



Why homeowners strive for energy self-supply and how policy makers can influence them



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ABSTRACT

In the past, households in Germany widely invested in renewable energy technologies (mostly photovoltaic) to receive guaranteed return rates based on extensive subsidies. These feed-in tariffs have been tremendously reduced and, consequently, households' behavioral motivations have changed: They have started to adopt various technologies to supply themselves with energy. In this study we investigate the underlying motivational factors that influence private households' intentions to purchase renewable energy system components with the purpose of partial energy self-supply. The study's data is comprised of qualitative interviews (N = 20) and a subsequent quantitative survey (N = 395) among homeowners of one-family houses and apartment houses from Germany. By studying their purchase intentions, we found perceived financial and autarky benefits are the most relevant attitudinal predictors, followed by environmental awareness and technology affinity. Besides attitude, subjective norm and perceived behavioral control are important predictors of purchase intention. Policy makers and the industry could promote homeowners' purchasing behavior with tailored information strategies that address perceived autarky, financial benefits and subjective norms. We suggest support schemes for renewable energy systems to address perceived behavioral control factors. These schemes include necessary ongoing subsidies and a reliable regulatory and financial policy framework. This article contributes theoretically and practically to the environmental behavior and policy literature: It explains underlying behavioral factors such as autarky benefits and links them to policy recommendations such as supporting loans for energy-related investments by applying a behavior-policy framework.

1. Introduction

Private households account for about thirty percent of total energy consumption in Germany (German Environment Agency, 2015). Understanding and influencing their environmental behavior allows policy makers to achieve ambitious goals for the expansion of renewable energies (Baake, 2015). In particular, households' aspiration for partial energy self-supply offers a promising additional pillar for the transition of the energy system.

To understand consumers' environmental behavior, researchers study all kinds of behavioral aspects for diverse renewable energy technologies. This allows one to describe consumers' behavior, explain behavioral changes and recommend suitable interventions for policy makers and marketers of renewable energy system components. In this line, scholars have studied the purchase intention and purchasing

behavior of photovoltaic (PV) systems (Korcaj et al., 2015), solar thermal systems (Woersdorfer and Kaus, 2011), renewable heating systems (Bjørnstad, 2012; Michelsen and Madlener, 2013), micro-generation technologies (Alam et al., 2014; Goto and Ariu, 2009; Leenheer et al., 2011), green electricity contracts (Litvine and Wüstenhagen, 2011) and electricity storage systems (Kairies et al., 2015; Römer et al., 2015). However, current literature presents a heterogeneous picture of pro-environmental purchasing behavior of private homeowners. For example, Leenheer et al. (2011) identifies environmental concerns, technology affinity and reputation of electricity companies as the most important drivers for Dutch households generating their own power via microgeneration technologies (e.g. micro-CHP). Financial factors and power outages did not have a significant effect. In contrast, for a German sample Korcaj et al. (2014) reveal that the aspiration of financial gains, autarky benefits and social status have

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a positive relationship to the attitude towards purchasing PV systems.

Not only does the current literature provide inconclusive results for understanding households' aspiration to purchase renewable energy system components but also market surroundings have changed in recent years: Feed-in tariffs for solar PV dropped significantly to about 13 cents/kWh for small-scale installations, while household electricity prices increased to around 25 cents/kWh. Thus, it can be beneficial to consume a certain percentage of one's own self-produced electricity instead of buying all of it from the grid. Considering total costs, renewable energy technologies for private households have become economically feasible or they are closer to economic viability than a few years ago (Khalilpour and Vassallo, 2015). Up to now, in Germany, solar PV was an investment vehicle with guaranteed payback for the vast majority of customers, which is currently changing: Not just innovators and early adopters but also average consumers start to consider using diverse renewable energy system components to supply themselves with their own energy. With a different behavioral purpose, also a different set of drivers should explain households' behavior.

The heterogeneous picture together with the changing market surroundings lead to the following research questions: Which factors determine private households' purchasing intention of renewable energy system components for self-supply? How can industry and policy makers address underlying motivational factors to influence households' purchase intentions?

The focus of this study is households' intention to purchase any kind of technology able to generate or store renewable energy with the purpose to be partially self-sufficient.¹ These technologies can be for instance solar PV systems, battery systems or solar thermal systems. To study the drivers of private households striving for partial energy self-supply this study applies a multistep approach based on Fishbein and Ajzen (2010) and links it to the policy framework of Steg and Vlek (2009). We conducted 20 semi-structured qualitative interviews among homeowners and deduced the theoretical model. In the quantitative main study, 395 homeowners of one-family houses and apartment houses from Germany participated. Finally, we derived policy interventions from the identified underlying drivers. This approach provides a comprehensive analysis of the underlying drivers and aggregation of potential policy interventions to foster the transition of the energy system via households.

The key findings of this study are: Private households purchase renewable energy system components and strive for partial energy self-supply for a set of reasons. Perceived financial benefits, perceived autarky benefits, their environmental awareness and technology affinity are positively related to households' attitude towards the intention to purchase renewable energy system components; in addition to attitude, households' social environment and perceived behavioral control (PBC) are positively related to the purchase intention. We suggest the following interventions: Attitudinal and subjective norm factors should be addressed via tailored information campaigns, a type of informational strategy. They should particularly focus on perceived autarky benefits and environmental awareness. Additionally, even though policy makers would like to reduce them, technology specific subsidies are the most effective intervention to address PBC. This study contributes to the literature on pro-environmental behavior, energy autarky and decentralized energy systems in a theoretical and practical way: It extends the theory of planned behavior (TPB) and applies it to households' behavioral purchasing intention. It identifies key drivers of households' intention to purchase renewable energy system components at a point of time in which people in Germany seriously start to consider generating their own energy for the first time. By linking identified drivers to suitable interventions, this study derives practical implications for policy makers and the industry of energy products addressing private

households.

The remainder of this study is organized as follows: Section 2 addresses the conceptual and theoretical background. Section 3 presents the methodological approach. Sections 4 and 5 describe the results of the study and discuss its implications for theory and practice. Finally, Section 6 concludes with the contribution and aggregates the policy recommendations.

2. Conceptual model and theoretical background

We apply the TPB from Ajzen (1991) as an underlying theory in combination with the pro-environmental behavior policy framework from Steg and Vlek (2009). First, we examine private households, in particular homeowners of one-family houses and apartment houses, to understand the motivational factors of their intention to purchase renewable energy system components. Second, we derive and present policy recommendations by linking these factors to corresponding intervention options.

2.1. Theory of planned behavior

Scholars recognize the TPB to be a strong and well-established theory predicting and explaining individual behavior. Applying the TPB model helps to grasp the volitional and non-volitional thoughts and decisions behind any type of individual behavior. We apply the TPB as a foundation of our adjusted theoretical model because of its empirical power and its appropriateness to derive concrete policy recommendations based on the policy framework of Steg and Vlek (2009).

The major advantage of the TPB as a theoretical foundation in the context of environmental behavior is its "ability to consider a large set of complex determinants in a relatively simple framework" (Litvine and Wüstenhagen, 2011, p. 463). The TPB has been successfully applied also in various fields of environmental behavior research to study individual behavior, such as purchasing green electricity (Litvine and Wüstenhagen, 2011), recycling (Cheung et al., 1999; Nigbur et al., 2010), monitoring electricity consumption (Webb et al., 2014), electricity saving and the energy efficiency behavior of households (Botetzagias et al., 2014; D'Oca et al., 2014; Estiri, 2015; Fornara et al., 2016; Gadenne et al., 2011; Scott et al., 2014; Webb et al., 2013), and saving electricity at work (Dixon et al., 2015; Zhang et al., 2014).

To investigate the antecedents, the TPB requires one to define the studied behavior. With the purpose of supplying oneself with energy, we specify the behavior as *purchasing renewable energy system components for private households within the upcoming three to five years*, which is a reasoned action in the sense of the TPB. We underlined and reminded survey participants of this behavior definition on each page of the questionnaire to ensure a clear understanding of the context. *Renewable energy system components* comprise any kind of renewable energy technologies or products that are suitable for private households to supply themselves with energy. This includes the generation or transformation as well as the storage of electricity and heat. Examples are photovoltaic, solar thermal, pellet heating, geothermal systems, and electricity storage systems. All these products are components of a system to supply households with their own energy.

According to the TPB, the three predictors *attitude*, *subjective norm* and *perceived behavioral control (PBC)* determine the behavioral intention, which itself has shown to be an accurate predictor of actual behavior (Ajzen, 1991). In a study of Armitage and Conner (2001), the TPB explains 39% and 27% of the variance in intention and behavior, respectively, and they report high correlations between behavior intention and actual behavior ranging from .47 to .53. Applying the TPB to the context of this study, *attitude* aggregates all beliefs and influences that explain the degree of a household to be in favor or to endorse the behavior of purchasing renewable energy system components. *Subjective norm* comprises the overall perceived influence and pressure a household's owner feels from his or her social environment to act and

¹ For reasons of readability the simplification "generating energy" is used which refers to the conversion of energy into a useful form of energy such as heat or electricity.

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