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Article
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DIW Economic Bulletin

Provided in Cooperation with:
German Institute for Economic Research (DIW Berlin)

Suggested Citation: von Hirschhausen, Christian; Holz, Franziska; Gerbaulet, Clemens; Lorenz, Casimir (2014) : European energy sector: Large investments required for sustainability and supply security, DIW Economic Bulletin, ISSN 2192-7219, Deutsches Institut für Wirtschaftsforschung (DIW), Berlin, Vol. 4, Iss. 7, pp. 31-36

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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 studies3 suggest that the electricity sector should make a significant contribution to decarbonization be-

3 See for example Fraunhofer ISI (2011): Tangible ways towards climate protection in the European Union (EU Long-term scenarios 2050). Karlsruhe;
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Table 1

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

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>European Commission 2011</td>
<td>Transmission grid</td>
<td>47.9</td>
<td>52.2</td>
<td>53.5</td>
<td>52</td>
<td>205.7</td>
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<td></td>
<td>Cross-border interconnection</td>
<td>13.1</td>
<td>0.3</td>
<td>0</td>
<td>0</td>
<td>13.04</td>
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<tr>
<td></td>
<td>Distribution grid</td>
<td>243.7</td>
<td>263.5</td>
<td>280.5</td>
<td>276</td>
<td>1063.7</td>
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<tr>
<td>ECF 2012</td>
<td>Transmission grid</td>
<td>46</td>
<td>22</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Distribution grid</td>
<td>130.3</td>
<td>178.4</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>IEA 2014</td>
<td>Transmission grid</td>
<td>38</td>
<td>50.4</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Distribution grid</td>
<td>104</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>ENTSO-E 2012</td>
<td>Transmission grid</td>
<td>17</td>
<td>2</td>
<td>4.3</td>
<td>7.3</td>
<td>30.6</td>
</tr>
</tbody>
</table>

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


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? 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 2050 add up from 1,028 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 CO₂ 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.

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

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.

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 1,200 to 2,300 billion euro. Hence, these investment expenditures have about the same magnitude as in the electricity sector.

Natural gas infrastructure

The 2014 conflict between Ukraine and Russia has shown, once more, that some European countries have a supply security problem. 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. 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. 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. In Slovakia, industrial production even fell by 40 percent which corresponds to a reduction of economic growth by 0.6–0.7 percentage points. Other countries such as Romania and Hungary were also 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 1239, DIW Berlin. In this paper, a comprehensive model of the European electricity transmission grid with more than 3,000 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 intracountry 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).
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Moreover, investments in import routes and intra-European interconnectors are necessary to reduce bottlenecks (Figure). 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 (Table 2). 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. 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.

In total, the European energy sector will require investments in the order of magnitude of 2500 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 billion euro per year will need to be invested.

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.  
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.\textsuperscript{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.\textsuperscript{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 sector, the “Marguerite Fund for Energy, Climate Change and Infrastructure”; six national developments banks participate in this initiative, one of them is the German KfW.\textsuperscript{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

\begin{footnotesize}
\textbullet\ See, i.e., European Commission (2012): Communication “Making the internal energy market work”. COM(2012)663.
\textbullet\ 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.
\end{footnotesize}
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price signals of congestion. 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.

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.

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JEL: L95, L95, Q43

Keywords: infrastructure, electricity, natural gas, modeling