Trust, awareness, and independence

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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, CO_2 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, CO_2 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

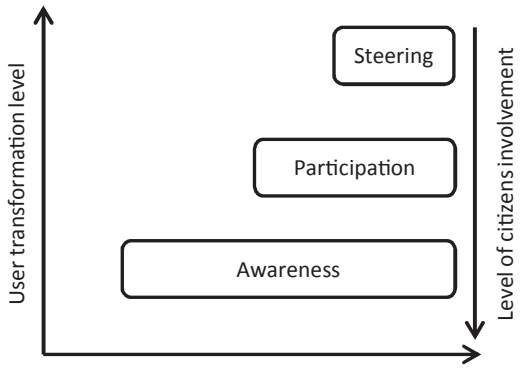

Fig. 1. User transformation in local energy system.

diffusion of novel technologies. End-user transformation also favor the emergence of innovative business models and technical solutions [41].

Local energy initiatives such as CESs emerge due to ongoing restructuring processes and changing energy landscape [3]. Fig. 1 also suggests that not all end-users will be driven by the process of user transformation and share of citizens willing to get involved shrinks from awareness to steering. Nevertheless, user transformation has potential to steer the energy system transformation [41]. In this research, the focus is on citizens willingness to participate in CESs and their willingness to steer transformative energy system such as CESs as well as their determinants.

2.3. Factors affecting CESs participation

Willingness to participate is vital for the success of novel community-based energy systems. In addition to community related factors for collective action, it is also affected by different factors affecting citizens' willingness to participate in renewable energy and energy efficiency projects. [10,21,42]. For example, despite large number of benefits of energy renovations, there are challenges to motivate Danish homeowners to participate in renovation of their homes [42]. Although community objectives such as economic incentives, environmental concerns and resiliency are important, different demographic and socio-economic factors such as age, family situation, home ownership, occupation and income affect citizens' willingness to participate [2,10]. Similarly, financial incentives such as tax deduction, energy price, age, household welfare status as well as perceived maintenance costs of renewables are statistically significant factors for willingness to adopt microgeneration in UK households [21]. Despite a general positive attitude of local citizens towards community energy in Germany, the willingness to participate in such systems is also affected by several socio-institutional and environmental factors such as social norm, trust, and environmental concern [10]. Therefore, a critical first step is to hypothesize what factors affect or might determine the willingness of Dutch citizens' to participate in CES initiatives.

2.3.1. Demographic factors

The willingness to participate may be affected by citizens' current position in life. Some of the key demographic factors that influence citizens willingness to participate in CESs are gender, age, education and income level [10,42,43].

2.3.2. Socio-economic factors

Socio-economic factors may play important roles in citizens' willingness to participate in local energy systems. Some of the key factors that influence citizens willingness to participate in CESs are homeownerships and energy bills [21].

2.3.3. Socio-institutional factors

Socio-institutional factors such as sense of community and trust may affect citizens' willingness to participate in CESs [10].

2.3.4. Environmental factors

Several environmental factors may play role on citizens willingness to participate in CESs. Pro-environmental factors such as ownership of distributed energy resources (DERs), resiliency, environmental concern and desire to reduce CO_2 emissions are expected to impact citizens willingness to participate in CESs [2,10,44].

These different demographic, socio-economic, socio-institutional and environmental factors are assumed to affect the Dutch citizens' willingness to participate in CESs. This research is set to determine the impact of these factors in willingness to participate in CESs and also to investigate which factors are more important in determining such willingness. Moreover, difference in factors affecting willingness to participate and willingness to steer local energy initiatives such as CESs will be determined.

3. Materials and methods

The research method is a statistical analysis based on an empirical survey conducted among a sample of the Dutch populations. The respondents for this survey are recruited with the assistance of students enrolled in an energy related course, at Delft University of technology. The students are instructed to pass on the link for the web based digital survey to mainly adult relatives and acquaintances, who could legally participate in community energy initiatives in their local area.

The questionnaire consists of statements, which respondents must rate based on the level of their agreement/disagreement for each statement. There are also some questions regarding respondents' familiarity with community initiatives and finally they are asked about demographics indicators such as: income, education, their housing situation and number of households.

In order to measure environmental concern of Dutch citizens several questions related to environment are included in the questionnaire. The respondents are asked about their interest in community-based energy system in general as well their acceptance towards local renewables based production such as solar PV and wind. The attitudes for local renewables and environmental concern were assessed on 5- or 7-Likert-type scale Higher scale were chosen due to the fact that survey questions with more categories are considered both more reliable and more valid [45].

First of all, the respondents were asked about their interests towards local energy initiatives such as CESs and their willingness to participate in such systems if the option is available at the local level in 5-likert type scale. The respondents were then asked regarding their willingness to volunteer and invest in the activities of CESs as well as their expectation regarding the payback period.

The scores that respondents to the statements, are used as measured observations to extract important factors affecting the willingness of local citizens to participate in CESs. These factors are determined through a factor analysis, using IBM SPSS software version 23 [46,47]. Factor analysis is used in order to simplify the data and to identify the underlying dimensions of willingness to participate in CESs.

Using the factor scores resulting from the factor analysis, a multivariate regression analysis is estimated. The multi-variate linear regression model is estimated, also using IBM SPSS software version 23, to predict willingness to participate in CESs [46,47]. This model uses the factor scores, as well as demographic and socio-economic variables to predict the importance of different variables on the willingness to participate. The inclusion of socio-demographic indictors is specifically done in order to make the regression analysis as representative as possible.

In order to perform these analysis the online survey is designed to include questions about demographics, socio-economic conditions, socio-institutional issues and environmental concerns as well as possible perceived drivers and/or barriers to participating in CESs.

Table 1
Demographic and socio-economic characteristics of the respondents.

Variables	Sample (N = 599) Frequency		Dutch average [47] Frequency
	Numbers	%	(%)
Gender			
Male	294	49	49.4
Female	305	51	50.6
Age			
15–24	85	14	12.3
25–34	74	12	12.1
35–44	56	9	14.6
45–54	232	39	15.0
55–64	116	19	13.2
65 +	33	6	15.6
Education			
Basic education	5	1	27
High school	54	9	
Secondary vocational education	59	10	
Higher vocational education	196	33	40
University education	282	47	33
Working hours per week			
0 (unemployed/retired)	91	15	–
1–10	41	7	–
11–20	59	10	
21–30	76	13	
31–40	173	29	–
40 +	156	26	
Income level			
basic	14	2	–
Less than € 28500	27	5	–
28500	62	10	–
Between €28500 and € 57000	151	25	–
Greater than € 57000	263	44	–
Do not want to disclose	79	14	–
House ownership			
Owners	478	80	60
Renters	121	20	40
Type of community			
Urban	452	76	90
Rural	147	24	10
Solar Panels ownership			
Yes	83	14	6
No	516	86	94

4. Results

The result of the survey is reported in the following three sub-sections. First, general descriptive statistics of the respondents who participated in this study are explained. Second, important factors affecting the willingness to participate are determined using factor analysis. Finally, a model to predict willingness to participate in CESs is developed using the results of factor analysis in multi-variate regression analysis.

4.1. Survey data and demographic analysis

The survey was performed in December 2015 using an online survey collector tool of Faculty of Technology, Policy and Management, Delft University of Technology. The online questionnaire was approached by 956 individuals form the Netherlands, of which 599 completed the survey. The response rate is 63 %. The demographic and socio-economic characteristics of the respondents is summarized in Table 1.

As can be seen from Table 1, among the respondents, were almost evenly distributed among men and women. Most respondents were of the age group between 45 and 54 years (39%); 26% were between 19 and 34 years, 9% between 35 and 44 years, 9% between 55 and 64 years, and 6% above 65 years. Regarding education level, 47% had university degree, 33% had higher vocational education, 10% had secondary vocational education and 9% had high school. The education level among our respondents is relatively skewed towards the higher educated section. Around 33% of the Dutch population have some sort of university degree compared to 47% in our sample and 40% of population have vocational education compare to 33% in our sample [48]. However, one should note that early adopters of innovative measures especially energy innovations are among the higher educated section of the society. This means that our sample could be more representative of the early adopters and technology enthusiasts [49,50].

The majority of the respondents were working full time (55%), 30% were working part-time and 15% had either no jobs or retired. As far as household level income is concerned, 44% reported income higher than € 57,000, 25% between € 28,500 and € 57,000, 17% below € 28,500, whereas 14% respondents did not disclose their income. Majority of the respondents (76%) live in urban area whereas 24% live in rural area.

4.1.1. Socio-institutional indicators

4.1.1.1. Sense of community. The sense of community is measured based on citizens involvement in the neighbourhood and number of neighbourhood activities. The respondents were asked how strongly they feel involved in their neighbourhood. Almost 47% of the respondents were neutral, whereas around 24% feel not involved in their neighbourhood and 29% feel strong involvement with their neighbourhood. The respondents were also asked regarding the numbers of neighbourhood activities organized per year. Almost one third (34.2%) of the respondents reported no neighbourhood activities, 30% reported one neighbourhood activities whereas 36% reported two or more neighbourhood activities per annum. Among the respondents, 79% are willing to work with their neighbourhood in the field of energy.

4.1.1.2. Community trust. The respondents were asked how much trust they have to the people of their community in 5- Likert-type scale. Among the respondents, 24% have no trust in their community, 29% neither trust nor distrust their community and 47% have trust in their community. The respondents were further asked if they have objection with the neighbours giving much less time in CESs project than themselves. Among the respondents, 14% will be so much offended that they will not like to participate in the CESs anymore, 47% will be objected but will continue to participate in CESs and 39% will not be affected at all.

4.1.2. Environmental indicators

The environmental questions helped to understand acceptance of general public towards renewables in general and community-based energy system in particular. Table 2 summarizes respondents' level of acceptance of the renewable energy sources.

The respondents find the sight of solar panel less disturbing than the sight of wind turbines, and the noise of wind turbines is the most disturbing. Among the respondents, 14% owned solar panels on their rooftop. 80% of the respondents showed awareness and positive interest towards the local energy systems such as CESs.

The respondents were also asked to rate the environmental and socio-economic-institutional drivers in Likert-type scales of 5 or 7 points. Table 3 summarizes the responses regarding the environmental

Table 2
Overview of renewables acceptance.

Renewable acceptance (N = 599)	Mean	SD	Scale
Sight of solar panels	3.82	1.242	5-point
Sight of wind turbines	2.94	1.295	5-point
Noise of wind turbines	2.71	1.25	5-point

Table 3
Drivers to participate in CESs.

	Drivers (N = 599)	Mean	SD	scale
Environmental	Good for the environment	5.45	1.55	7-point
	Climate change	4.10	0.98	5-point
	Less fossil-fuels consumptions	4.06	0.99	5-point
	CO2 emission reduction	4.25	0.91	5-point
Socio-economic-institutional	Economic benefits	5.19	1,54	7-point
	sense of community	3.80	1.72	7-point
	Democratic decision-making	3.67	1.14	5-point
	Regular updates on state of affairs	4.01	1.03	5-point
	Independence of national grid	3.62	1.87	7-point
	Independence from big energy suppliers	3.25	1.17	5-point
	Plenty of leisure time	2.45	1.59	7-point
	Awareness of local energy project	3.14	1.70	7-point

and socio-economic-institutional drivers to participate in CESs.

In addition, participants were asked what they think will inhibit them the most to set up or participate in CESs among lack of time, financial reasons, satisfaction with current energy systems, lack of trust in neighbourhood to develop CESs, not enough skills to support CESs or other reasons of their choice. The perceived barriers to participate in the CESs as presented in Fig. 2 are, lack of time (37%), financial reasons (18%), satisfaction with the current energy systems(16%), no trust in neighbourhood to develop CESs (9%), not enough skills to support CESs (10%) and other reasons (10%). The perceived barriers are in line with what has been reported in the literature which are lack of financing and technical expertise as well lack of technical support [33,51,52].

4.2. Willingness to participate and steer

Among the participants, 80% of the respondents showed positive interests towards CESs. As far as willingness to participate in CESs is concerned, 53% of the respondents showed positive willingness whereas 31 % of the respondents were undecided and choose the option to be neutral, and 16% of the respondents showed negative willingness to participate in CESs, as presented in Table 4.

In addition, we also asked participants about their willingness to invest and volunteer in CESs. Although education and income level positively impacted the willingness to investment, the willingness to volunteer does not seems to be correlated with a part-time or full-time employment of the respondents. Citizens' with house ownerships and male citizens are more likely to participate in CESs. Majority of the respondents expect return in investment within 10 year. In fact, only 14% of the respondents are fine with payback period higher than 10 years.

The survey participants were also asked which organizational responsibilities they are willing to undertake to steer CES activities. The participants could choose one among the following options a) not willing to participate in CESs, b) willing to participate without organizational responsibilities, c) willing to participate with minor organizational responsibilities such as attending members meeting, and d) willing to participate with substantial responsibility of steering a CESs. Among the respondents, 25% are not willing to participate at all, 37% are willing to participate but without organizational responsibility, 30% are willing to participate with minor responsibility such as attending member meeting, and 8% are willing to participate with substantial responsibility of steering the CESs such as member of the board.

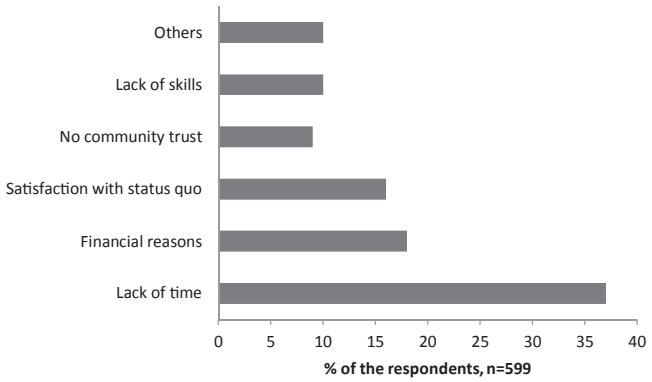

Fig. 2. Perceived Barriers to participate in ICESs.

User transformation level namely awareness, participation and steering were measured. To measure awareness, we asked participants if they have heard of CESs. Citizens' willingness to participate in CES is measured through 5-Likert-type scale. The Citizen's wiliness to steer CES was measured by asking participants which organizational responsibilities they are willing to undertake to steer CES activities as described in previous paragraph. The decreasing share of citizens' engagement with user transformation level is also validated, as presented in Fig. 3. Among the participants, 80% were aware of local energy projects such as CESs, 53% were willing to participate and 8% were willing to steer different activities of CES.

4.3. Factor analysis

Initially, the factorability of the 17 variables measured in the survey was examined. It has been observed that 14 out of 17 variables correlated at least, suggesting reasonable factorability. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.783. This indicates that the patterns of the correlations are relatively compact and factor analysis should yield distinct and reliable factors. The Bartlett's test of Sphericity was also significant ($\chi^2(136) = 3218$, $p < .001$). This means that the correlation matrix is not an identity matrix and there are some relationships between the variables being tested. Both KMO test and Bartlett's test confirm that the factor analysis is appropriate.

The initial eigenvalues associated with each factor represent the variance explained by that particular component and indicate the substantive importance of that factor. Initial eigenvalues indicate that the first five factors have eigenvalues just over one and explain 25%, 12%, 11%, 9% and 6% of the variance respectively. The five factor solution, which explains 63% of the variance is preferred because of the levelling off of eigenvalues in the scree plot after five factors. The extraction method used is principal axis factoring [47]. It is preferred over the more common principal component analysis when using factor analysis in causal modelling. In this research the focus is on the dimensions of willingness to participate in CESs and therefore the principal axis factoring method is used. After extraction, the five factors explained 22%, 10%, 9%, 6% and 3% of the variance respectively and 49% of the variance cumulatively.

The factors are rotated to approach a simple structure. As the factors are expected to correlated, direct oblimin rotation method is used [47]. Then, the factor labels were proposed after carefully looking at the related variables in the analysis and presented in Table 5. These are environmental concern, renewables acceptance, energy independence, community trust and community resistance, respectively. Factor scores were created for each of the five factors so that it can be used in subsequent analysis such as regression in the following sub-section.

4.4. Regression analysis

According to the results reported in Table 6, a regression equation is found which represents a substantial share of variance *(adjusted $R^2 = 0.39$, $F(14) = 23.46$, $p < .001$)* in the willingness to participate in CESs. According to the standardized coefficients, the statistically significant predictor in the order of importance are community trust ($\beta = .273$, $p < .001$) community resistance ($\beta = -.228$, $p < .001$),

Table 4
Willingness to participate in CESs.

Measures (N = 599)	Willingness (%)					Mean	SD	Scale
	Not very willing	Not willing	Neutral	Willing	Very willing			
Willingness to participate	6.2	9.5	31.4	44.9	8.0	3.39	0.98	5-point

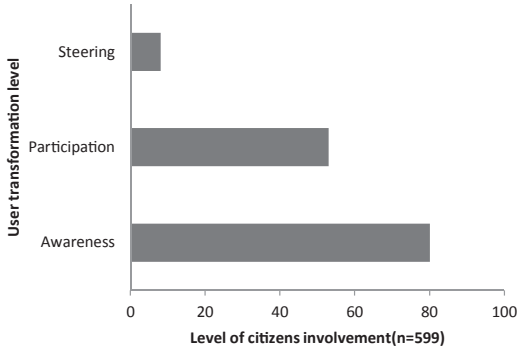

Fig. 3. User transformation vs. level of citizens' engagement.

energy independence ($\beta = .152$, p < .001), environmental concern ($\beta = .149$, p < .001), energy-related education ($\beta = .133$, p < .001), education ($\beta = .117$, p < .01) and awareness ($\beta = .09$, p < .05) about local energy initiatives. Age, gender, solar PV ownership, house-ownership, income, type of community as well as economic incentives are not statistically significant. The negative coefficient in community resistance indicate the inverse relation between willingness to participate and community resistance. The case of solar PV ownership is particularly interesting as many respondents with solar panels perceived that they could not take part in other local energy initiatives such as CESs.

A closer look at residual statistics and case-wise diagnostics showed the three cases as outliers for the regression analysis. However, no case with Cook's distance greater than one is found. It can be concluded that the influential data point(s) does not exist and the result of the regression analysis can be trusted.

5. Conclusions and discussions

Citizens' participation in the energy system is essential to sustain the ongoing energy system transformation. In this research, we introduced and tested a conceptual framework focusing on demographic, socio-economic, socio-institutional and environmental factors affecting the willingness of local citizens to participate in novel community-based energy systems such as integrated community energy systems (CESs). The percentage of the respondents willing to participate in such systems is slightly above the majority whereas one-third still remain undecided. The percentage of respondents willing to steer such systems, however, is rather small. The perceived barriers from local citizens in participation in CESs are lack of time, financial resources, technical expertise. Many respondents who already owned a PV installation perceived that as a barrier to participate in CESs.

The willingness of local citizens to participate in CESs is driven by environmental factors such as environmental concern and climate change as well as by community related socio-institutional factors such as community trust, and energy independence. The factor analysis exhibited that environmental concern, renewables acceptance, energy

Table 6
Coefficients of the regression analysis.

	Unstandardized Coefficients		Standardized Coefficients
	B	Std. error	Beta
(Constant)	2.480***	.278	
Environmental concern factor	.151***	.041	.149
Renewables acceptance factor	.066	.037	.066
Energy Independence factor	.166**	.055	.152
Community trust factor	.308***	.051	.273
Community resistance factor	−.259***	.060	−.228
Age	−.001	.003	−.008
Gender (female = 1)	−.074	.071	−.039
Education	.114**	.037	.117
Income	.007	.040	.007
Type of community (rural = 1)	−.046	.079	−.021
Energy education	.098***	.029	.133
House ownership (owner = 1)	.162	.114	.063
PV ownership (owner = 1)	−.143	.102	−.052
Awareness (Aware = 1)	.173*	.071	.090
Economic incentives	.013	.024	.021

Adjusted R square 0.39. Dependent variable: Willingness to participate in ICES.
* p < .05.
** p < .01.
*** p < .001.

Table 5
Factor analysis.

	Environmental concern	Renewable Acceptance	Energy independence	Community Trust	Community resistance
Good for the environment	.591				
Familiarity with CESs					−.635
Plenty of time					−.461
Grid independence			.623		
Positive sense of belongingness to the community					−.514
CO2 reduction	.906				
Fossil fuels reduction	.855				
Climate change	.868				
Independence from big energy suppliers			.847		
Sense of community				.821	
Trust in community				.667	
Acceptance of solar panels		.461			
Acceptance of wind turbines		.969			
Wind turbine noise tolerance		.601			

independence, community trust and community resistance are important factors in determining the willingness to participate in CESs. These normative positions of local citizens might partly guide their decisions and practices, thereby strongly affecting their willingness to participate in local energy initiatives such as CESs. The multi-variate regression analysis exhibits that community trust factor is the most important and statistically significant predictor of willingness to participate in CESs followed by community resistance, energy independence, and environmental concern factor as well as education, energy-related education and awareness about local energy initiatives. Age, gender, solar PV ownership, house-ownership, income, type of community are not statistically significant predictors.

This research reveals that a large share of the surveyed citizens are aware of local energy initiatives and exhibited positive interest towards CESs. This indicates a large potential for local energy initiatives in the Netherlands. The results of this research help in formation and operation of CESs by indicating the factor influencing citizens participation. With more than 500 local energy initiatives in place, more local communities could contribute in increasing the share of renewables in the Dutch energy mix.

Although the survey was based in the Netherlands, the results of this study could be useful in implementation and successful operation of CESs in other parts of the world as well. In particular, important factors such as community trust, environmental concern, energy independence as well as community resistance should be taken into account in such initiatives. The positive interests in local energy projects and higher acceptance of renewables could be useful to increase the share of renewables through community-based initiatives such as CESs. Despite the large share of the respondents showing positive interests in local energy initiatives such as CESs, the research also showed that the share of citizens' involvement diminishes from participation to steering.

As the data used in this research were collected through a survey, this research could have some limitation. For example, As the survey was mainly focused on intention of citizens to participate in CESs, the share of citizens willing to participate could be even lower in CES implementation. In order to obtain more reliable and valid responses on willingness to participate we used 5-Likert-type scale. In addition, we also asked about their willingness to invest and volunteer. Further research could distinguish between existing members and non-members of the local energy initiatives. As citizens willingness to steer local energy found to be rather low, future research could focus on factor influencing willingness to steer local energy systems.

For the successful energy transition, the society also needs to transform. The European Union and its member state policy on end-users involvement are still based on the traditional and centralized energy systems focusing on individual consumers-suppliers relations and undermines the possibility of collective action through local energy initiatives. A level playing field for enabling collective action should be provided. Policy makers should focus on removing the perceived barriers through empowerment of local communities and on increasing citizens' willingness to steer local energy systems. Nevertheless, this study showed that different demographic, socio-economic, environmental and socio-institutional factors should not be neglected while initiating local energy initiatives such as CESs. The relevance of these factors highlights the dynamics of citizens' participation in CESs which play transformative role in transition towards more sustainable and inclusive society. Increasing citizens' participation in CESs will transform it from a niche to a more mainstream system with higher relevance for the whole energy system.

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