricity Transmission Grid” (2013).

14 Association for Electrical, Electronic and Information Technologies (Verband der Elektrotechnik, Elektronik, Informationstechnik, VDE), ETG-Task Force Energiespeicherung, Energiespeicher für die Energiewende. Speicherungsbedarf und Auswirkungen auf das Übertragungsnetz für Szenarien bis 2050 (Frankfurt: 2012). Also Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Erneuerbare Energien in Zahlen, (2012)

Table 4

Pump Storage Projects in Germany

Company	Project	Output in GW	Planned commissioning	Investment in billion euros
Schluchseewerke AG	Atdorf	1.4	2018	1.4
Donaukraftwerk Jochenstein AG	Jochenstein / Energiespeicher Riedl	0.3	2018	0.4
Trianel Power	Simmerath / Rursee	0.6	2019	0.7
Trianel Power	Nethe/Höxter	0.4	2019	0.5
Stadtwerke Trier	Schweich	0.3	2019/2020	0.5
Stadtwerke Mainz	Heimbach	0.4–0.6	2019	0.5–0.7
Trianel Power	Gotha/Talsperre Schmalwasser administrative district	1.0	2019	1.1
Energieallianz Bayern	Jochberg/Walchensee	0.7	No data available	0.6
EnBW AG	Forbach (expansion)	0.2	No data available	No data available
Stadtwerke Ulm	Blautal	0.1	No data available	No data available
Total		5.4–5.6		5.6–5.8

Source: List of power plants from the German Association of Energy and Water Industries (BDEW); research by DIW Berlin.

Currently, investment of between five and six billion euros is planned for pump storage projects.

truction sector was at least 145 billion euros, and in 2012 the corresponding figure was 150 billion euros. Both of these figures represent almost a third of the total gross fixed capital investments in Germany. This demonstrates the high quantitative importance of residential construction investment for the Germany economy.[15]

The construction volume calculation by DIW Berlin includes detailed information on the structure of residential construction activity.[16] According to the calculation, in 2011, residential construction investment and non-investment construction activity amounted to 166 billion euros. Of the total volume, construction work on existing buildings accounted for 125 billion euros and new builds almost 41 billion euros.

From an environmental and climate policy perspective, investment aimed at improving energy efficiency is of particular importance.[17] According to estimates from DIW Berlin's construction volume calculation, based on investment enquiries made by building owners and property developers, in 2011, at least 38 billion euros were spent on energy-efficient refurbishment. However, this figure also includes investment in photovoltaic plants and the non-investment share of these construction measures.[18] If an appropriate sum is deducted, for 2011, the estimated relevant expenditure for energy-efficient refurbishment is then approximately 25 billion euros.[19] However, this data not only refers to energy-related incremental costs but also to other additive refurbishment costs. The share of total investment (full costs) attributed to energy-related incremental costs is likely to be between 30 and 40 percent for the majority of construction projects.[20] Accordingly, energy-related

15 Further, in 2012 an additional 110 billion euros were invested in non-residential construction projects. Apart from investment in non-residential buildings, this figure also includes investment in the transport infrastructure. For more on this, see U. Kunert and H. Link, "Verkehrsinfrastruktur: Substanzerhaltung erfordert deutlich höhere Investitionen,"Wochenbericht des DIW Berlin, no. 26 (2013): 32-38.

16 M. Gornig, B. Görzig, H. Hagedorn, and H. Steinke, "Strukturdaten zur Produktion und Beschäftigung im Baugewerbe – Berechnungen für das Jahr 2011," analysis commissioned by the German Federal Ministry of Transport, Building and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung) and the German Federal Institute for Research on Building, Urban Affairs and Spatial Development (Bundesinstitut –für Bau-, Stadt- und Raumforschung), BMVBS-Online-Publikation, no. 21 (Berlin: 2012). The construction volume calculation also includes non-investment measures, divided into new and existing buildings.

17 The following sections do not factor in the new build sector; it is to be assumed that a certain level of additional investment to improve energy efficiency is also required for new builds to ensure that the Energy Concept targets are met.

18 On this, see Heinze GmbH, "Struktur der Investitionstätigkeit in den Wohnungs- und Nichtwohnungsbeständen," report by Heinze GmbH commissioned by the German Federal Institute for Building, Urban Affairs and Spatial Development (Celle: 2011), eds. S. Hotze, C. Kaiser, and C. Tiller.

19 Prognos AG estimates the 2010 market volume to be considerably lower. Based on funded measures covering full budgetary costs, the volume of energy-efficient refurbishment is estimated at 12.5 billion euros. See Prognos AG, "Ermittlung der Wachstumswirkungen der KfW-Programme zum Energieeffizienten Bauen und Sanieren,"report commissioned by the KfW banking group, (Berlin/Basel: 2013), eds. M. Bömer, N. Thamling, M. Hoch, and G. Steudle.

20 IW Köln, "Energetische Modernisierung des Gebäudebestandes: Herausforderungen für private Eigentümer," analysis commissioned by Haus & Grund Deutschland, (Cologne: 2012).

additional costs for construction work conducted in 2011 would amount to between seven and ten billion euros.

A further indicator for assessing the scale of energy-efficient refurbishment is the investment contributed by the German Investment and Development Bank (Kreditanstalt für Wiederaufbau, KfW) under the auspices of its funding programs. In 2010, in the field of residential refurbishment, KfW either funded or approved funding for investment in energy-efficient refurbishment to the sum of seven billion euros. In 2011, the volume of funded investment fell[21] to 3.9 billion euros.[22] There is, however, no reliable data available concerning funded investment as a share of total investment for energy-efficient refurbishment.

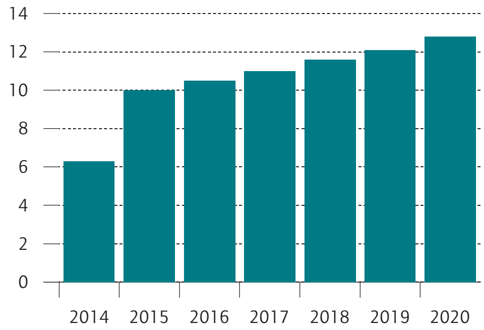
The future investment need for energy-efficient refurbishment measures in the building sector is considerable. The actual amount invested up until 2020 will be heavily dependent on future measures and regulations for the implementation of climate policy targets. For existing buildings, the previous energy-efficient refurbishment rate will need to be doubled from approximately one percent to two percent per annum. Thus, every planned refurbishment project will have to include energy efficiency components and these should be more comprehensive and ambitious than has usually been the case to date.

According to approximate model calculations by DIW Berlin based on the estimated future area of residential buildings requiring refurbishment and the trend of the specific refurbishment costs, between approximately seven and 13 billion euros in additional annual investment will be needed for the energy-efficient refurbishment of residential buildings up until 2020 (see Figure 2).[23] This sum primarily covers the energy-related incremental costs of these construction projects.

Figure 2

Additional Investment in Energy-Efficient Building Refurbishment

In billion euros



Based on 2012 prices.
Source: calculations by DIW Berlin.

Significant additional investment is required in the field of energy-efficient building refurbishment.

However, it is to be assumed that—due to the existing backlog of energy-efficient refurbishment projects—by 2020, the implementation of these projects will be accelerated, which, to a limited extent, will also result in the early implementation of general refurbishment projects.

Total Annual Investment: 31 to 38 Billion Euros

In summary, the expansion of renewable electricity and heat generation will involve annual investment of approximately 17 to 19 billion euros up until 2020. For power grids, the corresponding figure is around six billion euros and for additional investment in energy-efficient building refurbishment, it is between six and 13 billion euros. Around another billion euros will be required for the system integration of renewable energy sources, such as electricity storage systems, measures for the flexibilization of thermal power plants or for the system integration of future electric vehicle fleets. Thus, overall, from 2014 to 2020, these sectors will require annual investment of approximately 31 to 38 billion euros, the lion's share of which can be considered as additional investment resulting from the energy transition (see Figure 3).[24]

21 This could be attributed to an anticipatory effect in 2010 and also discussions at the time regarding possible improvements in funding conditions (special tax breaks). Bearing this in mind, the 2011 decline might have simply been a one-off atypical development.

22 Institute for Housing and Environment (Institut Wohnen und Umwelt, IWU) and Bremer Energie Institut, "Monitoring der KfW-Programme „Energieeffizientes Sanieren" 2010 und „Ökologisch/Energieeffizient Bauen" 2006–2010," analysis commissioned by the KfW banking group, (Darmstadt and Bremen: 2011). The Institute of Energy and Climate Research – Systems Analysis and Technology Evaluation (Institut für Energie- und Klimaforschung Systemforschung und Technologische Entwicklung (IEK-STE)) at the Forschungszentrum Jülich, "Wirkungen der Förderprogramme „Energieeffizient Bauen", „Energieeffizientes Sanieren" und „Energieeffiziente Infrastruktur" der KfW auf öffentliche Haushalte: Förderjahr 2011,"STE Research Report 07 (2012).

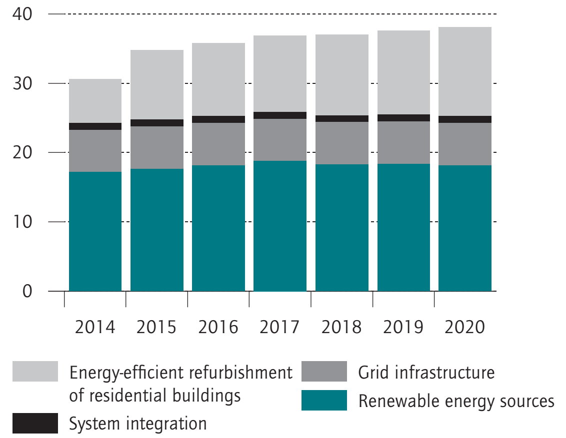
23 This is based on the assumption that the refurbishment rate will increase linearly from one to approximately two percent between 2013 and 2015 and, thereafter, will continue to grow slightly, partially to offset the accrued backlog of refurbishment work. There is also investment for improving energy efficiency in new builds and other non-residential buildings which is not considered here.

24 Particularly with regard to renewable power and heat generation, this additionality only applies on the assumption that previous funding measures will be largely discontinued.

Figure 3

Investment in the Implementation of the Energy Transition by Field of Activity

In billion euros



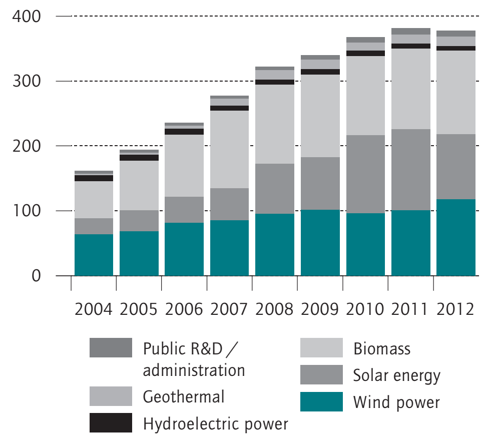
Based on 2012 prices. System integration includes energy storage and the flexibilization of power plants.
Source: calculations by DIW Berlin.

The total investment needs for restructuring energy supply will be between 31 and 38 billion euros a year until 2020.

Figure 4

Gross Employment due to Renewable Energy in Germany

Number of employees in thousands



Sources: German Aeronautics and Space Research Center (DLR), Institute of Economic Structures Research (GWS), Center for Solar Energy and Hydrogen Technologies Research (ZSW), DIW Berlin.

Since 2004, gross employment in the renewable energy field has more than doubled.

Macroeconomic Effects of Investment in Renewables

The following will look at different examples of the macroeconomic effects of investment in renewables. As a result of the significant expansion of renewables, in Germany, in the last few years, employment in this sector has dramatically increased. Gross employment in the sector has grown from 160,000 jobs in 2004 to almost 380,000 in 2012, i.e., almost doubled during this period (see Figure 4).

This section considers the possible net effects on the national economy of investment stimuli resulting from the expansion of renewables in electricity and heat generation. DIW Berlin has already analyzed the impact of the expansion of renewable energy based on a model developed specifically for this purpose, SEEEM (Sectoral Energy-Economic Econometric Model).[25] SEEEM is a macroeconometric multi-country model consisting of detailed representations of individual industries. It can be used to simulate the dynamic effects of economic stimuli (or shocks) both at the macroeconomic level and also with regard to their impact in the individual industries. The following presents updated findings based on more recent data.

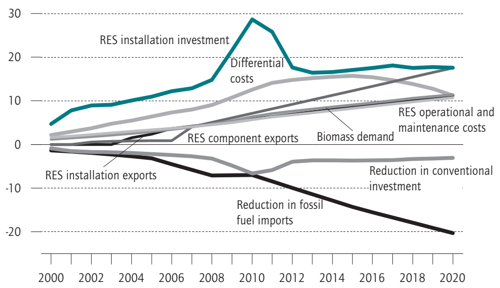
The economic effects are determined by comparing a policy scenario that draws on both current and planned investment, and a hypothetical “zero scenario” that assumes no investment in renewables from the year 2000. Based on this method, a share of the resulting positive effects is attributed to the expansion of renewables in Germany to date. The aforementioned 2011 Lead Study, which describes a possible path towards achieving the targets in the government’s Energy Concept, acts as the policy scenario.[26] As well as investment, further economic stimuli that form the basis of the model are: operational costs, a reduction in fossil fuel imports, and also exports of components and installations. Other

25 J. Blazejczak, F. Braun, D. Edler, and W.-P. Schill, “Economic Effects of Renewable Energy Expansion: A Model-Based Analysis for Germany,”DIW Discussion Paper 1156 (2011); Also J. Blazejczak, F. Braun, D. Edler, and W.-P. Schill, “Economic Opportunities and Structural Effects of Sustainable Energy Supply,” DIW Economic Bulletin, no. 20 (2011): 8–15; and J. Blazejczak, F. Braun, D. Edler, and W.-P. Schill, “Ausbau erneuerbarer Energien erhöht Wirtschaftsleistung in Deutschland,” Wochenbericht des DIW Berlin, no. 50 (2010): 10–16.

26 German Aeronautics and Space Research Center(DLR), Fraunhofer Institute for Wind Energy and Energy System Technology (IWES), Ingenieurbüro für neue Energien (IfnE), Langfristszenarien und Strategien (2012).

Figure 5

Economic Stimuli in Expansion Scenario 2000 to 2020
In billion euros



Based on 2012 prices. RES: renewable energy sources.
Sources: German Aeronautics and Space Research Center (DLR), Institute for Wind Energy and Energy System Technology (IWES), IfnE, Langfristszenarien und Strategien (2012); calculations by DIW Berlin.

As well as investment, other stimuli are also factored into the model.

Table 5

Impact of Expansion of Renewable Energy
Deviations from zero scenario

	2010	2020
	In percent	
GDP	2.1	2.8
Private consumption	1.1	2.2
Private capital investment excluding investment in residential construction	13.5	10.0
Export	1.0	1.2
Import	1.6	0.9
Per capita productivity	2.0	2.8
	In thousands	
Employees	43.0	14.0

Source: calculations by DIW Berlin.

The expansion of renewables results in increased growth as compared to the zero scenario.

stimuli factored into the model are a reduction in investment in the conventional power industry and also the additional costs (differential costs) of expanding renewables (see Figure 5).

Investment in Renewables Generates Sustained Increase in GDP

The model calculations indicate that the additional investment in expanding renewable energy sources in Germany, combined with exports of installations and components result in a sustained increase in added value. In the policy scenario, in 2010, GDP is 2.1 percent higher than in the zero scenario, and in 2020, it is 2.8 percent higher (see Table 5).

The employment effects that accompany this development largely depend on the scale of productivity growth acceleration. In 2010, per capita labor productivity was two percent higher than in the scenario with no expansion of renewables, and in 2020, the corresponding figure was almost three percent. A similar increase in added value and productivity creates merely a slight change in employment; only initially is employment slightly higher (by around 43,000 jobs). The model demonstrates that, in the long term, employment and production develop at the same pace. If the model were based on alternative assumptions, larger net employment effects might be observed.[27] Depending on labor market conditions, there could also be higher growth in employment even if productivity were to accelerate more slowly, particularly if suitable additional labor could easily be mobilized.

Initially, private capital investment (excluding residential construction) is, in real terms, at least 13 percent higher than without the expansion of renewables and in 2020, the corresponding figure is still as high as ten percent. This also reflects the increased investment activity in other branches of the economy as a result of an overall increase in economic activity. This additional investment also contributes to productivity growth. Increased income also facilitates increased private consumption, which, in 2010, was 1.1 percent higher than in the zero scenario, and 2.2 percent higher in 2020.

The expansion of renewables in Germany improves the global market position of German renewable energy companies. In real terms, total exports are approximately one percent higher than in the zero scenario.[28] At the same time, however, imports are also increasing. The relatively significant increase in imports observed in 2010 can be explained by the fact that use of renewable energy is still relatively restricted, resulting in only a marginal reduction in imports of fossil fuels; si-

27 For sensitivity calculations, see Blazejczak et al. "Economic Effects"(2011).

28 This is slightly less than the stimulus for the export of renewable energy plants and components. The observed lessening of the export stimulus can be attributed to the fact that a change in the relative prices resulted in fewer exports of other goods.

Table 6

Loans Granted by KfW Renewable Energy Program (New Approvals)

Program	Number (in thousands)					Volume (in billion euros)				
	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
Standard	26.0	36.6	63.2	34.9	25.7	2.8	4.6	8.9	6.5	7.6
Supplementary	–	0.0	0.0	–	–	–	0.6	0.4	–	–
Premium	0.4	2.1	2.3	2.8	2.7	0.0	0.3	0.3	0.5	0.4
Offshore wind energy	–	–	–	0.0	–	–	–	–	0.5	–
Total	26.5	38.7	65.5	37.7	28.4	2.8	5.5	9.6	7.6	7.9

Sources: KfW, Funding Report by KfW Banking Group (2013). Reporting date: December 31, 2012; calculations by DIW Berlin.

The KfW loan programs represent an important source of financing for renewable energy.

multaneously, the consumer import demand has a relatively high elasticity. Due to dynamic adjustment effects, at the end of the period examined, the external contribution is about the same as in the zero scenario, despite significant stimuli for the export of renewables and import of fuels.

Sensitivity calculations indicate that, even using alternative assumptions, for example, with regard to the development of the German economy's competitive capacity on global markets, additional investment could still result in positive net macroeconomic effects.[29] One reason for this is that, to a great extent, investment in renewables means that Germany can avoid importing fossil fuels while, at the same time, increasing its domestic economic activity.

Similar effects to those generated by investment in renewables can also be expected with regard to other types of investment. Energy-efficient refurbishment is a prime example of this. Investment is offset by future energy savings and thus also reduced energy imports. However, it can be assumed that the weighting of the effects varies. While technology content and thus also export opportunities presumably have less of an impact, the high share of domestic added value and the high labor intensity in the finishing construction sector are likely to result in stronger positive effects.

Stable Framework Necessary

The following section discusses the existing framework conditions as well as those that will be required in future to enable the aforementioned investment to be implemented. In all three areas, the focus is basically on mobilizing long-term private investment by creating a suitable framework. In future, institutional investors, such as pension providers, which, across Europe, are currently looking for large-scale long-term investment opportunities,[30] could play a bigger role.

Maintain Investment Framework for Renewables

To ensure that the targets for the expansion of renewable energy in Europe are met, a general framework is set out in the EU Directive 2009/28/EG. According to the subsidiarity principle, the choice of specific promotion programs and mechanisms are left up to the individual member states. In Germany, use of renewable energy is supported using a series of different measures. Apart from funding for research and development, the most important mechanism in the electricity sector is the German Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, EEG) which provides for guaranteed feed-in and fixed tariffs. In the heating sector, the expansion of renewables is primarily fostered through government subsidies (for measures in existing buildings and market incentive programs) and via regulatory provisions (mandatory use of renewables in new buildings and the German Renewable Energies Heat Act (Erneuerbare-Energien-Wärmegesetz, EEWärmeG)). The use of renewables in the transport sector, however, is primarily supported by way of biofuel quotas. These and similar measures will continue to be essential in future to ensure that the expansion targets are met. In

29 Blazejczak et al. "Economic Effects" (2011).

30 House of Lords, European Union Committee, "No Country is an Energy Island: Securing Investment for the EU's Future," 14th Report of Session 2012–2013 (May 2, 2013).

Germany, investment in installations for the use of renewable energy sources is also promoted by KfW loan programs (see Table 6).

The feed-in tariff (EEG) is of particular importance for the expansion of renewables. It has proven to be an effective instrument in fostering electricity generation from renewable energy sources and its basic structure has been adopted by a large number of other countries. The role of the EEG is shifting more and more from an instrument to subsidize renewables to an instrument to secure revenue streams to facilitate investment in renewables. This is reflected in falling generation costs from renewables and correspondingly dramatic reductions in tariffs.

The importance of the EEG as a financial instrument is particularly apparent in the field of wind and solar energy—two technologies where the cost of power generation is dominated by capital costs. Without EEG support, plant operators would be particularly exposed to the risks of the liberalized electricity market. Thus, for example, the economic crisis led to a decline in energy demand, bringing falling electricity prices in its wake. This effect is exacerbated by the currently very low and also unstable price of CO2 emission certificates. The energy transition has also resulted in other uncertainties. New technologies with a modified cost structure result in new market prices that are difficult to forecast. In the transitional period, the accelerated deployment of renewables reduces gemeration scarcity and thus also wholesale prices.

Against the backdrop of these uncertainties, a key advantage of the EEG becomes apparent. For investors, the feed-in tariff that is guaranteed for 20 years alleviates the impact of future regulatory decisions regarding the expansion of renewables and the power grids, but also of market design or the EU Emissions Trading System. The long-term social contract between producers and consumers implied in the EEG minimizes market risks on both sides. This safeguards long-term private investment and significantly reduces costs for financing power plants. Ultimately, this also leads to a reduction in overall costs.[31]

To date, investment required for the energy transition has been made largely by private households by virtue of the framework created by the EEG. Approximately 40 percent of the total investment in renewables originated from private households and a further 11 percent from farmers.[32] The number of energy cooperatives has increased particularly rapidly. However, without major investors, it will not be possible to successfully implement the energy transition.[33] These investors also need a stable framework in order to be able to make investments with a moderate minimal share of "own capital" and a predominant share of "borrowed capital" (up to 80 percent). Without borrowed capital, even the major energy suppliers would not be in a position to finance extensive investment in renewable energy projects, and would only be able to justify the remaining investment if they could expect significantly higher returns.

The further expansion of renewables also requires a stable framework for investors which can be provided by retaining the feed-in tariff system. Prudent adjustments are, however, necessary here to ensure that a balance is maintained between an acceptable financial burden for energy consumers and sufficient prospects of a sustained high level of investment. This would create a basis for further development of the value chain and also stimuli for further innovations.

Sufficient Investment in Power Grids

German national power grids are owned by private companies. Of the four transmission networks, the TransnetBW network is however owned by the federal state of Baden-Württemberg and the TenneT network is owned by the Netherlands.

The German Federal Network Agency (Bundesnetzagentur) is the regulatory authority that oversees network operators within the framework of incentive regulation. In particular, the Agency limits maximum permissible revenues with the aim of preventing network operators from taking advantage of their natural monopoly at the expense of the customer. At the same time, network operators are given incentives to improve quality and reduce costs. Linking incentives with future revenues, however, also results in uncertainty for investors. Therefore, a regulatory regime needs to achieve a balance between cost reduction incentives and adequate investment incentives. The introduction of incentive regulation meant that the focus was initially on developing cost reduction potential in power supply operation. With investment in maintenance and expansion increasing,

31 L. Butler and K. Neuhoff, "Comparison of feed-in tariff, quota and auction mechanisms to support wind power development," Renewable Energy 33 (8), (2008): 1854–1867.

32 German Renewable Energies Agency (Agentur für Erneuerbare Energien, AEE), Energie in Bürgerhand (Berlin: October 20, 2011).

33 C. Kemfert and D. Schäfer, "Financing the Transformation of the Energy System in Times of Great Instability of Financial Markets ," DIW Economic Bulletin, no. 31 (2012): 3–14.

the reduction of regulatory uncertainty and thus also investment risks is becoming increasingly important.[34]

This is reflected in questions surrounding the longer term approach to investment projects. The Federal Network Agency (Bundesnetzagentur) evaluates investment projects and determines whether it is permissible for the costs to be passed on to the final energy consumer. Currently, a return on equity of 9.05 percent before corporate tax (10.48 percent before corporate and commercial tax) is guaranteed on new and or expansion investments.[35] However, in each case, the decision to expand the grid only applies to the current regulatory period (five years) and can also include the next regulatory period (investment budgets). Thus, despite the government decision to expand the grid, medium-term risks arise relating to the extent to which the costs of these various power lines will be accepted and at what rate of return.

This is one of the factors explaining why, as in the rest of Europe, network operators in Germany only borrow approximately two euros for every euro of own capital despite apparently secure investment opportunities in a government-guaranteed infrastructure.[36] On the one hand, this increases the financing costs and, on the other hand, means that growth in own capital is essential to finance grid expansion. However, public-sector owners are hesitant about providing more capital themselves, yet, at the same time, are reluctant to accept additional owners. This is why the Federal Network Agency has recently been calling for a reduction in regulatory risks for investors. In this context, for example, improved liability regulations have been introduced for connecting offshore wind farms to the grid.

Additional Incentives for Investment in Energy-Efficient Building Refurbishment

Since the introduction of the German Energy Saving Ordinance (Energieeinsparverordnung, EnEV) in 1979, the heating requirements of new buildings have been reduced by a factor of three. This development can be attributed to a combination of standards and funding programs. Many of the components contributing to improved energy efficiency in new builds have also been adopted in the energy-efficient refurbishment of existing buildings.

The energy-related investment needs of existing buildings are far greater than in new buildings. However, investors often lack the capital and long-term planning perspective for and also interest and confidence in energy-efficient refurbishment. Further obstacles include the "owner-user dilemma" in the refurbishing of rental properties and the unique nature of the complex investment decision that has to be made by the proprietors of owner-occupied detached or semi-detached properties.

However, to date, financial incentives, combined with existing complementary measures (such as information provision, certification, and training) have not been sufficient to ensure that the Energy Concept targets are met. Therefore, in 2011, the German government proposed an additional tax incentive, which, however, was ultimately not approved by the Bundesrat (upper house of German parliament) due to the issue of cost sharing between the national government and the Länder. A political agreement on rapidly effective measures for existing buildings is urgently required since, without a dramatic improvement in energy efficiency, the targets for the entire energy transition will be jeopardized.

Conclusion and Economic Policy Implications

As outlined above, significant investment is required to meet the targets set out in the German government's 2010 Energy Concept and to implement the accelerated nuclear phase-out. This applies to installations for the use of renewable energy sources in the electricity and heating sector as well as infrastructure such as power grids, and also, in future, energy storage systems and other measures for the system integration of renewable energy sources. Significant investment is also needed to improve energy efficiency, for instance using heat insulation for buildings. Without a considerable increase in energy efficiency, the energy transition targets simply will not be met. In the aforementioned areas, between 2014 and 2020, annual investment of between 31 and 38 billion euros will be required.

Model calculations by DIW Berlin use examples to illustrate that the expansion of renewables could have a lasting positive effect on macroeconomic development in Germany. This stems from additional domestic investment and the knock-on reduction in imports of primary fossil fuels, the additional demand for biomass fuels, and also the possible development of further export poten-

34 European Commission, Green Paper on the long-term financing of the European economy, (Brussels: March 25, 2013), COM (2013) 150 final.

35 German Federal Network Agency (Bundesnetzagentur) press release, November 2, 2011. In practice, however, this figure is not often reached. U. Büdenbender, Die Angemessenheit der Eigenkapitalrendite im Rahmen der Anreizregulierung von Netzentgelten in der Energiewirtschaft (Düsseldorf: 2011).

36 For a detailed discussion, see K. Neuhoff, R. Boyd, and J. M. Glachant, European Electricity Infrastructure: Planning, Regulation, and Financing, workshop report (2012).

tial in the renewable energy sector. At the same time, it will also lead to a considerable reduction in energy-related greenhouse gas emissions.

The existing framework for investment in renewable electricity and heat generation is largely appropriate. In the electricity sector, the Renewable Energy Sources Act (EEG) is particularly central, and it is suggested that the law will, in essence, be retained in the foreseeable future. The fixed prices stipulated by the law provide security for private investors and thus also ensure low financing costs. Due to declining tariff levels, the additional financial burden borne by energy consumers is lower for new plants than for existing ones.

With regard to the power grids, the existing refinancing options for investments that are part of the incentive regulation framework are essentially adequate. A gradual reduction in regulatory risks would lead to a further reduction in own capital requirements for investors and thus also financing costs in the medium term.

Contrary to investment in renewables where the prevailing framework is, in essence, likely to be retained, there is a need for urgent action with regard to energy-efficient buildings refurbishment if government targets are to be met. The aim of accelerating the rate of refurbishment requires additional financial incentives for example through KfW funding programs. Further development of the qualification and certification processes for consultants and tradesmen is also needed here.

Fundamentally, all investment in the energy sector requires a reliable and long-term framework. This also implies making use of the possibilities available within the European framework and integrating longer term targets for emission reductions, improvements in efficiency, and the use of renewable energy beyond legislative periods. The European Commission has launched the debate on this subject with its Green Paper on a 2030 framework for climate and energy policies.[37] This should aim to create stable conditions for companies making investment decisions for the European market.

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JEL: Q42, Q43, Q48, Q52
Keywords: Energy transition, investment, renewable energy, energy efficiency

First published as »Energiewende erfordert hohe Investitionen«, in: DIW Wochenbericht no. 26/2013.

37 European Commission, Green Paper: A 2030 Framework for Climate and Energy Policies (Brussels: March 27, 2013), COM(2013) 169 final.

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Volume 3, No 9
27 September, 2013
ISSN 2192-7219