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SIMULATING THE EXPANSION OF RENEWABLE ELECTRICITY GENERATION IN GERMANY - AN AGENT-BASED APPROACH

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Overview

The German support scheme for electricity generation based on renewable energy sources has lead to a considerable increase of renewable electricity generation in Germany. The most remarkable example for the success of the German support is the development of wind energy with an increase of the installed capacity from 110 MW in 1990 to 17132 MW in June 2005 (Ender, 2005). But the dynamic development of wind energy in Germany also showed considerable weaknesses in the scientific capability to produce reliable projections on the future development of the installed capacity. Even the most optimistic projections for the development have been overtaken by the real development within one or two years. Conventional linear optimisation models or even hybrid models such as the Canadian Integrated Modelling System [CIMS] are not suited to produce reliable results concerning the development of renewable electricity generation (Sensfuss, 2004, p. 108 ff). This paper presents a new approach to the simulation of the development of renewable electricity generation which is based on the concept of agent-based simulation. In a case study a first version of the developed simulation platform is applied to analyse the development of wind energy in Germany.

Methods

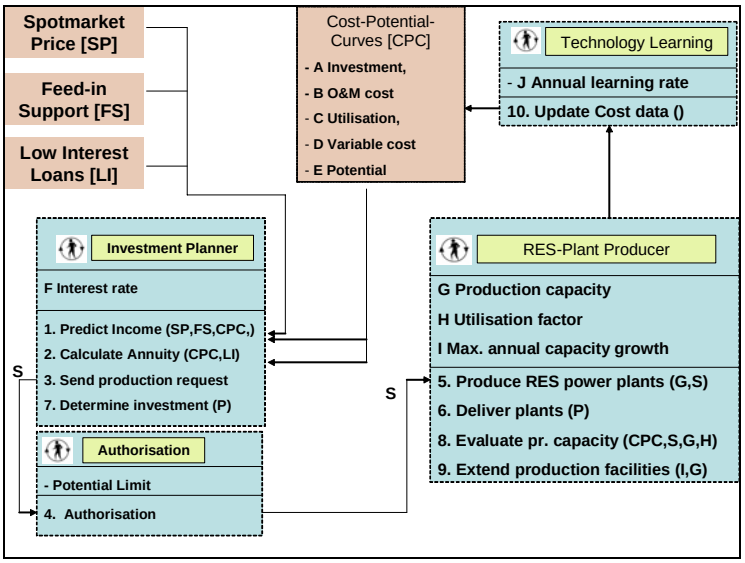

Fig. 1: Structure of the developed simulation platform

The approach of agent-based simulation draws on the concepts of several disciplines such as economy/game theory, social sciences and software engineering (see also Wooldridge, 2002, p.7 ff). Although there is no general scientific agreement on a clear definition of agent based simulation (Drogoul et al., 2002, p.1) it can be stated that agent-based simulation seeks to go beyond conventional modelling approaches by integrating the players perspective into the simulation. The developed module dealing with the expansion of renewable electricity generation is part of an agent-based simulation platform seeking to simulate the German electricity sector and its markets. A central basis for the simulation is a detailed database on

cost potential curves of renewable electricity generation technologies in Germany. An overview of the structure of the developed model is given in Figure 1.

Major players in the given simulation platform are an investment planner which determines the expected income of renewable investment options based on the available potential, the required interest rate and the available support. Based on these information a production request is generated which contains all investment options with a positive annuity. The Renewable Energy Source-plant producer builds new renewable power plants according to the available production capacity. Requests exceeding the production capacity are not fulfilled. If the requests for new plants exceed the production capacity the plant producer considers building new production facilities based on the remaining potential for the renewable technology and its own requirements concerning the expected utilisation of new plants. Thereby the RES-Plant producer of the simulation is used as an aggregate for all the planning and construction capability of a country needed to carry out projects for the construction and operation of renewable power plants. Interaction with construction and planning capabilities of neighbouring countries are not taken into account in the current version of the model. Two smaller modules seek to integrate the aspect of technology learning and the dampening effect of planning and authorisation procedures if the installed capacity gets close to the limitations of the available technological potential. In a case study the model is applied to simulate the development of installed capacity of onshore wind energy in the years 1998-2020. Thereby the period between 1998 and 2005 is used to calibrate the model. In a next step the impact of loans with reduced interest rates provided by the German “KfW promotional bank” is analysed by running the model with feed in support and additional loans and without loans.

Results

The results of the simulation run and the calibration are given in Figure 2. The calibration to the period between 1998 and 2005 shows a maximum deviation between real development and the simulated development of the installed capacity of 370 MW. A comparison of the simulation runs with and without additional low interest rate loans and with a quota of low interest rate loans of 81% shows the considerable impact of the availability of low interest rate on the simulated development of wind energy in Germany. At the end of the simulation period the difference between the installed capacities reaches 3800 MW which underlines the importance of the availability of these loans. In addition it has to be taken into account that the availability of low interest loans also helps to attract the additional private capital needed for the investments, an effect which is not yet covered in the simulation. These results might provide some insights for the support of the beginning development of the offshore wind energy in Germany.

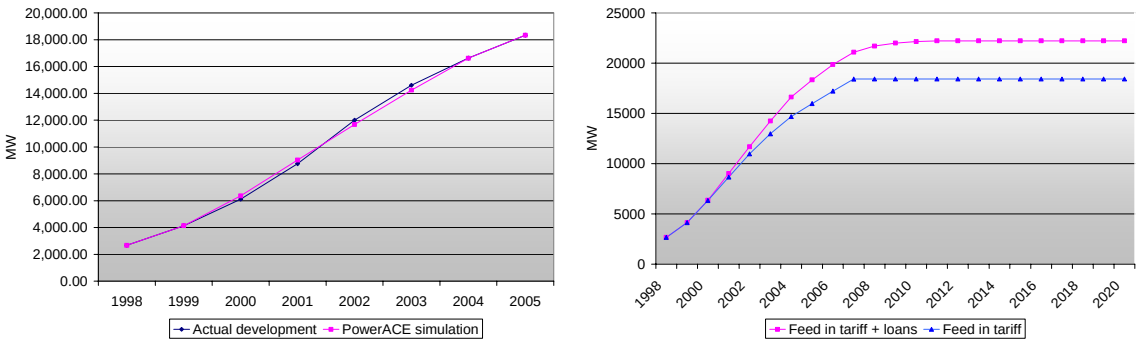

Fig. 2: Calibration and results PowerACE simulation runs

Conclusions

This paper presents a first version of an agent based approach to the simulation of the expansion of renewable electricity generation in Germany. Although the first version of the model is rather simple it can successfully be calibrated to reproduce the development of wind energy in the period 1998-2005. The described case study on the future development of wind energy with different support conditions shows the considerable impact of the availability of low interest rate loans on the actual development. However, the presented model represents work in progress. Future work will be directed to a better validation of parameters and a more detailed representation of investment decisions. But it has to be taken into account that a detailed agent-based simulation of player decisions requires extensive empirical data which may not be available in many cases. The goal is to develop a simulation platform which can be used to assess the impact of different support schemes on the development of renewable electricity generation. Thereby the impact of a green certificate system and the linkages of renewables to the "conventional" electricity sector and its markets play a major role. The first results presented in this paper show that the selected approach seems to be promising in order to get new insights into the model-based analysis of support policies.

References

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