HOLISTIC MODELING AND ANALYSIS OF A FUTURE GERMAN ENERGY SYSTEM

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In summer 2011 the German parliament approved ambitious targets for the transformation of the German energy system. The overall goal of these decisions aimed at a reduction of Germany's greenhouse gas emissions by at least 80% to up to 95% by 2050 as compared to 1990. In our work presented here we developed a holistic model to analyze a future German energy system including all energy conversion components and all end-use sectors that fulfills the climate policy targets. Based on an hour-by-hour simulation of the entire system and application of a techno-economic optimization we found results about the optimized composition of such energy system and values for its total annual cost. Main results are that (1) locally renewable energy sources are sufficient to meet Germanies future energy demand and that (2) the total annual cost of such system is in the same range as the cost of the German energy system of today.

Keywords: Future German energy system, intersectorial optimization, hourly simulation, holistic approach

Summary

In order to identify future least cost energy supply systems which are mainly based on solar energy, wind energy, biomass, hydropower and a rest use of fossil energy resources (mainly natural gas) comprehensive time resolved simulations have been performed for the case of Germany. The analysis considers a complete supply and demand system (electricity, heat and fuel for households, industry and transport) which is highly interlinked and thus does not focus exclusively on the electricity sector. The identified energy system supplies at all times of the year the energy demand and is in line with the ambitious goals of the German government for 2050 (e.g. reduction in CO_2 emission by 80% and a 60% contribution of renewables to the gross final energy demand). Least cost solutions were identified by applying numerical optimisation methods. The main characteristics of these systems are: (i) strongly increased energy efficiency, (ii) transition to a highly flexible electricity generation and load system, (iii) large scale generation of heat and gas (mainly H_2 for mobility) from electricity and (iv) extensive energy storage for heat, gas and electricity (stationary batteries and batteries used in electrical vehicles). It results from the calculations that the total annual cost of such a future energy system (after its transformation towards sustainability) will be not higher than the cost of today's conventional energy system and leads to a strongly reduced dependence on import of energy resources. The results are to a large extent applicable to other highly industrialised countries in moderate climates.

More details can be found in a number of recent publications. In [1] the methodology is described in detail, while [2] summarizes major findings for the electricity production and the heat sector. The latest publication [3] describes the methodology in brief and outlines latest results on optimization calculations for the entire German energy system.

References

[1] Henning, H-M., Palzer, A., A comprehensive model for the German electricity and heat sector in a future energy system with a dominant contribution from renewable energy technologies – Part I: Methodology. Renewable and Sustainable Energy Reviews, 30 (2014), pp 1003–1018

[2] Palzer, A., Henning, H-M., A comprehensive model for the German electricity and heat sector in a future energy system with a dominant contribution from renewable energy technologies – Part II: Results. Renewable and Sustainable Energy Reviews, 30 (2014), pp 1019–1034.

[3] Palzer, A., Henning, H-M., A future German energy system with a dominating contribution from renewable energies: a holistic model based on hourly simulation. Energy Technology 2014, 2, pp 13–28