EVALUATING SUSTAINBLE ENERGY TRANSITION SCENARIOS: INSIGHTS FROM A PARTICIPATORY STAKEHOLDER ASSESSMENT IN GERMANY

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Overview

In the light of climate change, governments all over the world need to change their nation's energy consumption behavior and the energy generation and transmission system in order to decrease greenhouse gas emissions. However, the preferred pathway for transforming the electricity sector and combining it with the heat and transport sector is often still unknown. Some key issues in the discussion on the possibile future energy transformation pathways are the extent of decarbonization of the power system, the degree of decentralization of the energy generation, the intensity of electrification of the transport and heat sectors, or the scope of cooperation on the electricity supply with other countries, among others. The variety of possible technical solutions for the energy transition and the inherent social, economic, and ecological consequences of these alternatives give rise to the question which of these alternatives is most suitable. The discussion is all the more challenging in the presence of a multitude of contradicting opinions of stakeholders. In order to demonstrate the consequences of possible transformation pathways, researchers frequently use energy models to define scenarios for the sustainable energy transition (Repenning et al. 2015; Gerbert et al. 2018; Matthes et al. 2017). However, it is unknown which of the variety of scenarios is preferred by the citizens. In our study, possible scenarios have been designed by relevant stakeholders from various fields, such as from environmental and consumers associations, trade unions, and churches, amongst others. The first scenario represents a conservative, slowly processing energy transition and acts as a reference scenario. The second scenario aims at reaching the Paris Climate Agreements and, therefore, is the most ambiguous scenario of all considered alternatives. The third and the fourth scenario also have high climate protection goals, but lower than the second scenario. Thereby, scenario three is characterized by a more central development of renewable energy sources (RES) and an optimal integration of the energy system with neighboring countries. In contrast, scenario four focuses on a more decentralized development of RES and a high participation of citizens. After defining the scenarios, the same stakeholders define objectives for the energy transition and state their individual preferences towards these objectives. This consensual objective system, supplemented with the subjective assessment of the objectives by different stakeholders builds the foundation of a holistic valuation system for energy scenarios. We use this system to systematically evaluate four different energy scenarios regarding their utility for the considered stakeholders. More specifically, we analyze the individual preferences of the stakeholders to define which objectives are particularly important and need to be fulfilled by the future energy system. Furthermore, we derive which scenarios are most suited for different stakeholder groups and explain why these scenarios are preferred. Thus, the aim of this paper is to give policy makers a structured and robust basis for determining a well-accepted energy transition.

Methods

In order to investigate different opinions towards the future energy system, we construct a group decision model with experts from different fields. In the first phase of the model, we use Value Focused Thinking to define and structure the objectives of the considered stakeholders (Keeney 1992, 1996). By structuring the objectives into means and fundamental objectives, we create a valuation system for the future pathway of the sustainable energy transition which reaches consensus among the stakeholders. In the second phase, we apply Multi-Attribute Utility Theory (MAUT) to evaluate individual preferences of the stakeholders towards these objectives (Keeney 1982; von Nitzsch 2017). Subsequently, we use the objective system and the individual preferences of the stakeholders to evaluate four different energy scenarios consensually developed by the same stakeholders. Finally, we apply clustering techniques to assess the differences and similarities within the stakeholder preferences. In summary, the merits of our paper are: (1) the incorporation of stakeholders in defining objectives for the energy transition, (2) the development of a holistic objective system, (3) the evaluation of four consensual energy scenarios, (4) the derivation of differences and similarities among the stakeholders by means of clustering techniques, and (5) the depiction of policy implications resulting from the clustering techniques.

Results

The objective system for the evaluation of the energy scenario consists of four fundamental objectives and 19 means objectives. Whereas the stakeholders mainly agree that the fulfilment of all fundamental objectives are important for the future energy system, they highly disagree regarding the importance of the means objectives. One stakeholder group prefers energy scenarios which reduce CO_2- and other pollutant emissions massively, while e.g. increasing the added value in the renewable energy sector and improving the participation of citizens at infrastructural projects. In contrast to this, another group does not attach much importance on the reduction of CO_2- and other pollutant emissions, but prefers scenarios that reduce the overall system costs, are well integrated with the neighboring energy systems, and reduce the energy import dependency of a country. This discrepancy affects the evaluation of the considered scenarios. Most stakeholders prefer the energy scenario, which fulfills the Paris Climate Agreement. A smaller group prefers the scenario, in which RES are installed in countries with preferable conditions and which build upon a high interconnectivity of neighboring countries. The more conservative scenario in which the energy transition advances slowlier performs poorly (i.e. is less favored) in contrast to the other considered scenarios.

Conclusions

Modeling energy scenarios is an effective way of showing the consequences of different possible energy transition pathways. Beyond that, the incorporation of different stakeholder opinions on such scenarios can assist policy makers in determining an appropriate energy transition. The implemented objective system and the individual preferences of the stakeholders suggest that the energy transition has to fullfill a variety of objectives and interests. However, although disagreeing on multiple aspects concerning the future energy system, some objectives emerge that are of particular importance for the stakeholders. A scenario fulfilling these aspects might be preferred by the citizens. The results of this paper suggest that a scenario, which has high climate protection goals, incorporates the citizens and that is embedded in an international cooperation is preferred on average. Policy makers who respect these preferences of stakeholders may improve the acceptance of citizens, thereby increasing the likelihood of a smooth realization of the energy transition.

*References*Literaturverzeichnis

Gerbert, Philipp; Herhold, Patrick; Burchardt, Jens; Schönberger, Stefan; Rechenmacher, Florian; Kirchner, Almut et al. (2018): Klimapfade für Deutschland. Hg. v. The Boston Consulting Group (BCG) und prognos.

Keeney, Ralph L. (1982): Decision Analysis. An Overview. In: *Operations Research* 30 (5), S. 803–838.

Keeney, Ralph L. (1992): Value-focused thinking. A path to creative decisionmaking. Cambridge, Mass: Harvard University Press. Online verfügbar unter http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=282778.

Keeney, Ralph L. (1996): Value-focused thinking. Identifying decision opportunities and creating alternatives. In: *European Journal of Operational Research* 92 (3), S. 537–549. DOI: 10.1016/0377-2217(96)00004-5.

Matthes, Felix Chr.; Emele, Lukas; Hermann, Hauke; Loreck, Charlotte; Peter, Frank; Ziegenhagen, Inka; Cook, Vanessa (2017): Zukunft Stromsystem. Kohleausstieg 2035 - Vom Ziel her denken. Hg. v. WWF Deutschland. Berlin, Germany.

Repenning, Julia; Emele, Lukas; Blanck, Ruth; Dehoust, Günter; Förster, Hannah; Greiner, Benjamin et al. (2015): Klimaschutzszenario 2050. Hg. v. Öko-Institut e.V. und Fraunhofer ISI. Berlin, Germany.

von Nitzsch, Rüdiger (2017): Entscheidungslehre. 9. Auflage. Aachen: Druck und Verlagshaus Mainz GmbH Aachen.