



# Transforming the energy system: Why municipalities strive for energy self-sufficiency



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## HIGHLIGHTS

- Municipalities striving for energy self-sufficiency can play a key role in the transition of the energy system.
- Tax revenues and environmental awareness main drivers behind mayors' attitude towards energy self-sufficiency.
- Citizens and the political environment main influencers of mayors striving for energy self-sufficiency.
- 19 expert interviews analyzed for the framework of the study based on the theory of planned behavior (TPB).
- 109 mayors and energy officers participated in the quantitative main survey.

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## ABSTRACT

Despite evidence that a rising number of municipalities in Germany are striving for energy self-sufficiency, there is little understanding of the driving factors behind this development. We investigate economic, ecological, social and energy system related factors that drive municipalities to strive for energy self-sufficiency with a focus on electricity supply. The empirical data for this study is based on insights generated through expert interviews (N = 19) with mayors, energy experts and scientists as well as a quantitative study among mayors and energy officers (N = 109) of German municipalities. Results show that environmental awareness, tax revenues and greater independence from private utilities are positively related to the mayors' attitude towards the realization of energy self-sufficiency. Furthermore, citizens, the political environment, the mayor's political power, and his/her financial resources are relevant factors for a municipality striving for energy self-sufficiency. Policymakers need to decide whether or not to support mayors in this development. For suitable policy interventions, the results suggest the importance of an integrated approach that considers a combination of identified factors. Finally, we propose a morphological box to structure different aspects of energy self-sufficiency and categorize the present study.

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## 1. Introduction

### 1.1. Motivation

Since the industrial revolution, the promulgated principle for a well-functioning energy system was a centralized energy supply based on fossil fuels and organized by large organizations. In certain countries, such as Germany, this is currently shifting towards a more distributed renewable energy supply. Within this

transition, a constantly rising number of municipalities and entire regions have set their own goals under the label of “energy self-sufficiency” in order to expand the share of locally generated energy, usually based on renewables and electricity (McKenna et al., 2014; trend:research, 2013). This development has the potential to become a key pillar of the transformation of the energy system (Schmidt et al., 2012).

The growing importance of this development has triggered scholars' exploration of the phenomenon with its diverse occurrences and discussion of positive and negative implications to analyze the feasibility. Research on autarkic energy systems is developing into its own stream of literature, touching the intersection of sustainable energy transition, studies on community energy, and research on decentralized energy supply. Energy self-

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sufficiency describes the capability to cover energy needs using local energy sources to a certain extent.<sup>1</sup> Scholars distinguish between relative and absolute energy self-sufficiency: relative energy self-sufficiency only indicates a local energy supply, but not necessarily direct self-consumption. The degree of energy self-sufficiency can be defined as the proportion of locally generated energy to the local energy demand. In contrast, absolute energy self-sufficiency refers to the ability of a region to fully supply itself with its own energy resources without the necessity of a grid connection or external resources (Schmidt et al., 2012). Both types of self-sufficiency are often, but not necessarily, based on renewable energy technologies, which is the same for decentralized energy. Müller et al. (2011) are the first to develop a comprehensive conceptual framework for sustainable regional development and analyze the ecological, economic and social effects of an autarkic energy subsystem on a region. Proponents list several potential advantages, for example an increase in local value generation, a rising number of local jobs, decrease in environmental pollution, a more reliable energy supply, boost in the regional attractiveness for inhabitants and tourists, and lower transportation effort and expense for renewable sources (Abegg, 2011; Berndes and Hansson, 2007; Rae and Bradley, 2012; Schmidt et al., 2012). Case studies from municipalities in Germany, Austria and Switzerland underline the positive effects and hypothesize different underlying drivers such as local value generation, job effects, a boost for the local tourism, and environmental beliefs (Busch and McCormick, 2014; Fuchs and Hinderer, 2014; Müller et al., 2011; Schmuck et al., 2013).

However, despite a discussion of the potential positive and negative effects of energy self-sufficiency, there is no clear picture of the underlying beliefs or motivational factors that drive decision-makers in municipalities. Only by understanding exactly why municipalities strive for energy self-sufficiency can policymakers design a corresponding policy framework and steer or support this development. Consequently, this raises the guiding research question of the present study: Which factors drive municipalities to strive for energy self-sufficiency? The aim of this study is to understand the precise economical, ecological and social factors that influence the decision to strive for energy self-sufficiency. This understanding allows policymakers to actively shape the transition of the energy system towards sustainable energy supply.

To achieve this goal, we first conducted expert interviews among nineteen mayors, energy experts and scientists and developed an extended model based on the theory of planned behavior. Next, an empirical quantitative study among 109 mayors and energy officers of German municipalities tested the model. The expert interviews shaped the conceptual background and discussion and were part of the methodological approach, which is based on Fishbein and Ajzen (2010), used to develop our research model. In our model, the intention to realize energy self-sufficiency has four antecedents: attitude, subjective norm, perceived behavioral control (PBC) and costs. Except for the latter, all antecedents are positively related. The first three are influenced by an underlying belief structure of attitudinal beliefs, normative beliefs and control beliefs. In addition to the theoretical model, we provide an overview of various energy self-sufficiency concepts to clarify the term and adequately classify research studies.

By studying the antecedents of the intention to realize energy self-sufficiency and discussing the concept, we contribute to the extant literature and provide advice to policymakers: first, we extend the theory of planned behavior to understand the factors that influence mayors' behavior on their energy policy. We show

that environmental awareness, tax revenues, and a higher independence from private utilities have an influence on the mayors' attitudes. Second, we show that citizens, the political environment, the mayor's political power, and financial resources are the most relevant social and control factors for municipalities striving for energy self-sufficiency. Third, we provide a classification scheme to categorize studies, including the present one, into the spectrum of energy self-sufficiency. Finally, we apply our findings to the discussion by proposing a set of policy recommendations derived from our analysis, the literature and expert interviews.

The remainder of this study is organized as follows: Section 2 provides the conceptual background by elucidating energy self-sufficiency in the context of this study, the theoretical background and the hypotheses. Section 3 describes the methodological approach and survey data; Section 4 presents the results of the survey and discusses its implications for theory and practice. Finally, Section 5 concludes with the contribution and aggregates the policy recommendations.

## 2. Conceptual background

### 2.1. Energy self-sufficiency in the context of this study

The concept of energy self-sufficiency – a synonym for energy autarky – has been studied and discussed in several publications from heterogeneous perspectives. Deuschle et al. (2015) describe it as a “key term in the debate about the future energy supply” (p.151) and a rising number of municipalities and regions strive for energy self-sufficiency (McKenna et al., 2014, 2015; trend:research, 2013). Researchers also refer to it with the terms *energy autarky*, *energy autonomy* and *energy self-reliance* (Hauber and Ruppert-Winkel, 2012; Müller et al., 2011; Rae and Bradley, 2012; Ruppert-Winkel and Hauber, 2014; Späth and Rohrer, 2010). A wide spectrum of facets and meanings have emerged in practice and appear in the scientific literature. In a broader sense, energy self-sufficiency describes a local energy supply that leads either to physical or to relative (theoretical) independence from external energy resources, which indicates several dimensions to be considered – the most important being: type of final energy consumption (electricity, heat, fuel, other), spatial extent (e.g. a municipality or a region), type of self-sufficiency (relative vs. physical) and degree of self-sufficiency (sub-classification of relative self-sufficiency). Table 1 presents a morphological box and a categorization of this study based on the key elements introduced above. For an extensive list of aspects that are discussed in the literature, we refer to McKenna et al. (2015). In practice, most municipalities and research articles discuss relative energy self-sufficiency, which indicates a certain degree of local supply. The degree of energy self-sufficiency is defined as the proportion of locally generated energy to the local energy demand. Another aspect, the degree of self-consumption, describes the proportion of local energy self-consumption to local energy supply. For example, a German municipality might have achieved 100% relative energy self-sufficiency in the electricity sector, but only a low degree of self-consumption; the reason is that the electricity is fed into the electricity grid, since the generated power does not equal the load at each point in time. Electricity feed-in is then compensated via the German EEG (Renewable Energy Act) surcharge. This municipality generates locally, and per year on average, the equivalent of the energy it consumes. This study focuses on municipalities striving for relative energy self-sufficiency based on electricity, which most municipalities currently aim for.

A different rich stream of literature, which touches the idea of energy self-sufficiency, discusses the concept of community energy. This refers to energy projects, usually based on renewable

<sup>1</sup> For a detailed description of energy self-sufficiency, see Section 2.1 and Table 1.

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