European Energy Sector: Large Investments Required for Sustainability and Supply Security

By Christian von Hirschhausen, Franziska Holz, Clemens Gerbaulet and Casimir Lorenz

For the European Union to keep on track with its energy and climate targets, large investments are required in electricity generation, infrastructure and energy efficiency. The electricity sector takes the center stage. This article delivers an overview of several estimates of the investment requirement in the European energy sector and estimates the total required investment expenditures until 2030. To ensure the financing of these investment expenditures, further adaptation of the legal framework in the European member states is necessary; even more importantly, the regulatory framework of cross-border infrastructure projects needs to be improved.

The European Union aims at a strong reduction of its greenhouse gas emissions from the energy sector. The "Energy Roadmap 2050", published in 2011, stipulates the long term climate target of a greenhouse gas emission reduction of 80 to 95 percent (compared to the 1990 level) until 2050.[1] This goal has also been endorsed by the European energy and climate package that was presented in spring 2014 and which specifies intermediate targets until 2030 of 40 percent emission reduction, a 27 percent share of renewables in final energy consumption and increased efforts for energy efficiency. Binding policy measures will be determined in the next months.[2]

In the next decades in Europe, there will be large investment requirements in the electricity generation fleet and renewable energies as well as in electricity grids and natural gas infrastructure. The investment requirements are driven by the European climate targets on the one hand and are renewal investments on the other hand. Investing will ensure secure energy supplies and increase energy efficiency.

Investments in cross-border electricity and natural gas lines — so-called interconnectors — are increasingly required. Cross-border connections play an essential role for the integration of European energy markets. At the same time, however, coordinating cross-border investments is more complex and challenging than for national infrastructure projects.

Large investment requirements in the European energy sector

Modeling results by the European Commission and other studies[3] suggest that the electricity sector should make a significant contribution to decarbonization be-

1 European Commission (2011): Energy Roadmap 2050.

2 See C. Kemfert, C.v. Hirschhausen, C. Lorenz: Europäische Energie- und Klimapolitik braucht ambitionierte Ziele für 2030. Wochenbericht des DIW Berlin no. 10 (2014).

3 See for example Fraunhofer ISI (2011): Tangible ways towards climate protection in the European Union (EU Long-term scenarios 2050). Karlsruhe;

Table 1

Investment requirements in European electricity transmission and distribution grids until 2050
In billion euro

		2011–2020	2021–2030	2031–2040	2041–2050	2011–2050
European Commission 2011	Transmission grid	47.9	52.2	53.5	52	205.7
	Cross-border interconnection	13.1[a)]	0.3	0	0	13.04
	Distribution grid	243.7	263.5	280.5	276	1063.7
ECF 2012	Transmission grid	46	22	n.a.	n.a.	n.a.
IEA 2014	Transmission grid	38[a)]	50.4	n.a.	n.a.	n.a.
	Distribution grid	130.3[a)]	178.4	n.a.	n.a.	n.a.
ENTSO-E 2012	Transmission grid	104[b)]	n.a.	n.a.	n.a.	n.a.
DIW Berlin	Transmission grid	17	2	4.3	7.3	30.6

a) Other time period 2014–2020
b) Other time period 2012–2022

Sources: Impact Assessment Energy Roadmap 2050, SEC(2011) 1565 final; ENTSO-E (2012): Ten-Year Network Development Plan 2012–2021; Egerer et al. (2013); IEA (2014, "New Policies Scenario"); EFC (2012, "On Track" scenario).

Investment requirements in transmission and distribution grids sum up to over 1 000 billion euro until 2050.

cause of its low-cost options to reduce greenhouse gas emissions. One of the main assumptions of almost all scenarios under discussion is that—based on the targets formulated by politics—the electricity sector will be largely carbon-free until 2050.[4]

The consultancy Ernst & Young in a recent study estimates that such a policy could considerably decrease the European import dependency, thereby reducing the energy expenditures by more than 500 billion euro.[5] In the transportation sector, the savings potential is estimated to be approximately 180 billion euro; European households could save 474 billion euro of energy expenditures. Compared to a business-as-usual scenario, the decarbonization scenarios have positive effects on economic growth and employment. Depending on the scenario definition, the European gross domestic production could be higher by 36 to 72 billion euro than in the reference scenario; between 0.5 and 1.08 million additional jobs could be created.

The estimates of the investment requirements in the electricity sector vary depending on the hypotheses on market developments and on specific investment costs. The European Climate Foundation (ECF) and the International Energy Agency (IEA) recently published detailed studies on the global and European investment requirements in the energy sector.[6]

For this decade, the investment requirement is estimated to 628 billion euro by ECF. Between 2021 and 2030 this sum will increase to 1 153 billion euro. The total investment requirements until 2030 add up from 1028 billion euro for electricity generation capacities, 57 billion euro for reserve capacities and 68 billion euro for the high voltage grid.[7] Hence, there is a yearly investment requirement of more than 100 billion euro after 2020 in the European electricity sector alone.[8]

The largest share of the investments in the electricity sector will have to be destined to the renewal of generation capacities and in particular the conversion of the European generation fleet to low-carbon technologies. Renewable energies will play a major role since the costs of renewable technologies continue to decrease while the costs of constructing new nuclear power plants are disproportionately high and the capture of CO_2 in coal power plants is currently not feasible from a technical or economic perspective.[9]

Electricity grid infrastructure

Electricity grid infrastructure is of strategic importance, even though the investment requirements are considerably lower than in electricity generation. On the one hand, the completion of the European Single Energy Market requires a well-functioning cross-border infrastructure. On the other hand, "smart grids" increase the flexibility of the electricity system, both in the long-distance transmission and the local distribution.

and Eurelectric (2011): Power Choices – Pathways to Carbon-Neutral Electricity in Europe by 2050, Brussels.

4 See the review or several analyses provided by L. Meeus, et al. (2012): Transition Towards a Low Carbon Energy System by 2050: What Role for the EU? Brussels, THINK Report No. 3.

5 Ernst & Young (2014): Macroeconomic Impacts of the Low-Carbon Transition for the European Union. Brüssel. http://europeanclimate.org/wp-content/uploads/2014/06/EY_ECF_Macro-economic-impacts-of-the-low-carbon-transition_Summary_2014-03-07_Alternative.docx.pdf

6 European Climate Foundation (2012): Power Perspectives 2030. Brussels; and International Energy Agency (2014): World Energy Investment Outlook. OECD, Paris.

7 See ECF (2012).

8 According to ECF the investment requirements in electricity generation could be considerably reduced by demand (load) management and the improvement of energy efficiency. In a scenario with load management, which leads to a reduction of peak demand, the investment requirement would fall to 930 billion euro until 2030, i. e. by about 20 percent. Similarly, in a scenario with high energy efficiency there would be less investments necessary in generation capacities, namely about 794 billion euro (about 30 percent less); investments in energy efficiency measures would also be necessary in this case but ECF does not quantify them.

9 See C.v. Hirschhausen, C. Kemfert, F. Kunz, R. Mendelevitch: European Electricity Generation Post-2020: Renewable Energy Not To Be Underestimated. DIW Economic Bulletin no. 9 (2013).

Table 1 presents the estimates of electricity grid investments by the European Commission and compares them to other studies. The European Commission's estimates of investment costs in the high-voltage transmission grid are in the same range as the 68 billion euro until 2030 estimated by ECF. The organization of the European transmission system operators ENTSO-E even calculates investment requirements of 104 billion euro until 2022. However, modeling results by DIW Berlin suggest that when assuming an efficient operation of the network the investment requirements for the period of large renewable expansion until 2050 could be only 30 to 60 billion euro.[10]

In addition, the IEA and the European Commission provide estimates of the — very large — investment requirements in the distribution grid. Most of these investments are needed for the roll-out of intelligent distribution networks (so-called "smart grids"). Until 2050, up to 1000 billion euro of investment are expected in the distribution grid — considerably more than in the long-distance transmission grid.[11]

Energy efficiency

Investments to increase energy efficiency are of major importance, too. Energy efficiency measures have a great greenhouse gas reduction potential in Europe, not only in buildings but also in the transportation sector and in industry. The IEA has estimated the investment requirements for energy efficiency measures in Europe at 1200 to 2300 billion euro. Hence, these investment expenditures have about the same magnitude as in the electricity sector.[12]

Natural gas infrastructure

The 2014 conflict between Ukraine and Russia has shown, once more, that some European countries have a supply security problem.[13] In order to improve the security of natural gas supply, further investments must be carried out. Investments in transportation and storage infrastructure are particularly required since it will be hard to expand domestic natural gas extraction given the current political opposition to fracking in many countries and the ongoing decrease of extraction in traditional producing regions such as the United Kingdom and the Netherlands.[14] In addition to the creation and expansion of infrastructure to import natural gas to Europe via pipelines or liquefied natural gas terminals, the improvement of interconnection within Europe is required.

Indeed, the expansion of interconnector pipeline capacities between EU member states is essential to facilitate intra-European trade and to secure member states from the complete disruption of supplies. With so-called reverse flows natural gas can be supplied against the traditional transportation direction. Reverse flows have been mandated by the European Commission for some years for all cross-border interconnectors.[15] However, the implementation has been somewhat sluggish which is why some East European EU member countries have had to fear supply disruptions and negative economic impacts during the Ukraine crisis 2014.

In early 2009, the 14 days-long disruption of Russian exports via Ukraine had tangible effects on the Bulgarian economy: Seasonally adjusted industrial production in January decreased by 10 percent compared to the previous month.[16] In Slovakia, industrial production even fell by 40 percent which corresponds to a reduction of economic growth by 0.6–0.7 percentage points.[17] Other countries such as Romania and Hungary were and will be similarly affected because they have hardly invested in their import infrastructure.

10 See J. Egerer, C. Gerbaulet, C. Lorenz (2013): European Electricity Grid Infrastructure Expansion in a 2050 Context. DIW Discussion Paper 1299, DIW Berlin. In this paper, a comprehensive model of the European electricity transmission grid with more than 3000 network nodes is applied to several scenarios. We show results of the reference scenario here. Depending on the scenario, the grid investments are between 30 and 56 billion euro and occur both on intra-country and cross-border lines.

11 See European Commission (2011): Impact Assessment Energy Roadmap 2050, SEC(2011) 1565 final, and ENTSO-E (2012): Ten-Year Network Development Plan 2012–2021, Brussels, and Egerer et al. (2013), and IEA (2014) "New Policies Scenario", and EFC (2012) "On Track" scenario. The differences in estimated costs of grid expansion between the studies are due to different calculation methods and aggregation levels. If efficient utilization of the transmission grid is assumed, the investment requirements are generally lower than in most other studies. DIW Berlin models all lines and nodes of the European high voltage transmission grid and computes the cost-efficient investments in the grid with a focus on expansions and neglecting replacement investments.

12 See IEA (2014).

13 H. Engerer, F. Holz, F., P.M. Richter, C.v. Hirschhausen, C. Kemfert (2014): Europäische Erdgasversorgung trotz politischer Krisen sicher. Wochenbericht des DIW Berlin no. 22 (2014).

14 Only 15 years ago, the United Kingdom was one of the largest natural gas producers in Europe with a yearly production of more than 100 billion cubic meters; after extraction of a large share of its conventional reserves the UK now produces less than 50 billion cubic meters per year. In the Netherlands, natural gas production will we be limited after earthquakes induced by natural gas extraction; moreover, constrained reserves will lead to the halving of yearly production until 2030 from about 80 billion cubic meters today. Likewise, natural gas production in Germany has fallen by a third since 2000, to about 10 billion cubic meters in 2012.

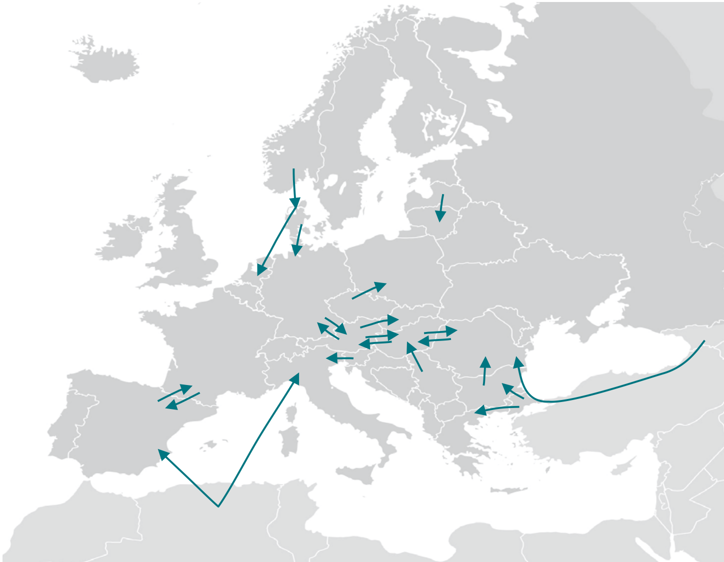
15 Regulation (EU) No 994/2010 of the European Parliament and of the Council of 20 October 2010 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC.

16 E.H. Christie, P.K. Baev, V. Golovko (2011): Vulnerability and Bargaining Power in EU-Russia Gas Relations. *FIW-Research Reports* 2010/2011 Nr. 3.

17 M. Radvansky, and L. Fašungová (2014): Economic Impact of Natural Gas Supply Disruptions – Case of Slovakia. *Journal of Economics (Ekonomický časopis)*, Issue 02/2014, S. 167–184.

Figure

Current bottlenecks[1] on cross-border natural gas interconnectors



1 utilization rates of 100 percent of the pipeline capacity in the Global Gas Model, model year 2015

Source: Map from Wikipedia; calculations by DIW Berlin.

Bottlenecks in the European natural gas infrastructure persist, especially in Eastern Europe.

Table 2

Investment requirements in natural gas infrastructure within and into the EU

In billion euro

	Until 2020	2020–2030	Until 2030
European Commission (2011)	70	n.a.	n.a.
DIW Berlin (2013)	23,6	0,7	24,3
IEA (2014)	65	100	165

Sources: European Commission SEC(2011) 755 final; Holz et al. (2013); IEA (2014).

Continuous investment requirements to remove pipeline bottlenecks in the next years.

Moreover, investments in import routes and intra-European interconnectors are necessary to reduce bottlenecks (Figure).[18] The European Commission estimates that investments in the order of 70 billion euro are necessary in the natural gas infrastructure until 2020, which is similar to the estimates by the IEA (64 billion euro) for this period[19] (Table 2).[20] In contrast, model computations by DIW Berlin show that if infrastructure management was carried out efficiently somewhat lower investment of about 23.6 billion euro are needed until 2020. While the IEA also expects large investment requirements in the decade thereafter until 2030, the results by DIW Berlin suggest a strong focus of investments in the years until 2020, especially to remove bottlenecks.

In addition to pipeline interconnectors, many countries, particularly in Eastern Europe, must also invest in expanding natural gas storage capacities in order to cover demand in winter times and to hedge against supply disruptions.[21] After completion of the terminals in Poland and Lithuania the import infrastructure of liquefied natural gas is sufficiently available in Europe to secure additional and diversified supplies.[22]

In total, the European energy sector will require investments in the order of magnitude of 2 500 billion euro until 2030 for energy efficiency measures, electricity generation as well as electricity and natural gas grids. This corresponds to almost 150 billion euro per year. The major share of these investments has to be carried out in the electricity sector where more than 70 billion euro will have to be spent every year, of which almost 20 billion euro are directed to the distribution grid and, according to the calculations by DIW Berlin, only a considerably smaller sum of about 1 billion euro to the transmission grid. More than 50 billion euro per year will need to be invested in electricity generation, more than half of which to the expansion of renewables. Investments requirements in energy efficiency are about 70 billion euro per year; hence, almost as high as in the electricity sector. In contrast, in the natural gas transmission only a comparably small amount of about 1 bil-

18 F. Holz, P.M. Richter, R. Egging (2013): The Role of Natural Gas in a Low-Carbon Europe: Infrastructure and Regional Supply Security in the Global Gas Model. Discussion Paper 1273, DIW Berlin.

19 European Commission (2011): Energy Infrastructure Investment Needs and Financing Requirements. SEC(2011) 755 final, and IEA (2014).

20 In contrast to the electricity sector, the natural gas transmission system operators – represented by ENTSO-G – do not give any estimates of the costs of removing the pipeline bottlenecks in the next ten years. Even though many investment projects are being discussed, for only a few the final investment decision has been taken. See ENTSO-G (2013): Ten-Year Network Development Plan 2013–2022, Brussels.

21 European Commission (2014): European Energy Security Strategy. Communication from the Commission to the European Parliament and the Council. SWD(2014) 330 final, 28.5.2014.

22 European Commission SEC(2011) 755 final; Holz et al. (2013); IEA (2014).

lion euro will have to be invested, according to model runs at DIW Berlin.

Incentives for investments must be set by the legal framework

The investments can be facilitated by incentives that are set by the legal and regulatory framework in the energy sector. On the one hand, uncertainty and risk must be reduced for the effective financing of capital costs. On the other hand, incentives and project-specific knowledge of investors must be taken into account. The European Union has already some promising support schemes and instruments in place which must be expanded and applied more largely. For example, the Internal Energy Market and the Third Energy Package have set an appropriate regulatory framework for both the electricity and natural gas markets. Their rules are set to ensure efficient operations of networks and generation capacities in competitive markets. However, as of yet they have not been fully transposed to national regulations in all EU member states.[23] More regulatory initiatives to support investments, in particular in cross-border networks, have been initiated and some of them are briefly discussed in the following.

At the end of 2013, the European Commission published a list of 248 "Projects of Common Interest" (PCI). These are projects of which the realization would benefit to at least two member states and which lead to a better integration of markets, to more competition or to an improvement of supply security. These projects benefit from accelerated approval procedures and can obtain loans at favorable conditions from the "Connecting Europe Facility". The facility has 5.85 billion euro at its disposition for the period 2014–2020 in order to help projects bridge funding gaps or leverage other funding sources.[24]

In general, in all EU member states, funding of grid infrastructure is supervised by national regulatory authorities; most infrastructure companies are subject to cost-oriented regulation.[25] At the national levels, this regulation generally warrants sufficient investments but other issues may hinder investments such as insurance questions of the connection of offshore wind farms to the onshore grid.

Investments in cross-border infrastructure are more challenging. The European Union has established a legal framework in 2013 which must now be put to the test.[26] Multinational and Europe-wide cooperation is necessary in order to push market integration and warrant the positive effects of investments in the electricity and natural gas infrastructure. In addition to the stimulus funds for the "Projects of Common Interest" the European Investment Bank (EIB) disposes of other instruments such as the Structured Finance Facility, Equity Funds in some European regions, and the programs JESSICA and JASPER in the framework of regional development schemes.[27] It is yet unclear which importance project bonds guaranteed by the EIB may gain for the energy sector. Moreover, the European Economic Recovery Plan (EERP) in 2008 included a specific fund for the energy secotr, the "Marguerite Fund for Energy, Climate Change and Infrastructure"; six national developments banks participate in this initiative, one of them the German KfW.[28]

In the natural gas sector, considerable efforts have been made since the supply disruption crises of 2006 and 2009 to diversify imports and expand infrastructure. In particular the capacity of import terminals of liquefied natural gas has been considerably increased: from 145 billion cubic meters in 2009 to now more than 184 billion cubic meters per year. This is more than the total imports from Russia to the EU (about 130 billion cubic meters per year). Moreover, several pipeline projects have been finalized and now contribute to increased supply security, e.g. the interconnection between the United Kingdom and the Continent and the pipeline connections between North Africa and the EU.

However, several EU standards still wait for the full implementation in order to achieve the Internal Market for natural gas. These include the requirement of vertical unbundling of natural gas trade and infrastructure operations which is a pre-requisite for a competitive market. Moreover, the current system of national or regional "Entry-Exit" prices for infrastructure utilization hampers the efficient utilization and expansion of the natural gas grid because there are no economic

23 See, i.a., European Commission (2012): Communication "Making the internal energy market work". COM(2012)663.

24 See European Commission: Energy: Commission unveils list of 250 infrastructure projects that may qualify for € 5,85 billion of funding. IP/13/932 14/10/2013 http://europa.eu/rapid/press-release_IP-13-932_en.htm

25 For example, investments in the German electricity network have a regulated rate of return of 9.27 percent (nominal), i.e. significantly above the current capital market interest rate.

26 Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) no. 713/2009, (EC) no. 714/2009 and (EC) no. 715/2009.

27 See C.v. Hirschhausen (2011): Financing Trans-European Energy Infrastructures – Past, Present and Perspectives. Berlin, Brussels, Report for the Think Tank "Notre Europe".

28 For more details see C. Kemfert and D. Schäfer (2012): Financing the Energy Transition in Times of Financial Market Instability. DIW Economic Bulletin 9/2012.

price signals of congestion.[29] Pricing should rather be re-organized by linking the regional markets to a cross-border congestion pricing (so-called "market coupling"). This was done in the U.S. natural gas market after liberalization in 1978 and yielded a nation-wide liquid and transparent market.[30]

Conclusions

Until 2030 about 2 500 billion euro will have to be invested in the European energy sector; this corresponds to an annual investment requirement of almost 150 billion euro per year. The investment requirements in the electricity sector are estimated to be at least 70 billion euro per year, two thirds of which are for electricity generation and one third for the electricity network. In addition, investment expenditures of about the same order of magnitude of 70 billion euro will have to be covered for energy efficiency measures. In the natural gas transmission infrastructure there will be additional investment requirements in order to ensure diversification and security of supplies to the EU member states.

The appropriate regulatory framework is needed to ensure that investments are carried out at the national and European levels. In particular cross-border investments are still problematic. Multinational and Europe-wide cooperation are needed to advance the market integration and warrant that the positive effects of infrastructure investments can be harvested. The European Union has a prominent role to play beyond providing funding support, in particular in the energy corridor planning. Moreover, the "project bonds" by the European Investment Bank may be a suitable instrument to support sustainable energy infrastructure investments in Europe at large scale.

29 In the entry-exit regime, network users pay for feeding in natural gas in an entry-exit zone and can offtake it from the network at any exit point of the same zone. Hence, the tariff is independent of the feed-in and the offtake point as well as of the transportation route within the zone. The system operator must make the provisions to technically enable the feeding-in and offtakes.

30 See J.D. Makholm (2012): *The Political Economy of Pipelines*. Cambridge Univ. Press.

Christian von Hirschhausen Research Director International Infrastructure Policy and Industrial Economics at DIW Berlin | chirschhausen@diw.de

Franziska Holz coordinates the research topic resource markets in the Department Energy, Transportation, Environment | fholz@diw.de

Clemens Gerbaulet is research associate at TU Berlin and was previously with DIW Berlin | cgerbaulet@diw.de

Casimir Lorenz is guest researcher in the Department Energy, Transportation, Environment and doctoral student at TU Berlin | clorenz@diw.de

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DIW Berlin — Deutsches Institut
für Wirtschaftsforschung e. V.
Mohrenstraße 58, 10117 Berlin
T +49 30 897 89 –0
F +49 30 897 89 –200

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