



Original research article

## Does (Co-)ownership in renewables matter for an electricity consumer's demand flexibility? Empirical evidence from Germany

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## ABSTRACT

Motivating consumers to adjust their electricity demand with a volatile electricity supply is an important aspect of the energy sector's transition from fossil to renewable energy sources. (Co-)ownership in renewable energy production facilities turned out to be successful in engaging citizens to finance infrastructures and research indicates that it can also induce behavioural changes in energy consumption. Based on the results of a survey comprising of a sample of 2143 completed questionnaires collected through an online survey and analysed with propensity score matching, this paper looks at the relationship of (co-)ownership in renewable energy production facilities and demand side flexibility.

Our results show a statistically significant effect of (co-)ownership of renewable energy production facilities on the willingness of citizens to adjust their consumption behaviour to match their electricity demand to production levels. However, this relation is complex: Only when consumer (co-)owners have the choice between self-consumption and sale of the surplus electricity production to the grid, a statistically significant difference is observed. Furthermore, positive effects on flexible consumption were only found for the usage of household appliances.

### 1. Introduction

On 30 November 2016, the European Commission presented a package of measures aiming at facilitating the sustainable transition of its members' energy sectors, reforming the design and operation of the European Union's electricity market and keeping the European Union competitive as the clean energy transition changes global energy markets. Overall, the so-called "Clean Energy Package" includes eight legislative proposals to ensure the achievement of three main goals: putting energy efficiency first, achieving global leadership in renewable energies (RE) and providing a fair deal for consumers. Within this legislative package, the aspects of better accommodating the rising share of mostly variable renewables and empowering consumers by offering possibilities to become more active on the energy market are recurrently emphasized [1].

Both topics are also in the focus of scientific discourse. Studies on concepts of empowering citizens and engaging them to have (co-)

ownership in RE instalments focus on business models, member characteristics, and/or country studies (e.g. [2–4]). Demand side management (DSM) and demand flexibility are analysed majorly from a techno-centric perspective, e.g. studying the impact of demand flexibility on grid stability or the use of technical devices to promote flexible consumption behaviour (e.g. [5,6]). However, the latter aspect, i.e., the techno-centric focus in strategies to promote demand flexibility, is often criticized as they include an "inflexible" consumer figuration. Hence, complementing these approaches with a social and more differentiated perspective on demand flexibility are needed [7].

Departing from these observations and the discussion on adding a social perspective to the dominant techno-centric focus in demand side management, the question arises whether (co-)ownership in RE installations as a socio-economic driver and important new development in the transition to RE can be a factor in promoting flexibility in energy consumption. The aim of this article is to link the socio-economic setting, i.e., citizens being (co-)owners of RE facilities, to the willingness of

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individuals to consume energy in a more flexible way, a prerequisite to adjusting their electricity consumption to given production levels. Based on data from a questionnaire among users of a real estate platform in Germany, we compare the stated willingness of (co-)owners of RE installations to adjust their demand to the stated willingness of Non-owners using the propensity score matching technique (PSM) as econometrical analysis tool. With our approach, we are in line with general calls for a social science research agenda in contemporary energy studies [8] and recent research on cultural and socio-economic factors on individual energy consumption behaviour and the way social influences connect with technical means (e.g. [9,10]).

Germany was chosen as a case study since the country takes a leading role in various domains object to our analysis. As the European Union's largest economy Germany witnessed a dynamic development of (co-)ownership models with citizens investing both individually or collectively in RE production facilities during the active transformation of its energy sector ("Energiewende") [11]. Furthermore, the country recently introduced regulations aiming at the promotion of demand flexibility with the so-called "Gesetz zur Digitalisierung der Energiewende" which among others requires the step-by-step introduction of smart meters in households. Accordingly, studies on measures and factors that determine electricity consumers' demand flexibility can be either a prime example or a cautionary tale for other countries within the EU and across the globe. This is particularly the case for those countries with a comparable stage of development of their economy and comparable framework such as the UK, the USA, or the Netherlands.

## 2. Literature review

Against the challenges arising from the fluctuant nature of wind and solar energy several studies (e.g. [12–14]) highlight the importance to change behaviour of electricity consumers promoting demand flexibility to ensure system stability in the course of the energy sector's sustainable transition. While the literature on the effectiveness of techno-centric strategies (e.g. [15,16]) and dynamic pricing schemes as a socio-economic strategy [17,18] to induce behavioural changes and foster demand flexibility offers substantial insights, studies linking the social context consumers live in to changes in energy consumption are just entering academic debates. Studies analyse how energy-related behaviour patterns are formed and how they change, for example, under measures and policies addressing norms, attitudes and emotions of energy consumers [19–21].

The aspect of norms and attitudes has a specific link to the phenomenon of (co-)ownership of citizens in RE infrastructures: Business models allowing for (co-)ownership are often based on their initiators' pro-environmental attitudes, social norms, and trust in their community [22–24]. Hence, the question arises whether these settings bring together energy consumers with particular characteristics and whether social mechanisms that link (co-)ownership and electricity consumption behaviour are inclined to engage consumers more deeply in demand side management systems and therefore can impact energy consumption behaviour [25,26].

Regarding the first question, a study focusing on RE cooperatives in Flanders, Belgium and comparing members' and non-members', energy consumption indicates that people with higher electricity consumption are more likely to join (co-)ownership based business models. A possible reason for this observation is the social context of these business models which is likely to support capacity development among (co-)owners regarding questions on the adoption of green technologies or energy efficiency measures [27]. Regarding the latter, a study based on a series of choice experiments focuses on prosumers, i.e., consumers that also produce parts of the energy they consume, and analyses their willingness to be flexible in their consumption patterns. Here, the findings indicate that prosumers exhibit a higher willingness to co-create flexibility in domains such as electricity production from PV and

the use of electric cars [28]. However, comprehensive studies analysing explicitly behavioural aspects within various (co-)ownership forms and their link to behavioural changes regarding demand flexibility do not exist so far. This study contributes to fill this gap by analysing differences in willingness to show demand flexibility along three different possibilities to use produced energy for RE (co-)owners with corresponding possibilities to use the energy produced, that is, exclusive self-consumption, exclusive selling of produced energy to the grid and receiving a fixed feed-in tariff, and the dual option of self-consumption and sale to the grid, as compared with those who are not (co-)owners of RE facilities.

## 3. Hypotheses

In order to analyse whether the socio-economic setting of (co-)owning a RE production facility has an effect on an individual's willingness for demand flexibility, six main hypotheses are drawn up.

The hypotheses were derived from studies analysing energy consumption patterns of individuals and demand flexibility. Accordingly, individuals have several roles when dealing with questions related to energy. Besides their role as citizens subject to energy policy measures, individuals have a multiplicity of roles as energy consumers adopting their behaviour when implementing these measures across different domains of activities in daily life [29].

As our focus is on electricity consumption and our study was conducted in Germany, we further analysed different forms of (co-)ownership. The analysis revealed that existing (co-)ownership forms can be divided into three categories. These are a) individual ownership, especially for small PV or battery storage projects, normally used exclusively for self-consumption ("Self-Consumers"), b) collective investments of citizens in RE facilities through legal forms such as civil law partnerships, limited liability companies, or energy cooperatives which typically exclusively sell the produced energy to the grid and receive a fixed compensation per produced unit ("sellers"), and c) business models recently entering the market (i.e., specific forms of so-called tenant's electricity supply ("Mieterstrom")) where (co-)owners can decide whether they sell the produced energy or whether they consume their produced energy by themselves ("Consumer-Seller") [30]. From these three different forms of (co-)ownership, six hypotheses were derived comparing the willingness of different (co-)owners (i.e., consumers, sellers, and Consumer-Sellers) to Non-owners and also comparing different (co-)ownership types with each other.

**Hypothesis 1 (H1).** Citizens who (co-)own renewable energy production facilities and use the electricity they produce for their own consumption as well as for sale to the grid (hereinafter referred to as "Consumer-Seller") are more willing to adjust their electricity demand to production levels than citizens who do not (co-)own renewable energy production facilities (hereinafter referred to as "Non-owner").

**Hypothesis 2 (H2).** Citizens who (co-)own renewable energy production facilities and use the electricity they produce solely for their own consumption (hereinafter referred to as "Self-Consumer") are more willing to adjust their electricity demand to production levels than citizens who do not (co-)own renewable energy production facilities (Non-owner).

**Hypothesis 3 (H3).** Citizens who (co-)own renewable energy production facilities and use the electricity they produce solely for sale (hereinafter referred to as Seller) are more willing to adjust their electricity demand to production levels than citizens who do not (co-)own renewable energy production facilities (Non-owner).

**Hypothesis 4 (H4).** Citizens who (co-)own renewable energy production facilities and use the electricity they produce for their own consumption as well as for sale (Consumer-Seller) are more willing to adjust their electricity demand to production levels than citizens who

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