



Original research article

Trust, awareness, and independence: Insights from a socio-psychological factor analysis of citizen knowledge and participation in community energy systems



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ABSTRACT

In order to decarbonize the energy sector, there is a widespread consensus that the role of end-users in the energy system should change from passive consumption to active prosumption and engagement. This is of particular importance as an increasing number of technologies and business models are focusing on the end-users. These developments provide new opportunities for further technical and social innovation to smarter, flexible and integrated systems such as community energy systems (CESs). Through system integration and community engagement CESs assist in transition to a low-carbon energy system. Despite the high importance, there is limited knowledge on willingness of local citizens to participate in the local energy systems such as CESs as well as associated factors determining such willingness. Through a survey among 599 citizens in the Netherlands, this research analyses the impact of demographic, socio-economic, socio-institutional as well as environmental factors on willingness to participate in CESs. Factor and multi-variate regression analysis reveals that the environmental concern, renewables acceptance, energy independence, community trust, community resistance, education, energy related education and awareness about local energy initiatives are the most important factors in determining the citizens' willingness to participate in CESs. Citizens should be empowered to take active role in steering the local energy initiatives.

1. Introduction

Transforming societies into sustainable patterns of production, consumption and prosumption is a key challenge of this century [1]. In addition to individual behavioral change, system wide transformation through collective action is required to solve the challenges of the present energy systems as collective action has historically been a successful motor of social transformation [2]. In this regard, local energy systems can potentially contribute to the efficient overall energy production and distribution and also help meeting climate objectives by helping reversal of energy consumption and emissions trends [3]. The energy system, providing heat and electricity to houses and businesses, is transforming from a centrally coordinated fossil-fuels powered system towards a bottom-up and decentralized low-carbon systems [4,5].

These developments provide new opportunities to create smarter, flexible, integrated and local systems such as community energy systems (CESs) creating value both for whole energy systems as well as the

end-users [3,6,7]. CESs provide new roles for local citizens and communities putting them at the centre of the energy system [3,8,9]. The acceptance, support and participation of citizens is essential to successfully manage these ongoing energy transitions [10].

Community energy systems (CESs) are considered an important modern development for low-carbon transition of the local energy system through energy system integration and community engagement [3]. CESs are multi-faceted energy systems for supplying a local community with its energy requirement from high-efficiency co-generation or tri-generation as well as from renewable energy technologies coupled with innovative energy storage solutions as well as electric vehicles and demand-side measures [6]. Households which are part of CESs can balance their energy requirement through local energy exchange. CESs focus on better synergies among different energy carriers as well as among local households. CESs aim not only at the self-provision for the local communities but can also provide system services to the energy systems such as balancing and ancillary services bringing additional revenue to the local communities.

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Local energy initiatives are becoming a societal movement in Europe, which indicates rapidly growing societal demand for sustainable and 'self-owned' energy with potentially significant impact on the energy system [11,12]. For example, there are around 2800 energy co-operatives in Europe, of which around 1000 energy co-operative are in Germany with 165,000 members [12–14]. With more than 313 local energy cooperatives and 50,000 citizens as members and increasing, local communities are expected to play a significant role in the transformation of the Dutch energy system [15,16]. However, with only 5.5% of its primary energy generated by renewables, The Netherlands is lagging behind all other EU member countries except Malta and Luxembourg [17]. This lag can be partly attributed to delays in offshore wind projects as well as to lagging energy efficiency projects in buildings. Yet, the role of the built environment, which consume approximately one-third of the total Dutch primary energy, and citizens participation therein, cannot be neglected [18]. This makes the Dutch case particularly interesting for analysing citizens' willingness to participate in local energy initiatives.

Moreover, the local energy initiatives are emerging with varying numbers, success rate and strategies in the Netherlands and Europe [19]. The diversity in success of these community initiatives could be partially attributed to prevailing structural, strategic and biophysical conditions. Community spirit, co-operative traditions and the norms of locality and responsibility as well as environmental concerns are central drivers behind the emergence and constitution of these local energy initiatives [20]. Demographic and socio-economic factors such as age, education, tax deduction, income are important determinants for renewables adoption in households [21]. These socio-institutional features along with other demographic, socio-economic and environmental factors might influence the way the citizens participate in the local energy systems.

The willingness of local citizens to engage in such local energy systems is vital. The willingness is defined as 'the quality or state of being prepared to do something [22]. For energy systems to provide more value to the society, different energy sectors at the local level have to be integrated with the engagement of the local communities [3,23,24]. Local citizens and communities engagement could lead to a low-carbon, affordable and secure energy system [25–28]. Local communities are well-placed to identify local energy needs, take proper initiatives and bring people together to achieve common goals such as the reduction of energy costs, CO₂ emissions and resiliency [26,29]. In the energy domain, literature to date that focusses on willingness, ranges from willingness to pay, willingness to accept, willingness to participate and willingness to adopt [2,10,21,30,31]. To the best of our knowledge, there is limited research to capture the opinion and attitude of Dutch citizens on the CESs formation, their willingness to participate and their determinants.

This study aims at determining the willingness of Dutch citizens to be part of local energy initiatives such as CESs. The influence of different motivations such as economic incentives, environmental concerns and energy independence as well as demographic and socio-economic characteristics in the willingness to participate in such systems is studied. The drivers which help emergence of CESs and the barriers which inhibit CESs are also investigated.

The goal of this research is to explore the extent to which people's willingness to participate can be predicted using demographic, socio-economic, socio-institutional and environmental factors. The goal is addressed empirically by surveying a sample of Dutch citizens. In order to have detailed understanding of willingness to participate in CESs factor analysis and multivariate regression are performed.

This paper is organized as follows. First, a brief review of literature and our research framework is presented in Section 2. In Section 3, methods and measures used in this study is reported. Section 4 presents the results of descriptive statistics, factor analysis and multi-variate regression analysis. Finally, Section 5 provides conclusions and policy recommendations.

2. Literature review and research framework

2.1. Community engagement in CESs

There is a substantial amount of literature indicating the importance of more deliberative and inclusive participation of consumers in the energy system [32,33]. Increasing numbers of consumers are becoming co-providers by engaging themselves in generating, storing, conserving, importing and exporting energy locally thanks to recent developments such as implementation of suitable policies, cost reduction of renewables and energy storage technologies, emergence of information and communication technologies (ICTs), as well as environmental awareness [34]. When consumers have more control, they tend to self-organize and co-operate to form a community energy system [20,35–39]. This makes more energy options at community level feasible, like community solar, wind farm, district heating, community energy storage and biogas production. Sometimes an integrated energy system at community level can be pursued when electricity and heat are generated together or when waste heat from nearby industry as well as flexibility of electric vehicles and storage systems could be utilized.

Local citizens can be engaged in CESs through several means subjected to particular CESs activities. Some examples of CESs activities are supply side activities, such as collective purchasing of solar panels or collective ownership of wind farms, and demand side activities, such as energy conservation, retrofitting of dwellings or energy awareness raising activities [11]. Although there are many benefits associated with citizens engagement in CESs, they also have several barriers and challenges [11,19,36,37]. The benefits of CESs include reducing energy cost, CO₂ emissions, and dependence on the national grid as well as (self-) governance. CESs help to increase penetration of intermittent renewables and bring new roles for the local communities such as flexibility and ancillary service providers [40]. CESs might provide cost-effective solutions to local congestions and help avoid or defer grid reinforcement foreseen with increasing penetration of the local renewables. The main barriers for implementation of bottom-up energy initiatives such as CESs come from the centralized design and regulation of present energy systems which do not always provide level playing field for CESs. CESs could often be inhibited by technical barriers such as lack of equipment, technical knowledge and expertise [37]. Other challenges include financing, operation, revenue adequacy, community participation as well as the fair allocation of costs and benefits. Despite being local initiatives, CESs might still face resistance from the local communities if they do not align with the local interests. For example, the issues of coordination and split-incentives can arise when costs and benefit of CESs do not boil down to the same actor.

In this research, the focus is on citizens' engagement through investment, volunteering as well as exchange of energy and the related demographic, socio-economic, socio-institutional and environmental factors.

2.2. User transformation

End-user transformation is a gradual and time consuming process. As presented in Fig. 1, the different levels of end user are awareness, participation and steering [41]. Awareness refers to citizens getting knowledge of the developments in the changing energy landscape including local energy projects. The citizens who are aware of these possibilities can either participate in an existing local energy project or set-up and steer their own local energy system. We use the notion of end-user from the centralized energy system. User transformation in energy system can be achieved through providing them with information, choice, and engaging them to provide flexibility to manage demand as well as supply. Local communities are being transformed by challenging their traditional identity as passive consumers to active prosumers, which are both consumers and producers. User engagement in implementation of local energy systems supports acceptance and

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