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The reference forecast of the German energy transition—An outlook on electricity markets

Andreas Knaut [a], Christian Tode [a,*], Dietmar Lindenberger [b], Raimund Malischek [b], Simon Paulus [b], Johannes Wagner [b]

[a] Institute of Energy Economics and Department of Economics, University of Cologne, Universitätsstrasse 22a, 50937 Cologne, Germany
[b] Institute of Energy Economics, University of Cologne, Vogelsanger Strasse 321a, 50827 Cologne, Germany

HIGHLIGHTS

- Policy evaluation of the German 'Energiewende'.
- Analysis and modeling of the German electricity sector embedded in an European framework.
- Our results suggest that almost all political targets are not reached.

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ABSTRACT

The enactment of the Energy Concept by the German Government in 2010 set ambitious targets for the future energy transition in Germany. The most prominent goals include a greenhouse gas (GHG) emission reduction of the economy and an increase in the share of renewable energy in the whole energy sector. Since the long run effects of these policy measures are hard to assess, science-based policy evaluation methods are needed to identify weak points and areas with a need for action. This paper presents the results of the German Energy Reference Forecast with a focus on the electricity sector. It is based on an investment and dispatch model for the European electricity sector over the planning horizon of the 'Energiewende' up to 2050, with an emphasis on the time period up to 2030. We find that almost all targets of the German 'Energiewende' are not reached, for the case in which no further measures are undertaken. In particular reductions in GHG emissions fall short to the target value. Contrary to the negative results, e.g., regarding GHG-emissions as well as gross electricity consumption, generation from renewable energy sources will exceed the policy's target value.

1. Introduction

The enactment of the Energy Concept by the German Government in 2010 set ambitious targets for the future energy transition in Germany (BMWi,BMU, 2010). The most prominent goals include a greenhouse gas (GHG) emission reduction of the economy and an increase in the share of renewable energy in the whole energy sector. This policy decision was supported by a study defining scenarios for the future energy system up to 2050, applying a consistent modeling framework (Schlesinger et al., 2010). After the Fukushima nuclear disaster in 2011, a part of the Energy Concept was revised as policy makers reached the decision that nuclear power should be phased out by 2022, which gained strong public support. The combination of the nuclear phase out, ambitious CO_2 and renewable energy targets in Germany is commonly referred to as the 'Energiewende' (energy transition). This challenge of an industrialized country seeking to restructure its energy supply is observed with great interest among scientists and politicians worldwide (von Hirschhausen, 2014).

The Energy Concept and its accompanying policies consist of a total of 12 targets that aim to restructure the whole energy sector. These targets address various areas of the energy sector and range from overall targets for emission reduction and efficiency increase to sector-specific targets in the electricity, transportation and

* Corresponding author.
E-mail addresses: andreas.knaut@ewi.research-scenarios.de (A. Knaut), christian.tode@ewi.research-scenarios.de (C. Tode), dietmar.lindenberger@uni-koeln.de (D. Lindenberger), raimund.malischek@ewi.research-scenarios.de (R. Malischek), simon.paulus@ewi.research-scenarios.de (S. Paulus), johannes.wagner@ewi.research-scenarios.de (J. Wagner).

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household sectors. The overall goal of reducing CO_2 emissions in the German energy sector on 40% by 2020 and 80% by 2050 – compared to the level of emissions in 1990 – will have a great impact on the supply structure of the power sector. Furthermore, this national goal has to be achieved under the European Emissions Trading System (EU-ETS). This context makes the implementation of ambitious and effective national policies within a European framework rather complex. Another target of the Energy Concept aims to increase the share of renewables in the energy sector and especially in the power sector, meaning that the share of renewable generation in gross electricity consumption should be 35% by 2020 and 80% by 2050. This is an additional attempt to reduce CO_2 emissions by defining a part of the future technology mix in the power sector. As previously mentioned, these targets are accompanied by the decision of a nuclear phase out by 2022.

In order to achieve these long term goals, an effective policy framework needs to be in place. Since the long run effects of these policy measures are hard to assess, science-based policy evaluation methods are needed to identify areas with a need for action. This is why the Federal Ministry for Economic Affairs assigned a study named "Development of Energy Markets – Energy Reference Forecast" to the consortium of Prognos AG, GWS mbH and the Institute of Energy Economics at the University of Cologne (EWI). EWI's contribution focuses on the analysis and modeling of the German electricity sector embedded in a European framework. In this paper, we present the results of the investment and dispatch model for the European electricity sector in the planning horizon of the 'Energiewende' up to 2050, with a focus on the time period to 2030. The modeling approach is able to calculate the development of installed capacities, electricity generation, wholesale prices, end consumer prices and CO_2 emissions for the respective time period, accounting for all policies implemented thus far.

The key element of the paper is the reference forecast up to the year 2030. The reference forecast presents the probable development from the view of the authors. This development is extrapolated in the trend scenario to the year 2050. The results act as a guidance for policy makers to help identify weak points in the policy framework. In order to test for the robustness of the results, sensitivity analyses are performed. Namely, five sensitivity calculations are used to test how different prices for fossil fuels, alternate assumptions about plant cost developments related to renewable energy use as well as higher CO_2 prices would affect key results.

2. Literature review

In accordance with European energy policy, the EU implemented the so-called '20-20-20' goals that focus on environmental sustainability and provide a potential roadmap for the European Union as a whole. These goals specifically mandate a reduction of greenhouse gas emissions by 20%, an improvement of energy efficiency by 20% and a deployment of renewable energy of 20% by 2020 across the EU. Despite the European-wide goals, the authority on how to best reach these goals lies with the national governments. Within this context, Germany plays a major role in the achievement of these targets; however, its chosen path (i.e., increasing deployment of renewables) stands not without critique among the current European discussion. Within the current literature many studies investigate on country specific roles within the EU. The study at hand sheds light on key opportunities and challenges for Germany. Among others, key enablers for a low carbon society are the chosen policy instruments, on a national and supra-national level.

One mutual instrument across member states regarding energy policy is the EU-ETS. It impacts the current and future emission level through emission caps and a yearly reduction rate for total allowances in the European Union. With this instrument in place, the EU emission's landscape is subject to a change eventually leading to renovations of existing power plants and potentially new 'carbon free' capacity additions in Europe. Although the EU-ETS remains the major instrument for achieving a reduction in emissions, energy portfolios on a country level are also impacted by access to local resources and policy decisions (i.e., the nuclear phase out decisions). However, most studies have analyzed the impact of the EU-ETS on European energy supply with many of them focusing on the interdependence between prices of emission certificates and electricity prices. Whereas the studies differ in their methodical approach, they consistently emphasize the importance of the EU-ETS as an instrument to a less carbon intense energy system. Lise et al. (2010), for example, analyze the impact of the EU-ETS on electricity prices by using a bottom-up modeling method. They find that a significant part of the costs from buying emission allowances is passed on to consumer prices, resulting in higher electricity prices and additional ('windfall') profits for power producers, even in cases of full auctioning. Aatola et al. (2013) use several econometric models with multiple stationary time series and discover a strong relationship between German electricity prices and coal and gas prices with the price of European emission allowances (EUA). Kirat and Ahamada (2011) and Bonenti et al. (2013) come to similar results.

Additionally, the literature provides a full range of studies that model electricity markets on a European and national level. Most of them build on modeling different assumption-driven scenarios for the energy market. Studies based on such scenarios are often quantitative projections of energy consumption, supply, technological development, fuel and certificate prices as well as plenty of other variables that determine the overall future energy trend (see Newell and Iler, 2013). Furthermore, they differ in regional scope (national to global, electricity market to the whole energy system) time horizon (mostly up to 2020 or 2050) and time resolution (hourly, monthly or yearly). However, one key difference lies in the design of scenarios and in the assumptions used, often distinguished between target-oriented, current-policy and reference scenarios. Current-policy scenarios take into account only existing or predetermined energy and environmental policies (see EC, 2013). They therefore avoid judgments on policy proposals that have not yet been decided and provide a useful baseline against which other scenarios can be measured (Newell and Iler, 2013). Target-oriented scenarios focus on specific goals to be reached, however these goals may or may not be reached depending on the approach being used. In that respect, many studies focus on minimizing total system costs in order to reflect cost-efficient technology deployment under a certain set of assumptions. The results of target-oriented scenarios provide substantiated appraisals on the feasibility of reaching a certain (political) goal and often show different possibilities on how to reach these goals. Reference scenarios try to present the most probable trajectory of the future energy system. They also consider measures that have not yet been decided on, but that - according to the authors seem probable to be implemented (see for example UBA, 2013; Newell and Iler, 2013; BP, 2014; Spiecker and Weber, 2014). Our study falls in the latter category.

In addition to the previously mentioned studies that focus on the feasibility of transforming the German economy into a less carbon-intensive economy, Kirsten (2014), Gawel and Hansjürgens (2013) as well as Agora Energiewende (2014) focus, in contrast, on the transition of the German energy system often referred to as 'Energiewende' and the interaction between national and international policies. Gawel and Hansjürgens (2013) find that Germany's pioneering attempt to integrate a steadily increasing share of non-dispatchable electricity from renewable sources is jeopardizing the stability of the future European energy system.

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