Energy Policy 59 (2013) 350–360

Contents lists available at SciVerse ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Long-term scenarios and strategies for the deployment of renewable energies in Germany

Thomas Pregger*, Joachim Nitsch, Tobias Naegler

German Aerospace Center (DLR), Institute of Technical Thermodynamics, Department of Systems Analysis and Technology Assessment, Pfaffenwaldring 38-40, 70569 Stuttgart, Germany

HIGHLIGHTS

- Long-term scenario for the German energy system according to the political targets.
- Comparison of three variants with differing developments of the fleets of vehicles.
- Analysis of economic effects: investments, generation and differential costs.
- Importance of strategies in the sectors electricity, heat, and transportation.
- Recommended measures for the successful implementation of the CO_2 reductions.

ARTICLE INFO

Article history:
Received 28 July 2012
Accepted 26 March 2013
Available online 1 May 2013

Keywords:
Energy scenario
Renewable energy
Economic effect

ABSTRACT

The transformation of the energy supply in Germany (the "*Energiewende*") as described in the German Federal government's 'Energy Concept' (Energiekonzept, 2010) is based on a political consensus about long-term targets for energy efficiency and renewable energies. The aim of this article is to present a consistent scenario for this transformation process reflecting the long-term implementation of renewable energies and the possible future structure of the German energy system as a whole. Structural and economic effects of this development are derived and discussed. It summarizes results of scenario analyses done by the department of Systems Analysis and Technology Assessment of the German Aerospace Center as part of a three-year research project for the German Federal Ministry for the Environment. The underlying study provides a detailed data base reflecting a long-term roadmap for the energy system transformation in Germany. The scenarios show that the policy targets are consistent and can be achieved, if appropriate policy measures are to be implemented. The economic analysis shows the amount of investments and the strong market dynamics required for new generation technologies but also the huge economic benefits that can result from this development path in terms of fuel cost savings and lower fuel imports.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

The German Federal government's 'Energy Concept' (Energiekonzept, 2010) of 28 September 2010 and the subsequent energy laws of summer 2011 present a long-term political timetable for climate protection and the transformation of the energy supply in Germany (the "*Energiewende*"). It calls for emissions of greenhouse gases in Germany to be reduced by 80% to 95% from the 1990 level by the year 2050. For energy-related CO_2 emissions alone, this target requires a reduction of at least 85%. A transformation of the supply to renewable sources of energy, accompanied by a substantial increase in energy efficiency, is the appropriate strategy for this. The challenges presented by this transformation of the power system are considerable, and their full extent has not yet been grasped. On the one hand, specific energy consumption needs to be significantly reduced in all sectors of the energy system. On the other hand, the long-term expansion of renewable energies needs to take place in permanent technology markets with partly strong market dynamics. Fossil power plant capacities with low operational flexibility need to be decommissioned and new highly efficient and flexible gas power plants need to be installed in order to meet the remaining loads depending on the fluctuating renewable power generation. Other challenges of the transformation are the limited availability of sustainable sources of biomass, how to achieve a high share of renewables in the transport sector, and concepts for integrating high shares of solar

* Corresponding author. Tel.: +49 711 6862 355; fax: +49 711 6862 747.
E-mail address: thomas.pregger@dlr.de (T. Pregger).

0301-4215/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enpol.2013.03.049

and geothermal energy into the heat market. This article presents results of systems-analysis examinations of the transformation of electricity, heat, and fuel generation that were developed in order to give answers to these challenges. The main objective of this study is to provide–compared to earlier scenario studies for Germany–a robust, transparent and consistent data basis for further analyzing the transformation process according to the German 'Energy Concept' taking into account as far as possible various technical, political, economic and social aspects. Related costs and economic benefits are shown up to the time horizon of 2050. The work has been done as part of a three-year research project (final report (Nitsch et al.. 2012)) which is based on scenario projects carried out in previous years by the DLR with varying project partners for the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU) and the German Federal Environment Agency (UBA) (e.g. (BMU, 2004)). Compared to these earlier studies, the latest project was able to significantly improve the scenario basis regarding heat and power demand, cogeneration, transport scenarios and plausible assumptions for techno-economic development pathways of relevant technologies. A much deeper analysis of possible structures of the future energy supply system was carried out, applying a temporally and, in part, spatially resolved simulation of the electricity supply (see (Nitsch et al., 2012)).

2. Methodology and main assumptions of the scenario analysis

The long-term scenarios presented in this article are target-oriented scenarios developed using a backcasting approach. Comparing the present situation and targets for the future and taking into account economic, political and social realities, interests, and the resulting barriers and incentives results in consistent development paths which point out required measures for each sector of the energy system to get to this future state. Therefore, these scenarios must not be interpreted as a "forecast" of the future development of the energy system. The quantified political targets for transforming the energy system in Germany, approved and confirmed by the package of energy laws in summer 2011, set the framework for their design. The scenarios were designed and calculated with an accounting framework. They represent the energy system with a detailed and transparent data structure (s. Nitsch et al., 2012). The main premises applied for the development paths are described in the following. These are the most essential part of the methodology of target-oriented scenarios.

The scenarios are oriented to the overall goal of the Energy Concept, an eighty-percent reduction in greenhouse-gas emissions by 2050, and also meet the subsidiary goals with respect to expansion of renewables and increases in efficiency for the most part (Table 1). This also includes the target of a 25% reduction in electricity consumption by 2050 (relative to its consumption as final energy in 2008). This consumption of electricity includes electromobility and other new consumers such as heat pumps but not the electricity demand for generating hydrogen or synthetic methane. The scenarios show clearly the structural changes associated with meeting the political goals. The main focus of the scenarios is the expansion of technologies for the use of renewable energies. Fossil power plant capacities are set in the scenarios by the required demand for secure capacity and the necessity to meet the remaining loads. Their operation and fuel use is limited by meeting the CO_2 targets without Carbon Capture and Storage (CCS). Among other things, the scenarios illustrate different paths of development in the transportation sector, and their implications for an energy system with high proportions of renewable sources. For this purpose, the following variants of the scenarios are examined:

Scenario A is the middle variant of the three "main scenarios" with respect to energy demand and the pathway of expansion of renewables. Fully electric vehicles and plug-in-hybrid vehicles reach a share of the mileage of passenger cars of 50% in 2050. Other motor-vehicle transportation is provided by means of biofuels, vehicles using hydrogen, and remaining conventional vehicles that are more efficient than today. Hydrogen is also applied as a chemical storage medium for electricity from renewables and used in cogeneration for provision of heat and electricity, as well, and for short periods also reconversion into electricity. The national abandonment of nuclear power, in accordance with the Bundestag decision of 30 June 2011 (13th Amendment of the Atomic Energy Act), is taken into account.

Scenario B is based on the same assumptions about consumption and generation structure as Scenario A. But it varies from Scenario A in that hydrogen produced by renewables is converted to synthetic methane by methanation. The possibility of direct injection into the natural-gas grid makes the storage and transportation of CH_4 from renewable sources of energy possible without any additional infrastructure. Methane is used in the transport sector, through an increasing share of gas-powered vehicles, for cogeneration in CHP facilities, and in power plants for reconversion into electricity.

Scenario C represents, in contrast to Scenario A, a complete coverage of passenger-car mileage in 2050 by fully electric vehicles as well as plug-in-hybrid vehicles (approx. 80% electric propulsion), i.e. without the use of hydrogen or methane in transportation. In the other final-consumption sectors, the Scenario C is identical to Scenarios A and B.

The principal demographical, structural, and economic particulars, that, along with the level of economic activity, determine the overall demand for energy, are matched to the scenarios of the Federal government's Energy Concept (EWI 2010). In these scenarios, the gross domestic product grows in real terms by more than 40% by the year 2050 (from the 2010 level). The population of Germany declines by 10% by 2050, while the parameters that determine energy demand–passenger mileage, and residential and

Table 1
Quantified targets of the German Federal government's 'Energy Concept'.

	2020	2030	2040	2050
Reduction of GHG emissions (related to 1990)	−40%	−55%	−70%	−80 to−95%
Minimum share of renewables in the (gross) final energy consumption	18%	30%	45%	60%
Minimum share of renewables in the (gross) electricity demand	35%	50%	65%	80%
Reduction of primary energy demand [a]	−20%			−50%
Reduction of electricity demand	−10%			−25%
Reduction of final energy demand transport	−10%			−40%
Reduction of heat demand (2020) resp. fossil primary energy demand (2050) of buildings[b]	−20%			−80%

[a] Increase of energy productivity with respect to GDP by on average 2.1% per year.
[b] Increase of energy-saving renovation rate from 1% to 2% per year.

Download English Version:

https://daneshyari.com/en/article/7404371

Download Persian Version:

https://daneshyari.com/article/7404371

Daneshyari.com