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The regional and social impact of energy flexible factories

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Abstract

The change of electricity supply from conventional to renewable energy sources is a challenge for the whole society. This transition causes an increase of volatility in electricity supply and therefore threatens both, grid stability and, also, electricity price stability. Besides cost-intensive countermeasures such as grid expansions and power-to-X storage technology, the incentivized change in electricity use (energy demand flexibility) is a promising approach. Today, when it comes to production matters, energy is considered as a resource which is immediately available on demand. In contrast, future scenarios draw a picture, in which electric energy will become a resource that requires planning and control. Energy flexible factories will be an important part of our society with an important ecological and social impact. The paper presents a transdisciplinary approach to shape a sustainable electricity supply in the discourse with regional stakeholders from a technical, ecological and social background.

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Keywords: energy flexibility, model region, trandisziplinary research, desing thinking

1. Introduction

Global greenhouse gas emissions continue to grow. In 2015, participants of the UN Climate Change Conference in Paris agreed to pursue efforts to limit the temperature increase to 1.5 degrees Celsius above pre-industrial lev-

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els [1]. Germany, one of the top five countries in renewable power generation [2], has claimed to take a worldwide lead in climate protection [3]. In 2016, renewable energies already reached 31 % of the German electricity mix [4]. The expansion target for renewable energies, imposed by the Germany federal government, amounts 80 % up to the year 2050 [5]. This ambitious project will enable a gradual withdrawal from Germany's nuclear energy programme by 2022 and to reduce its greenhouse gas emissions by 80 to 95 % until 2050 compared to 1990 [4]. The change in German energy policy, that is called *energy transition,* addresses complex interrelations between heterogeneous actors from the technical, political, legal and societal sector.

One of the biggest challenges for the energy transition is the intermittent nature of photovoltaic and wind power systems, which constitute the largest share within the German renewable electricity generation [5]. Uncontrollability and difficult predictability of solar radiation and wind conditions threaten the balance between electricity supply production and demand. Consequently the grid stability in central Europe is challenged. Besides cost-intensive solutions of grid expansions and power-to-X storage technology, demand side management (DSM) is a promising approach for utilizing flexibility in electricity demand to balance fluctuating energy availability [6]. Thereby, DSM was originally defined as "the planning and implementation and monitoring of […] activities designed to influence customer use of electricity in ways that will produce desired changes in the […] load shape, i.e., changes in the time pattern and magnitude of […] load" [7]. Palensky and Dietrich [6] divide DSM further into Energy Efficiency, Time of Use, Demand Response (DR) and Spinning Reserve. For purpose of simplification, we summarize Time of Use and Demand Response by the term *energy flexibility,* describing the ability of a manufacturing company to adapt the production to short-term changes in electrical energy provision with least possible loss in time, effort, costs and performance [8,9]. It induces changes in electricity demand through incentives such as varying electricity prices that are an important measure to encounter fluctuating energy availability [10]. Especially the industrial sector, which is by far the largest electricity consumer with a share of 47 % of the total German net electricity consumption in 2016 [11] has a high potential for energy flexibility. Although there are some companies in the industrial sector that already participate in energy flexibility markets, e.g. balancing power markets, most of the capability of energy flexibility remains unused. Recent studies assess the potential of DSM in German industries between 1.8 and 15 GW [12,13].

Apart from monetary incentives and technological enablers to leverage this potential, ecological and social aspects of energy flexibility have to be considered in order to achieve a broad public acceptance. For this reason a subproject of the project *SynErgie*, funded by the German Federal Ministry of Education and Research (BMBF), aims for prototyping a new form of cooperation between society and the energy flexible factory with transdisciplinary research (TR) and design thinking. "TR deals with problem fields in such a way that it can grasp the complexity of problems, take into account the diversity of life-world and scientific perceptions of problems, link abstract and case-specific knowledge and develop knowledge and practices that promote what is perceived to be the common good" [14].

SynErgie has the objective to conceptualize, develop and implement a digital market platform for the trading of energy flexibility within the industrial sector. This is why the project team pursues a bottom-up-approach by taking one region into a closer examination and transferring the results to other regions. In the context of the SynErgie project, the aim of the so-called *energy flexible model region Augsburg* is therefore to take a holistic perspective on energy flexibility in a regional context to uncover the local obstacles for energy flexibility with regard to ecological and social aspects. Thus, a holistic perspective must integrate the impacts on all technological, ecological and social stakeholders and it demands for a collaboration of those stakeholders from different disciplines and backgrounds. Stakeholders like scientists, plant operators, plant employees or conservationists must perform a transdisciplinary discussion process to uncover and assess different problem areas that emerge from a regional integration of energy flexibility. This offers a basis to develop appropriate measures that utilize and increase energy flexibility and to transfer the knowledge gained into other regions and therefore on a national level. In order to contribute to the transdisciplinary efforts of SynErgie and the energy flexible model region Augsburg, the authors aim for working on the following research objective:

Designing and illustrating a transdisciplinary approach to utilize (industrial) energy flexibility with respect to technological, ecological and social restrictions.