Willingness to Participate in Integrated Community Energy Systems

Abstract

In order to decarbonize the energy sector, there is widespread consensus that the role of end-users in the energy system should change from passive consumption to an active 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 integrated community energy systems (ICESs). Through system integration and community engagement ICESs assists 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 ICESs 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 ICESs. Factor and multi-variate regression analysis reveals the importance of environmental concern, renewables acceptance, energy independence, community trust, community resistance, education, energy related education and awareness about local energy initiatives in determining the citizens' willingness to participate in ICESs.

Keywords: Energy communities, Distributed energy resources, Energy transition, Citizen participation

1. Introduction

Transforming societies into sustainable patterns of production and consumption 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 and 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 and integrated systems such as integrated community energy systems (ICESs) creating value both for whole energy systems as well as the end-users [3,6,7]. ICESs provide new roles for local citizens and communities putting them at the centre of the energy system [3,8]. The acceptance, support and participation of citizens is essential to successfully manage these ongoing energy transitions [9].

Integrated community energy systems (ICESs) are considered an important modern development for low-carbon transition of the local energy system through energy system

integration and community engagement [3]. ICESs 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 ICESs can balance their energy requirement through local energy exchange. ICESs focus on better synergies among different energy carriers as well as among local households. ICESs 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 communities.

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 [10]. With more than 500 local energy initiatives, local communities are expected to play a significant role in the transformation of the Dutch energy system [11]. 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 [12]. 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 [13]. 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 [14]. 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[15]. Demographic and socio-economic factors such as age, education, tax deduction, income are important determinants for renewables adoption in households[16] 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 [17]. 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. Local citizens and communities engagement could lead to a low-carbon, affordable and secure energy system. 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 [18,19]. 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 [2,9,16,20,21]. To the best of our knowledge, there is limited research to capture the opinion and attitude of Dutch citizens on the ICESs 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 ICESs. 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 ICESs and the barriers which inhibit ICESs are also investigated.

The main research questions for this study are:

a) What is the willingness of local citizens to participate in ICESs?
b) What are the most important socio-institutional and environmental factors associated with willingness to participate in ICESs?
c) To what extent can people's willingness to participate be predicted using demographic, socio-economic, socio-institutional and environmental factors? What are the main influential factors?

These research questions are answered empirically by surveying a sample of Dutch citizens. In order to have detailed understanding of willingness to participate in ICESs multivariate regression and factor analysis is 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 ICESs**

There is a substantial amount of literature indicating the importance of more deliberative and inclusive participation of consumers in the energy system [22,23]. 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, emergence of information and communication technologies (ICTs) and environmental awareness [24]. When consumers have more control, they tend to self-organize and co-operate to form a community energy system [15,25–29]. 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.

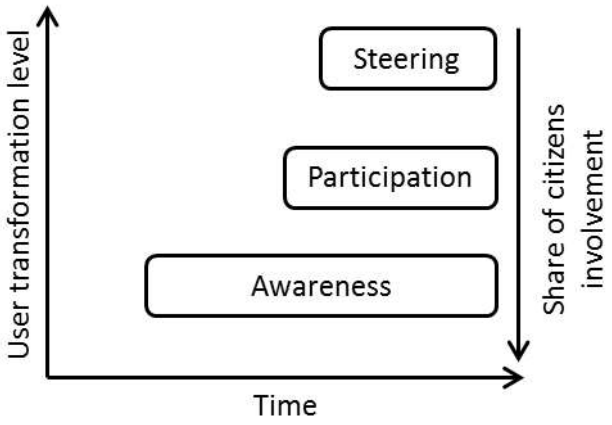
Local citizens can be engaged in ICESs through several means subjected to particular ICESs activities. Some examples of ICESs activities are supply side activities, such as collective purchasing of solar panels or collective ownership of wind farms, and demand side activities, such as energy conservation, retrofitting of dwellings or energy awareness raising activities [10]. Although there are many benefits associated with citizens engagement in ICESs, they also have several challenges [27] [26] [14] [10]. 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 process. As presented in figure 1, the different levels are awareness, participation and steering [30]. 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 diffusion of novel technologies. End-user transformation also favor the emergence of innovative business models and technical solutions [30].

Figure 1: User transformation in local energy system



Local energy initiatives such as ICESs emerge due to ongoing restructuring processes and changing energy landscape [3]. Figure 1 also suggests that not all end-users will we driven by the process of user transformation and the level of involvement of citizens shrinks from awareness to steering. Nevertheless, user transformation has potential to steer the energy system transformation [30]. In this research, the focus is on citizens willingness to participate in ICESs and their willingness to steer transformative energy system such as ICESs as well as their determinants.

2.3 **Factors affecting ICESs 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. [9,16,31]. For example, despite large number of benefits of energy renovations, there are challenges to motivate Danish home-owners to participate in renovation of their homes [31]. 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. 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 [16]. 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 in community, and environmental concern [9]. Therefore, a critical first step is to hypothesize what factors affect or might determine the willingness of Dutch citizens' to participate in ICES initiatives.

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 ICESs are gender, age, education and income level [9,31,32] .

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 ICESs are home-ownerships and energy bills [16].

Socio-institutional factors: Socio-institutional factors such as sense of community and trust may affect citizens' willingness to participate in ICESs [9].

Environmental factors: Several environmental factors may play role on citizens willingness to participate in ICESs. Pro-environmental factors such as ownership of distributed energy resources (DERs), resiliency, desire to reduce CO_2 emissions are expected to impact citizens willingness to participate in ICESs [2,9,33].

These different demographic, socio-economic, socio-institutional and environmental factors are assumed to affects the Dutch citizens' willingness to participate in ICESs. This research is set to determine the impact of these factors in willingness to participate in ICESs 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 ICESs will be determined.

3 Materials and Methods

The research method is a statistical data analysis based on an empirical survey conducted among a sample of the Dutch populations. The important factors affecting the willingness of local citizens to participate in ICESs are determined through a factor analysis. Using the factor scores resulting from the factor analysis, a multi-variate regression analysis is estimated.

3.1 Survey data

Data were collected in December 2015 using an online survey collector tool of Faculty of Technology, Policy and Management, Delft University of Technology, the Netherlands. The online questionnaire was send to 956 Dutch citizens of which 599 completed the survey. The response rate is 63 %. The demographic and socio-economics of the respondents is summarized in Table 1.

3.2 Measures

The online survey consisted of 37 questions about demographics, socio-economic conditions, socio-institutional issues and environmental concerns as well as perceived drivers and barriers to participate in ICESs.

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

Variables	Sample(N=599)	
	Frequency	
	Numbers	%
Gender		
Male	294	49
Female	305	51
Age		
15-24	85	14
25-34	74	12
35-44	56	9
45-54	232	39
55-64	116	19
65+	33	6
Education		
Basic education	5	1
High school	54	9
Secondary vocational education	59	10
Higher vocational education	196	33
University education	282	47
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
Renters	121	20
Type of community		
Urban	452	76
Rural	147	24
Solar Panels ownership		
Yes	83	14
No	516	86

3.2.1 Demographic factors

Among the respondents, 51% were female and 49% were male. 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 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.

3.2.2 Socio-economic factors

80% of the respondents are owner of their house. The monthly energy (gas and electricity) bills of the majority of the households (52%) was higher than € 125.

3.2.3 Socio-institutional factors

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.

Community Trust: The respondents were asked how much trust they have to the people of their community. 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 ICESs project than themselves. Among the respondents, 14% will be so much offended that they will not like to participate in the ICESs anymore, 47 % will be objected but will continue to participate in ICESs and 39 % will not be affected at all.

3.2.4 Environmental factors

In order to measure environmental concern of Dutch citizens several questions related to environment were included in the questionnaire. The respondents were 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 were assessed on a Likert-type scale from 1 (very negative) to 5 (very positive) and summarized in Table 2. The respondents find the sight of solar panel less disturbing than the sight of wind turbines whereas the noise of wind turbines is the most disturbing. These questions helped to understand acceptance of general public towards renewables in general and community-based energy system in particular. Among the respondents, 14% also own solar panels on their rooftop. 80 % of the respondents showed positive interest in the local energy systems such as ICESs.

Table 2: Overview of renewables acceptance

Measures (N=599)	Renewables acceptance (%)					Mean	SD	Scale
	Very negative	negative	Neutral	positive	Very positive			
Sight of solar panels	6.2	10.9	17.9	24.9	40.2	3.82	1.242	5-point
Sight of wind turbines	16.5	22.4	25.9	20.5	14.7	2.94	1.295	5-point
Noise of wind turbines	19.2	28.0	25.5	16.5	10.7	2.71	1.25	5-point

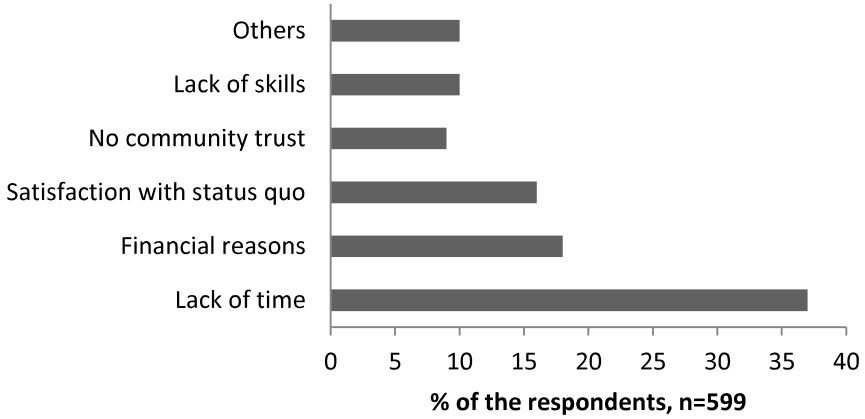
The respondents were also asked to rate the environmental and socio-economic-institutional drivers in Likert-type scales of 5 or 7 points. Table 3 summarizes the responses regarding the environmental and socio-economic-institutional drivers to participate in ICESs.

Table 3: Drivers to participate in ICESs

	(N=599)	Drivers(%)							Mean	SD	Scale
		Entirely disagree	Mostly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Mostly agree	Entirely agree			
Environmental	Good for the environment	4	2.3	4.7	9.8	21.9	27.7	29.5	5.45	1.55	7-point
	Climate change	-	2.5	4.2	16.0	35.9	41.4	-	4.10	0.98	5-point
	Less fossil-fuels consumptions	-	2.5	4.7	16.5	36.9	39.4	-	4.06	0.99	5-point
	CO2 emission reduction	-	2.0	3.2	10.7	36.2	47.9	-	4.25	0.91	5-point
Socio-economic-institutional	Economic benefits	3.5	3.5	5.5	16.0	22.5	27.5	21.4	5.19	1,54	7-point
	Community identity	14.5	11.5	12.5	22.9	22.2	11.9	4.5	3.80	1.72	7-point
	Democratic decision-making	-	6.2	7.7	26.2	32.9	27.0	-	3.67	1.14	5-point
	Regular updates on state of affairs	-	4.3	3.2	17.4	37.7	37.4	-	4.01	1.03	5-point
	Independence of national grid	18.7	14.2	14.0	18.9	14.9	12.9	6.5	3.62	1.87	7-point
	Independence from big energy suppliers	-	8.7	16.2	33.7	24.2	17.2	-	3.25	1.17	5-point
	Plenty of leisure time	38.7	21.9	14.4	13.9	5.3	3.3	2.5	2.45	1.59	7-point
	Awareness of local energy project	23.4	17.7	15.4	21.9	11.9	6.7	3.2	3.14	1.70	7-point

In addition, participants were asked what they think will inhibit them the most to set up or participate in ICESs. The perceived barriers to participate in the ICESs as presented in Figure 2 are, lack of time (37%), financial reasons (18%), satisfaction with the current energy systems(16%), no trust in neighbourhood to develop ICESs (9%), not enough skills to support ICESs (10%) and other reasons (10%). The other reasons reported are, too much focus on the environment, trust in the government, limited thinking space, too big risk, already ownership of solar panels and heat-pumps, expectation of government initiative, financial sustainability, inclusive rent, old age, moving in near future, renting, no interest in initiative and leadership, lack of experience and already participating in a local energy system. 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 [23,34,35].

Figure 2: Perceived Barriers to participate in ICESs



4 Results

The result of the survey is reported in the following three sub-sections. First, general descriptive statistics with respect to willingness to participate and willingness to steer is presented. Second, important factors affecting the willingness to participate are determined using factor analysis. Finally, a model to predict willingness to participate in ICESs is developed using the results of factor analysis in multi-variate regression analysis.

4.1 Willingness to participate and steer

First of all, the respondents were asked about their interests towards local energy initiatives such as ICESs 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 ICESs as well as their expectation regarding the payback period.

Among the participants, 80% of the respondents showed positive interests towards ICESs. As far as willingness to participate in ICESs 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 ICESs, as presented in Table 4. As illustrated in Table 5, 73 % of the respondents are willing to invest in ICESs and approximately same amount of the citizens are willing to volunteer. 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.

Table 4: Willingness to participate in ICESs

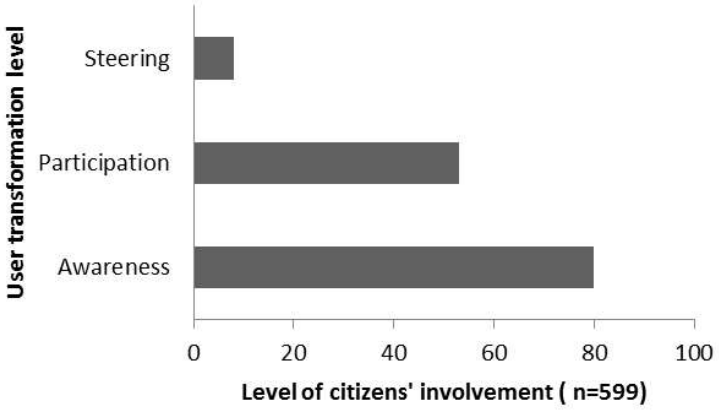
Measures (N=599)	Willingness (%)					Mean	SD	Scale
	Not very willing	Not willing	Neutral	Willing	Very willing			
Willingness to participate	6.2	9.5	31.4	44.9	8.0	3.39	0.98	5-point

Table 5: Willingess to invest and volunteer in ICESs

Measures (N=599)	Willingness (%)		
	Low	Medium	High
Willingness to volunteer	27.7	41.6	30.7
Willingness to invest	27.0	42.9	30.1

The survey participants were also asked which organizational responsibilities they are willing to undertake to steer ICES activities. 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 ICESs such as member of the board. In accordance with the Figure 1, the latter represents the respondents willing to steer the ICESs, thereby transforming the energy system. The hypothesis on decreasing share of citizens' engagement with user transformation level is also validated, as presented in Figure 3.

Figure 3: User transformation vs. level of citizens' engagement



4.2 Factor analysis

Factor analysis is used in order to simplify the data and to identify the underlying dimensions of willingness to participate in ICESs. Initially, the factorability of the 17 variables 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 ($x^2(136) = 3218$, $p < 0.001$). 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. 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 ICESs 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. Then, the factor labels were proposed after carefully looking at the related variables in the analysis and presented in Table 6. 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.

Table 6: Factor analysis

	Environmental concern	Renewable Acceptance	Energy independence	Community Trust	Community resistance
Willingness to participate					
Good for the environment	,591				
Economic incentives					
Familiarity with ICESs					-,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	
Neighborhood activities					
Trust in community				,667	
Acceptance of solar panels		,461			
Acceptance of wind turbines		,969			
Wind turbine noise tolerance		,601			

4.3 Regression analysis

A multi-variate linear regression model was estimated to predict willingness to participate in ICESs based on the factor scores from the previous section as well as demographic and socio-economic variables. This is specifically done in order to make the regression analysis as representative as possible.

According to the results reported in Table 7, a regression equation is found which represents a substantial share of variance *(R^2 = 0.41, F(15) = 21.88, p < .001)* in the willingness to participate in ICESs. According to the standardized coefficients, the statistically significant predictor in the order of importance are community trust, community resistance, energy independence, environmental concern, energy-related education, education and awareness 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 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 ICESs.

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.

Table 7: 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 0.388

Dependent variable: Willingness to participate in ICES

Notes: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

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 (ICESs). A large share of the surveyed citizens are aware of local energy initiatives and exhibited positive interest towards ICESs. The percentage of the respondents willing to participate in such systems is slightly above the majority whereas one-third still remain undecided. Respondents exhibited similar willingness to volunteer and invest in ICESs. 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 ICESs. The percentage of respondents willing to steer such systems, however, is rather small.

The perceived barriers from local citizens in participation in ICESs are lack of time, financial resources, technical expertise. Many respondents who already owned a PV installation perceived that as a barrier to participate in ICESs.

The willingness of local citizens to participate in ICESs 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 independence,

community trust and environmental resistance are important factors in determining the willingness to participate in ICESs. 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 ICESs. The multi-variate regression analysis exhibits that community trust factor is the most important and statistically significant predictor of willingness to participate in ICESs 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.

Although the survey was based in the Netherlands, the results of this study could be useful in implementation and successful operation of ICESs 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 ICESs. Despite the large share of the population in local energy initiatives such as ICESs, the research also showed that the share of citizens' involvement diminishes from participation to steering. As the survey was mainly focused on intention of citizens to participate in ICESs, the share of citizens could be even lower in ICES implementation.

The European 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 ICESs. The relevance of these factors highlights the dynamics of citizens' participation in ICESs which play transformative role in transition towards more sustainable and inclusive society. Increasing citizens' participation in ICESs will transform it from a niche to a more mainstream system with higher relevance for the whole energy system.

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Figure

Figure 1: User transformation in local energy system

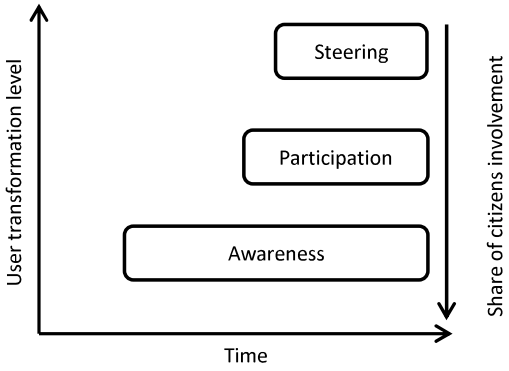

Figure 2: Perceived Barriers to participate in ICESs

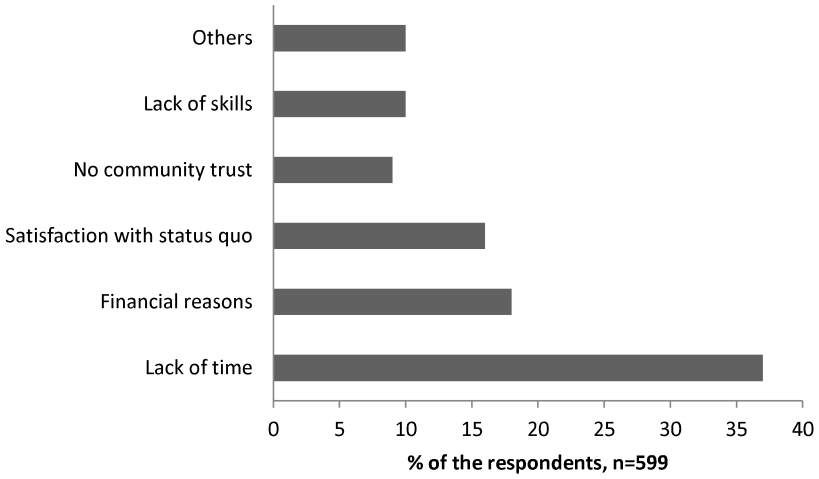

Figure 3: User transformation vs. level of citizens' engagement

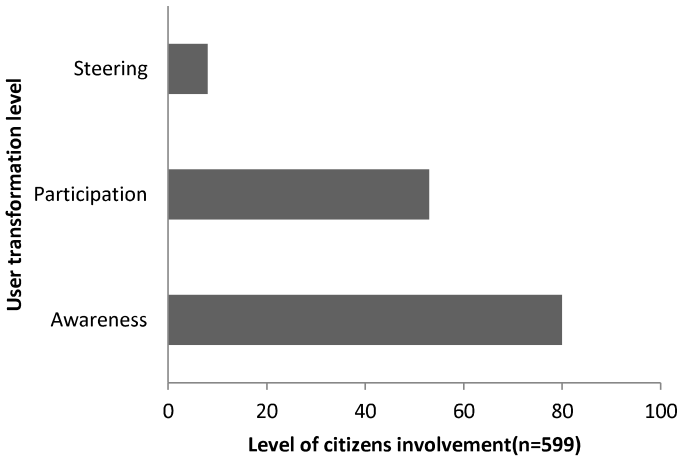

Table 1

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

Variables	Sample(N=599)	
	Frequency	
	Numbers	%
Gender		
Male	294	49
Female	305	51
Age		
15-24	85	14
25-34	74	12
35-44	56	9
45-54	232	39
55-64	116	19
65+	33	6
Education		
Basic education	5	1
High school	54	9
Secondary vocational education	59	10
Higher vocational education	196	33
University education	282	47
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
Renters	121	20
Type of community		
Urban	452	76
Rural	147	24
Solar Panels ownership		
Yes	83	14
No	516	86

Table 2

Table 2: Overview of renewables acceptance

Measures (N=599)	Renewables acceptance (%)					Mean	SD	Scale
	Very negative	negative	Neutral	positive	Very positive			
Sight of solar panels	6.2	10.9	17.9	24.9	40.2	3.82	1.242	5-point
Sight of wind turbines	16.5	22.4	25.9	20.5	14.7	2.94	1.295	5-point
Noise of wind turbines	19.2	28.0	25.5	16.5	10.7	2.71	1.25	5-point

Table 3

Table 3: Drivers to participate in ICESs

	(N=599)	Drivers(%)							Mean	SD	Scale
		Entirely disagree	Mostly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Mostly agree	Entirely agree			
Environmental	Good for the environment	4	2.3	4.7	9.8	21.9	27.7	29.5	5.45	1.55	7-point
	Climate change	-	2.5	4.2	16.0	35.9	41.4	-	4.10	0.98	5-point
	Less fossil-fuels consumptions	-	2.5	4.7	16.5	36.9	39.4	-	4.06	0.99	5-point
	CO2 emission reduction	-	2.0	3.2	10.7	36.2	47.9	-	4.25	0.91	5-point
Socio-economic-institutional	Economic benefits	3.5	3.5	5.5	16.0	22.5	27.5	21.4	5.19	1,54	7-point
	Community identity	14.5	11.5	12.5	22.9	22.2	11.9	4.5	3.80	1.72	7-point
	Democratic decision-making	-	6.2	7.7	26.2	32.9	27.0	-	3.67	1.14	5-point
	Regular updates on state of affairs	-	4.3	3.2	17.4	37.7	37.4	-	4.01	1.03	5-point
	Independence of national grid	18.7	14.2	14.0	18.9	14.9	12.9	6.5	3.62	1.87	7-point
	Independence from big energy suppliers	-	8.7	16.2	33.7	24.2	17.2	-	3.25	1.17	5-point
	Plenty of leisure time	38.7	21.9	14.4	13.9	5.3	3.3	2.5	2.45	1.59	7-point
	Awareness of local energy project	23.4	17.7	15.4	21.9	11.9	6.7	3.2	3.14	1.70	7-point

Table 4

Table 4: Willingness to participate in ICESs

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

Table 5

Table 5: Willingness to invest and volunteer in ICESs

Measures (N=599)	Willingness (%)		
	Low	Medium	High
Willingness to volunteer	27.7	41.6	30.7
Willingness to invest	27.0	42.9	30.1

Table 6

Table 6: Factor analysis

	Environmental concern	Renewable Acceptance	Energy independence	Community Trust	Community resistance
Willingness to participate					
Good for the environment	,591				
Economic incentives					
Familiarity with ICESs					-,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	
Neighborhood activities					
Trust in community				,667	
Acceptance of solar panels		,461			
Acceptance of wind turbines		,969			
Wind turbine noise tolerance		,601			

Table 7

Table 7: 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 0.388

Dependent variable: Willingness to participate in ICES

Notes: *p < 0.05, **p < 0.01, ***p < 0.001