Doctoral Dissertation
Doctoral Program in Urban and Regional Development (33rd Cycle)

Beyond the Build Environment: the Role of the Human Dimension towards a Co-ownership in a Sustainable Energy Community

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September, 2021

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Maria Valentina Di Nicoli

Torino, September 2021

Summary

Nowadays, considering the several environmental issues that are leading to changes, even important ones, in the biosphere, a paradigm shift related to our choices, in different aspect of our life, is necessary.

Climate change is a reality and only paying attention to the carbon budget, the concentration of CO_2 present in the atmosphere that is allowed to erode, and pursuing behavioural paths, it is possible to avoid an increase of the global average temperature higher than 2°C, compared to the pre-industrial average temperature. The decarbonization process and the energy transition, understood as a process aimed not only at avoiding the use of energy resources from fossil sources in favour of renewable ones, but also at improving the energy efficiency related to the energy production and at defining more conscious energy consumption and choices by users/citizens, are part of this perspective. For this purposes, with regards the construction sector, a series of laws and incentives have been enacted, in order to promote the achievement of the planned energy and environmental objectives. These provisions are aimed at achieving a certain energy efficiency requirement in a given time and, mainly, concern the envelope and the energy system, i.e. the material component of buildings. However, the city system is made up not only of buildings, technologies and infrastructures but, also, of users, citizens, that play a fundamental role. Indeed, several possible scenarios of energy retrofit, established by regulations and promoted by incentives, may not reflect the real situation of intervention. In other words, the proposed scenarios may not achievable due to the influence of individual' features: when individual/citizen is called upon to make a decision or to carry out a behaviour, various characteristics (social, demographic, economic, psychological, attitudinal, etc. drivers) intervene, determining the users' possibilities in engaging or not engaging in actions, behaviours or initiatives. Consequently, the social component is also important and, only in recent years, a

legislative framework is being formed (at different levels - national and European) paying also the attention to the users, to the citizens, promoting their active role through the establishment of an energy community (EC). An EC represents the union of several users (municipalities, small and medium-sized enterprises (SMEs) and citizens), located in a specific area, who share the willingness to self-produce and self-consume energy from renewable sources; it is an innovative model of supply, distribution and consumption of energy with the aim at facilitating its production and exchange between users. Social acceptance and sense of community play a key role in the energy communities.

The main objective, addressed by this Ph.D. research, is understood if the energy communities are potential solution to achieve energy transition objectives. In this regard, the dissertation sets the following purposes:

- to define which elements make up an energy community and which relationships are established between them.
- to structure a work path that leads to the creation of energy communities.
- to analyse and to study the existing literature in order to define a new classification of the factors/variables that affects the energy consumption and behavioural choices of users.
- to define strategies to involve citizens in active participating in an energy community;
- to extrapolate users' profiles who share the same characteristics in order to promote tailor-made environmental and energy policies.

A first study of the literature and a discussion with a panel of experts highlighted how energy communities are based on the synergy of three elements: the technical structure (building identification, data collection, definition of energy retrofit alternatives and best scenario selection), the social structure (identification of key persons, informative event and workshop organization and questionnaire administration) and the legal and financial structure (definition of financial contract/agreement and co-ownership implementation). The definition of the relationships between these elements led to the work path drafting concerning the methodology underlying the energy community creation. The research wanted to go beyond the built environment (public and/or private buildings) and, mainly, to focus its attention on the less investigated component, the human dimension. Since there is a gap between expectation and reality, the role of the user, of the citizen, as an individual with an active role (prosumer), is analysed in detail, paying attention not only to citizens represented by men, high-income people and with a high level of education; but to different segments of population, including underrepresented and vulnerable people which are usually not included in community-based projects. On one side, through informative events and workshops citizens were actively included in the debate on energy communities; through activities tailored to each type of stakeholder, the different visions of the energy community were defined and the strengths and weaknesses were explored. Contextually, the existing scientific literature on energy saving behaviours, on energy efficiency investment actions and on engagement in renewable energy projects is studied in order to define a new classification of the factors/variables/drivers (individual self-characteristics, personal characteristics, economic characteristics, household characteristics, building characteristics, community and neighbourhood characteristics, government, regulation and policies and external characteristics) that favour or hinder the citizens' effective inclusion, participation and investment in energy community project and the citizens' making decision and action implementation. The identification of the factors, that promote individuals' behaviours and the decision-making choice, is the step preceding the characterization of the population in a given context. Indeed, the research allowed to define the methodology for a questionnaire in order to characterize the population and to understand if it is possible to divide it into clusters (characterized by level of attitude and willingness towards community projects based on renewable energy and towards energy saving practices and by feelings and level of identity towards the community/territory to which they belong) and, consequently, to promote specific inclusion strategies and tailor-made environmental, energy and social policies aimed at involvement in energy community project and to address the current issues.

The research is supported by the European project Horizon 2020 "SCORE" which fostered discussion between different experts and stakeholders and allowed the methodology to be applied in three European contexts: Susa Valley (Italy), Litoměřice (Czech Republic) and Essen (Germany).

Acknowledgment

The Ph.D. path offers me the opportunity to enrich my academic knowledge but, also, to grow personally.

First, I would like to thank my supervisors, Prof. Patrizia Lombardi and Prof. Stefano Paolo Corgnati, which allowed me to continue my training by combining interesting themes: the energy issue declined on a broader scale, the urban one. Specifically, I thank Professor Stefano Paolo Corgnati and his teamwork for making me passionate about the world of energy, building consumption and human behaviour, leading me, after the master's thesis, to want to undertake a doctoral course on similar topics. I very very thank Professor Patrizia Lombardi and also Sara Torabi for accepting the challenge and for guiding and supporting me in my research path for these three years. It was an incredible opportunity, especially considering my inclusion and participation in the HORIZON 2020 SCORE project ("Supporting Consumer co-Ownership in Renewable Energies"). Specifically, this project is the result of research activities that was supported by meetings and collaborations with several expert in the field. Consequently, a thank you goes to all the members of the SCORE consortium, certainly to Project Coordinator Prof. Jens Lowitzsch and his teamwork; in addition, a special thanks go to Italian partners (Michela Rapolla, Giorgio Talachini, Alberto Dotta, Maicol Guiget and all those who made themselves available for the preparation of the informative events/workshops and for the distribution of the questionnaire) that supported me in retrieving information and establishing contacts with the local population of Susa Valley.

A special thank you goes to colleagues (the "marecane" teamwork) who have become, above all, friends, friends of gatherings, that helped me move forward despite my difficult times.

Thanks to my friends and to the ones of/in my heart that, even with small gestures, have dedicated their time and supported me always, even in this path, making me feel loved.

A unique thank you goes to my family (mum, dad and brother); only you know how important you have been and how important you are: without your love this milestone would not have been possible.

Last, but not least, not a thank you but a consideration: from a personal point of view, the PhD path was not easy. In these years, I have allowed to understand my limits but also my strength; indeed, if I am here, this means that that from difficult situations you get out perhaps stronger than before and maybe it takes time but, in the end, everything is overcome.

To my mum and dad
for being by my side,
always.

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Nomenclature

ABC	Attitude Behaviour Context
ARERA	Regulatory Authority for Energy, Networks and Environment
BAU	Business as usual
CO_2	Carbon dioxide
COP21	XXI Conference of Parties
CS	Current situation
CSOP	Consumer Stock Ownership Plan
DH	District Heating
DHW	Domestic Hot Water
DIY	Do It Yourself
EC	Energy Community
ECP	Energy Community Project
EE	Energy Efficiency
EEI	Energy Efficiency Investment
EER	Energy Efficiency Retrofit
EP	Energy Poverty
ERE	Engagement in Renewable Energy
ESB	Energy Saving Behaviour
ESCo	Energy Service Company
FG	Focus Group
GDPR	General Data Protection Regulation
GHG	Greenhouse gas
GJ	Giga Joule
GSE	Gestore Servizi Energetici (Energy Service Manager)
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
ISTAT	Istituto Nazionale di Statistica

KPI	Key Performance Indicator
MCA	Multi-criteria analysis
NEP	New Ecological Paradigm
NPV	Net Present Value
NZEB	Nearly Zero Energy Building
PBP	PayBack Period
PV panel	Photovoltaic panel
RE	Renewable Energy
REC	Renewable Energy Community
RECP	Renewable Energy Community Project
RED II	Recast of Renewable Energy Directive
RES	Renewable Energy Sources
RQ	Research Question
RS	Retrofitting situation
SCORE	Supporting Consumer co-Ownership in Renewable Energies
SDG	Sustainable Development Goal
SEN	National Energy Strategy
SME	Small and Medium Enterprise
TBP	Theory of Planned Behaviour
VBN	Value Belief Norm
WP	Work Package

Never doubt that a small group of thoughtful,
committed citizens can change the world;
indeed it is the only thing that ever has.

Margaret Mead

Chapter 1

Introduction

1.1 Problem statement

The relationship between man and environment is an ancient theme, but fairly recent if, instead, it refers to the environmental degeneration, which has arisen due to an absent vision of sustainable development. Indeed, the ongoing research for human better wellness conditions was made possible thanks to an ever-increasing use of energy, resulting in Prometheism, a term used by H. Jonas in his “Das Prinzip Verantwortung” (Jonas, 2002) to denote the set of unlimited interventions on nature due to a great development of the technique. Nowadays, considering the several environmental issues that are leading to changes, even important ones, in the biosphere, a paradigm shift related to our choices and our behaviour in different aspect of our life is necessary.

Due to our *modus vivendi*, the amount of carbon dioxide (CO_2) emissions raises troubles. The relationship between the carbon dioxide production of fossil fuels and the temperature increase is a reality. Now, the fact that the human activities are changing the natural greenhouse balance is shared by the totality of the scientific community. Rather than re-establishing the balance, not compromising the current situation, is the challenge to tackle by our generation. Indeed, in case of an absence of interventions (or in any case faint actions), the consequences of climate change (“natural” disasters such as floods, hurricane or blackouts) will be more and more frequent, until an irreversible condition is reached. In order to avoid or, at least, reduce the problem it is essential to prevent a temperature increase over 2°C (as recommended during the United Nations Framework Convention on Climate Change, COP21 (United Nations, 2015a)) and preserving the remaining carbon budget. The carbon budget outlines how much CO_2 is granted to emit in order that the global warming remains within the critical threshold of 2 °C with respect to the pre-industrial average temperature (Friedlingstein et al., 2019). Knowing how much residual carbon budget remains allows to define containment paths, achievable through lifestyles, behaviour and programs, that include the reduction of energy demand (and consequently the energy consumption), and the use of renewable energy sources in order to decrease emissions by 40%-70% by 2050 and almost zero by 2100, as recommended by the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2014).

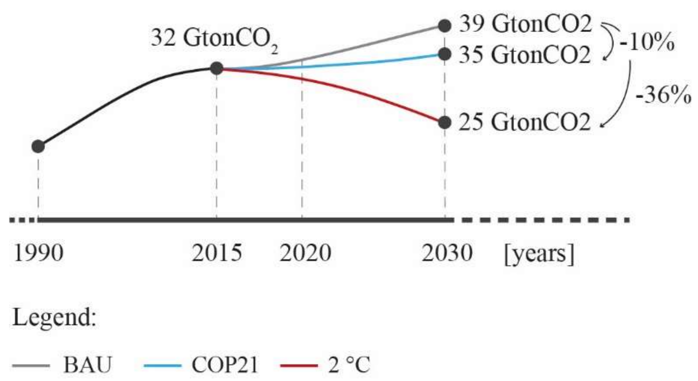

Figure 1. Three key scenarios related to carbon dioxide emissions.

Figure 1 (Descalzi, 2016) shows the consequences of CO_2 emissions into the atmosphere considering three key scenarios, characterized by a different contribution of the interventions. The first is the classic business as usual scenario (BAU, characterized by no type of intervention) that provides an emission increase from 32 $GtonCO_2$ (in 2013) to 39 $GtonCO_2$ (in 2030); the second regards compliance with the agreements determined during the XXI Conference of Parties (COP21), and consequently the implementation of purposes set by the each States, which brings emissions from 32 $GtonCO_2$ (in 2013) to 35 $GtonCO_2$ (in 2030) with a decrease, compared to the BAU scenario of 10%; finally, the third scenario concerns the non-overshoot the critical threshold of 2 °C, holding the emissions from 32 $GtonCO_2$ (in 2013) to 25 $GtonCO_2$ (in 2030), with a decrease of 26% in comparison to BAU scenario. Considering the scenario related to COP21 and investigating the consequences on the remaining carbon budget, even if all nations had to respect the commitments, by 2030, our disposal carbon budget would be eroded almost completely. Therefore, what is established during the agreements represents only a part of the necessary actions, to which it is important to add research, the use of new technologies and, above all, a new awareness, to obtain more prestigious purposes, considering these can be achieved through a real joint commitment towards the decarbonization process. However, if on the one hand, the resources consumption (soil and energy) should not be underestimated, as well as the consequent the produced pollution, on the other hand, it is essential to ensure high levels of well-being, increased comfort and access to services to everyone. Consequently, in this context, a decarbonization process, through an energy transition, is a way to address the above mentioned environmental issue. Heading towards an energy transition means, not only, to revise current energy mix and the avoid the use of energy resources from fossil sources in favour of renewable ones, but also to improve energy efficiency related to the energy production and to raise awareness and to define a more conscious energy consumption by people.

Cities certainly play a crucial role in this transition. Remembering that, the cities, or rather the urban activities, are responsible for 75% of energy consumption and for the 80% of carbon dioxide emissions that are globally produced every year (United Nations Environment Programme (UNEP), 2007), they are the cause of degenerative phenomena. Nevertheless, at the same time, cities suffers the effects. Indeed, an increasing number of cities could be a victim of climate change; but, on the other hand, cities, by their nature, can face the problem. In this way, cities must address problems and to face new challenges in order to deal with current environmental and energy issues. New technologies should be developed not only in the production, management or use of energy field, but also in mobility and transport, water, waste system and buildings. Precisely, this last sector (the construction sector), with a large share (40%) of total primary energy consumptions, in most developed countries (International Energy Agency (IEA), 2015), is one of the main energy consumers and global greenhouse gas emissions contributors. For these reasons, the building sector and the role the city system have become a main focus for energy consumption efforts and, more widely, for the energy transition.

1.2 Legislative framework and incentives

In order to reduce greenhouse gas (GHG) emissions and, thus, to achieve the energy transition, a series of policies and measures, related to the environmental, the energy and the building sectors, have been enacted. A series of incentives are added to this framework so that the suggested and planned interventions are actually implemented. The main strategies are described below.

1.2.1 The European Legislative framework

The Climate-Energy Package 20-20-20 (June 2009). The 20-20-20 Plan collects all the measures, developed by the European Union, in the period following the end of the Kyoto Protocol (December 2012). The first international agreement between industrialized countries is represented by the Kyoto Protocol (December 1997 and came into force on February 2005); it aimed at reducing the GHG emissions, responsible for global warming. The 20-20-20 Plan prescribed to reach by 2020: the 20% of greenhouse gas emissions reduction, the 20% of share increase of energy produced from renewable sources and the 20% of energy consumption reduction (European Commission, n.d.)

Legislative Decree 3 March 2011 and new EU Directive on buildings energy efficiency. The Legislative Decree no. 28 ("Implementation of Directive 2009/28/EC on the promotion of the use of energy from renewable sources, amending and subsequent repeal of directives 2001/77/EC and 2003/30/EC" – entered into force on March 29, 2011). The provision defines, for the first time, the tools, mechanisms, incentives and the institutional, financial and legal framework necessary to achieve the objectives, up to 2020, in the field of energy from renewable sources. In 2018, Directive (EU) 2018/844 of the European Parliament and of the Council of May 30, 2018 was published in the Official Journal of the European Union, amending Directive 2010/31/EU on energy performance in buildings and Directive 2012/27/EU on energy efficiency. The objective of the Directive (of July 9, 2018) is (i) to achieve, by 2050, the construction of public and private buildings with energy consumption almost zero (NZEB - Nearly Zero Energy Building), (ii) to ensure the reduction of gas emissions to greenhouse effect by at least 40% by 2030 compared to 1990 and, (iii) to increase the share of energy consumption from renewable sources and improving energy savings.

Renewable Energy Directive (RED II). On November 13, 2018, the European Parliament voted on Directive on the promotion of the use of energy from renewable sources, published in the Official Journal of the EU on December 11, 2018. This Directive (which must be implemented by the Member States by 30 June 30, 2021) concerns, in particular, the use of energy from renewable sources in the transport sector and the reduction of greenhouse gas emissions for biofuels, bio liquids and biomass fuels. It aims to accelerate the transition from fossil fuels and sets, by 2030, a precise target for renewable energy, which have to cover, at least, the 32% of total energy consumption. With this Directive, the focus is not only on electricity production from renewable sources but also on heating from renewable sources (European Commission, 2018a).

European Green New Deal. The EU Parliament on January 14, 2020, approved an investment plan aimed at transforming Europe into a country with "zero climate impact" by 2050. The goal is to decarbonise the energy sector, to implement buildings retrofit, to support industry with a green economy process and to make the transport system cleaner, all this by focusing on energy from renewable sources. All European States will receive a financial aid package to kick-start the transition and several funds will be activated, necessary to start the economic, productive and labour conversion by the Member States.

Integrated National Energy and Climate Plan (Piano Nazionale Integrato Energia e Clima - PNIEC). The Plan regards Italy and sets, by 2030, the 30% of the energy consumed have to come from renewable sources. The document (published on January 21, 2020) collects the guidelines to be followed and the objectives to be achieved in Italy in the field of energy and environmental protection, for the period 2021-2030. It marks the beginning of a strategic change in energy and environmental policy, towards a decarbonization process. Specifically, the lines of action include decarbonization, energy efficiency and security, development of the internal energy market, research, the innovation and competitiveness (Ministero dello Sviluppo Economico (MISE), 2019).

1.2.2 The Italian public incentives

In Italy, public incentives for the installation of plants for the production of renewable energy and for the building retrofit are been established. Some of key incentives are illustrated below.

Conto Energia 2020. “Conto Energia” was introduced with the implementation of the EU Directive 2001/77/EC, through the Legislative Decree 387/2003. Its goal is to improve the energy performance of buildings through the installation of photovoltaic systems. In this context, the State provides, in a period of twenty years, a sum of money deriving from the electricity produced the system. It refers to the Ministerial Decree of July 4, 2019 and establishes that only certain types of plants can access the incentives, i.e. new components and component with a nominal power equal or greater than 1 kW. In addition, the essential condition is that the installed photovoltaic systems are connected to the electricity grid or to small decentralized grids.

Conto Termico 2020. The “Conto Termico” is managed by the Energy Services Manager (GSE, Gestore Servizi Energetici). It allocates economic contributions for the improvement of energy efficiency through the production of thermal energy from renewable sources. It concerns and economic incentive equal to 65% of the expenditure incurred for the energy efficiency improvement and the energy saving in buildings and for the renewable energy production. It regards public administrations and private individuals (enterprises or residences); the State provides 900 million euros per year: 200 for public administrations and 700 for private entities. The 65% of expenses are reimbursed by the GSE within two months; private individuals can submit reimbursement requests at the end of the works, instead public administrations, on the other hand, can take advantage of incentives before starting work.

Decree on Renewable Energy Sources (Decreto FER 1). The Decree (August 10, 2019) provides requirements for access to incentive mechanisms in support of the production of energy from renewable sources. Specifically, it facilitates small plants for the production of energy from renewable sources (up to one megawatt of energy produced) such as photovoltaic, wind, hydroelectric and gas purification plants. The incentive rates go up to 150 €/MWh for wind power, 155 € for hydroelectric power, 110 € for gases produced by purification processes and 90 € for small photovoltaic solar plants. For facilitating applications, there will be thirty days from the date of publication of the invitation tender.

National Energy Efficiency Fund. It was established by the Ministry of Economic Development and it economically supports the energy efficiency interventions completed by enterprises (including Energy Service Companies - ESCo) and by the Public Administration, on buildings, energy plants system and production processes. The financial resources disbursed are 310 million euros, divided in guarantees (30%) and subsidized loans (70%). The benefits granted to enterprises can be combined with other contribution or financial concessions provided by EU, national and regional regulations. Instead, the benefits granted to the Public Administration can be combined with other incentives, within the limits of a maximum total financing equal to 100% of the eligible costs.

Gestione Riconoscimento Incentivo (GRIN). Since 2016, the incentive named "Certificati Verdi" has been replaced by a new form of incentive; it allows to access the new incentives provided by the Ministerial Decree 06/07/2012 for all qualified plants fuelled by renewable sources ("IAFR, Impianti Alimentati da Fonti Rinnovabili"). The IAFR plant indicates not only photovoltaic systems but, more generally, all those plants that use renewable sources for the production of clean energy, i.e. sun, wind, heat from the earth, up to biogas and the waves of the sea. The IAFR qualification is a certificate issued by the GSE (Energy Services Manager) which certifies the ownership, for an energy system, of the requirements to be able to access to State incentives. The new mechanism guarantees, on the net energy production, the payment of a sum, by the GSE, additional to the revenues deriving from the energy valorisation.

Ecobonus 2020. The benefit consists of a deduction and is granted for interventions related to energy efficiency increase of existing buildings. In general, deductions are recognized for: reduction of energy need for heating, thermal improvement of the building (e.g. insulation, windows, etc.), installation of solar panels and the replacement of heating systems. The deduction, also, concerns installation of solar shading, the installation of winter air conditioning systems with heat generators powered by biomass fuels, the installation of multimedia devices for remote control of heating systems, hot water production or air conditioning, the installation of micro-cogenerators to replace existing plants, the installation of condensing hot air generators and the replacement of winter air conditioning systems with hybrid appliances consisting of a heat pump integrated with a condensing boiler. Intervene on an existing single housing unit or on a buildings is the mandatory condition to obtain the benefit. The incentive could be requested for expenses incurred by December 31, 2020. For most of the interventions the deduction is equal to 65%, for others it is 50%. Instead, for intervention in condominium higher deductions (70 or 75%) are requested to achieve a specific energy performance level (maximum 40,000 euros multiplied by the number of real estate units that make up the building) (Agenzia delle Entrate, 2020a).

Superbonus 110% of 2020. It is a subsidy provided by the Decree-Law no. 34/2020 (named "Decreto Rilancio") and it sets the deduction rate for expenses incurred from July 1, 2020 to December 31, 2021 to 110%. This benefit is added to the deductions for the refurbishment for the reduction of seismic risk (named "Sismabonus") and for energy improvement of buildings (named "Ecobonus"). In addition, it is possible, on one side, the direct use of the deduction, and on the other, to opt for an advance contribution, a discount from the suppliers of goods or services or for the credit transfer corresponding to the deduction. The possible interventions fall into two categories: the "driving actions" (the main interventions) and "pulled action" (which can only be performed when combined with the first). The driving actions are: the envelope thermal insulation, the replacement of winter air conditioning systems on common areas, the replacement of winter air conditioning systems on single-family buildings or on property units of functionally independent multi-family buildings and anti-seismic interventions. The pulled actions concern the energy efficiency measures, the installation of photovoltaic solar systems and the infrastructure for charging electric vehicles. Also for the Superbonus, as seen for the Ecobonus, as an alternative to the direct use of the deduction, it is possible to opt for an advance contribution in the form of a discount from the suppliers of the goods or services (discount on the invoice) or for the transfer of the credit corresponding to the deduction (Agenzia delle Entrate, 2020b).

1.3 Research gap, PhD objective and research questions

The goal is to pursue an environmental sustainability path and to achieve that it is not enough counting exclusively on passive "action", e.g. the incentives, provided by the State, related to the prescription of energy efficiency target, for the envelope or energy system, or to energy consumption reduction to be reach in a specific time (as mentioned in the previous paragraphs 1.2). However, the city system it is made up not only of buildings, technologies and infrastructures but, also, of users, citizens, that should play an increasingly active role. In this perspective, rethinking the city system as a community, made up primarily of citizens and relationship between them, could be a way through which it is possible to provide a concrete response to the aforementioned environmental and energy issues. In addition, considering the ambitious purpose of greenhouse gas emissions reduction by 80-95% with reference to 1990, set by the European Union (European Commission, 2012), to achieve this target, it is necessary to tackle a decarbonization path through, not only, the revision of current energy mix (nowadays the fossil fuels are still our biggest sources of energy) but, most of all, the reflection on the role of city system in this energy transition. Specifically, with reference to cities, the most influential sectors, in energy consumption, are represented by industry (28%), by transport (32%) and by buildings (40%) (International Energy Agency (IEA), 2015). To address the environmental and energy target, it has already been said that a legislative framework is present and it is establishing. It focuses not only on the building but also it pays attention to the user/citizen in order to promote his/her active role. Indeed, the Energy Community (EC) initiatives (i.e. association of several stakeholders, located in a specific area with the willingness to self-produce, self-consume, and exchange energy from renewable energy sources among different users in different end-use buildings (Brummer, 2018; Romero-Rubio and de Andrés Dìaz, 2015)) are born to give an answer to these objectives. The Energy Community topic (and related legislations) is deepened in Chapter 2, however, here, it is highlighted that with RED II the birth of these communities is sanctioned at European level, starting a new legislative framework trend. On November 30, 2016, the European Commission presented the "Clean Energy for All Europeans" package which several measures in the fields of energy efficiency, renewable energy, and internal energy market power are included (European Commission, 2019). The Renewable

Energy Directive II and the new directive on the new rules of electricity market (2019) are, among all, important since address the Energy community issues. Instead, at the Italian level the foundations are laid, in the 2017, with the National Energy Strategy (SEN). It contains the ten-year plan of the Italian Government to manage the change in the energy system and to place the consumer at the centre of the energy transition. In addition, the Law 221 of 2015 ("Environmental provisions to promote measures of green economy and to contain the excessive use of natural resources") in article 71, the possibility of creating areas free from dependence on fossil fuels (named "oil-free zone") are established. Finally, Piedmont Region is the first Italian region, through the Regional Law 12/2018 ("Promotion of the institution of energy communities"), that encourages the new paradigm related to energy communities.

Consequently, in this context, several possible scenarios of energy retrofit, established by regulations and promoted by incentives, may not reflect the real situation of intervention. Indeed, sometimes, the proposed scenarios may not achievable due to the influence of users' features because these define the users' possibilities in engaging or not engaging in different actions. Therefore, the intervention strategy is to define several scenarios considering, at the same time:

- the different energy consumption and characteristics of the buildings;
- the user's characteristics related to different aspect (attitude and willingness, socio-demographic, economic and psychological).

Only obtaining a match between this two aspects, a future real scenarios of intervention could be create. For this reason, in Chapter 3, entitled "The role of the citizen in the energy transition", the type of behaviours and related drivers, that a user/citizen can implement when he/she makes a decision, for example in order to reduce energy consumption, are explored. These behaviours refer to three types: a) energy efficiency investments actions (EEI), b) engagement in renewable energy projects (ERE) and c) energy-saving behaviours (ESB).

For a more exhaustive understanding of the aforementioned issue, this is described in a simplified way through three elements, taking into consideration a fictitious neighbourhood consisting solely of single-family residential houses, inhabited by a single user. Specifically, for simplicity, the reached level of the two elements (level of energy efficiency of the buildings and level of energy and environmental education of the occupant) are defined by two colours: green if the level is positive, red if it is negative.

- <u>Level of energy efficiency of the buildings.</u> Each building is characterized by an energy efficiency level. Consequently, the energy consumption is determined by the state of the envelope system (e.g. presence of thermal insulation, type of windows, etc.) and of the energy system (e.g. efficiency of the heat engine, type of energy supply, etc.). In Figure 2, the first and fourth buildings are characterized by a good level of energy efficiency as regards the envelope system and the energy system; on the contrary, for the second and third buildings, the level of energy efficiency is poor.

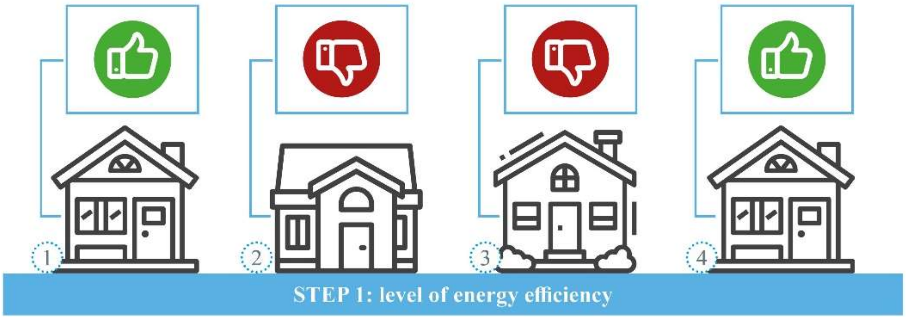

Figure 2. Level of buildings' energy efficiency.

- Level of energy education/behaviour of the occupant. In addition, each building is characterized by an energy consumption which is determined by user's behaviour (Janda, 2011). The behaviours can concern how the user interacts with the building systems (e.g. interaction with the thermostat and definition of a set-point temperature, etc.) and/or choices and actions related to an investment (e.g. changing the gas boiler to favour of a heat pump). Figure 3 shows that users of the first and third buildings are characterized by a good level of energy-related behaviour; on the contrary, the level of energy-related behaviour is poor for the users of the second and fourth buildings.

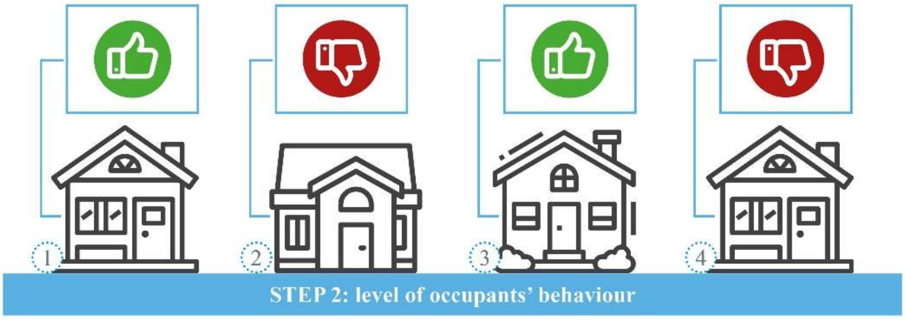

Figure 3. Level of occupants' behaviour.

Considering the combination of level reached in the first and second step, overall, only the first building does not need any action; the other three require interventions on the building or on the behaviour of the occupants.

- Description of occupant's characteristics. Each user is characterized by some features related to different aspects (e.g. social, demographic, economic and psychological). These drivers could favour or hinder the engagement in user's behaviour. Figure 4 shows how the users are varied considering only the characteristics of age, economic condition and environmental concerns.

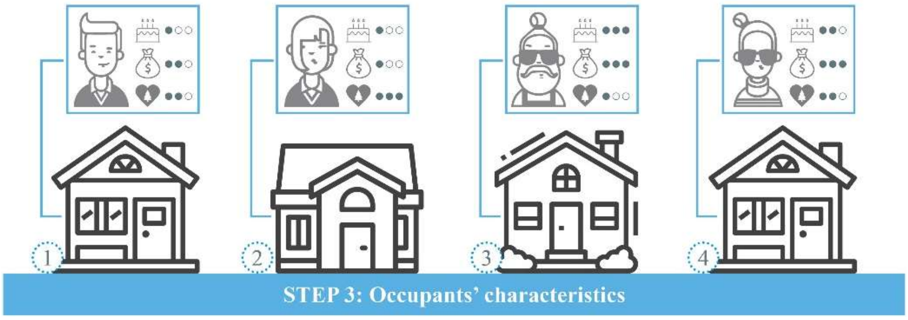

Figure 4. Occupants' characteristics.

While some energy targets to be achieved are defined, these may not necessarily be pursued, since the actions are determined by some objective and subjective drivers of the user. In other words, when a user has to take a decision, various difficulties may arise (Kaiser et al., 1999). Considering, for example, the second and third buildings, some conclusions could be traced in order to highlight the limitation of the current research. In the second building, the user is characterized by precarious economic situation, she is a nature lover and she is between 20 and 30 years old. Given her economic situation, probably, even if she wants (since she is sensitive to environmental issues) she is not able to support the investment for the retrofit of the building. In the third building, the user is characterized by a comfortable economic situation, he has not an interest towards the environment issue and he is between 65 and 80 years old. On one side, given his economic situation, probably, since he is the owner of the building he could easily undertake a retrofit of the building; on the other hand, having no interest in environmental issues and considering the long payback periods of the investment (also considering his age), it may not engage in a retrofit project.

As mentioned, this is a simplified example where only one user was considered per single building. Understandably, the reality is much more complex. A district consists of public and private buildings, residential buildings and buildings intended for the tertiary sector; moreover, residential buildings can be single-family buildings or multi-family condominiums, etc. In addition, the variety of users/citizens are also great. Furthermore, it is interesting to extend the reasoning to more buildings, investigating not only the occupant interaction but also the interactions between citizens and between citizens and buildings, arriving at evaluating the dynamics at the base of a community, an energy community.

The main objectives that this thesis aims to achieve are:

- to define which elements make up an energy community and which relationships are established between them;
- structuring a work path that leads to the creation of energy communities;

- to analyse and to study the existing literature in order to define a new classification of the factors/variables that affects the energy consumption and behavioural choices of users;
- to define strategies to involve citizens in active participating in an energy community;
- to extrapolate users' profiles who share the same characteristics in order to promote tailor-made environmental and energy policies.

However, at this point, "i*s it possible to define and create an energy community as a potential solution to achieve the energy transition?*". This is the main challenge that this thesis sets out to face. In this dissertation, the answer to this question occurs by proceeding by step, answering the sub-questions listed in the table below (Table 1) in which the applied methodology and the expected results are expressed. Research questions are detailed in the next paragraph 1.4.

Table 1: List of research questions

Question number	**Research questions**	**Methodology**	**Expected results**
1	What elements are necessary for the birth of an energy community?	Literature review Discussion with expert	Structured workflow
2	How can people be included to participate actively, becoming prosumer and/or plays an active role in society?	Literature review Workshop Survey Questionnaire	Citizens description and citizens inclusion strategies
3	What are the factors that determine the human behaviour related to energy use/consumption and engagement in Renewable Energy (RE) projects?	Literature review Workshop Survey questionnaire	Citizens description and citizens inclusion strategies
4	It is possible to define citizens homogeneous groups based on the same characteristics?	Cluster analysis	Citizens clusters

1.4 Methodological approach and expected results

As mentioned in the previous paragraph, the main research question is the following: "*is it possible to define and create an energy community as a potential solution to achieve the energy transition?*". The research methodology was articulated through the formulation of 4 sub-questions (Table 1); below, the detail of the methodological path, on which this dissertation is articulated, is explained.

- *"What elements are necessary for the birth of an energy community?"*
  To answer this question, a first review of the existing literature was carried out in order to understand what an energy community was (Chapter 2). It is an emerging theme, therefore, it is necessary to

understand which elements it is composed of and which elements it is flanked/derive from. Associated with the concept of energy community, the following concepts were explored: energy poverty, prosumership and CSOP financing model. This first research and a parallel discussion with a panel of experts made it possible to define a structured workflow that has become the core of the thesis itself (described in Chapter 4). From the study of the energy community literature, it emerged that a fundamental element is constituted by society, people, citizens and users. In short, not only material elements intervene but there is an unpredictable component given by citizens and their possibilities.

- *"What are the factors that determine the human behaviour related to energy use/consumption and engagement in Renewable Energy (RE) projects?"* To answer this question, a second review (Chapter 3) of the existing literature was conducted, more in-depth than the previous one. Specifically, the study concerned the identification of factors (socio-demographic, economic, psychological, etc.) that determine the user behaviour related to three aspects: the engagement in renewable energy project, the energy related behaviours and the energy efficiency investments. Several drivers have been identified and a new classification has been produced, grouping them in different areas. This study also made it possible to define, in detail, the social component included in the structured workflow (together with the technical and legal component) (Chapter 4) and becoming the core of this dissertation. In other words, the citizen behaviour is studied in order to understand the drivers that push a person to perform certain actions.
- *"How can people be included to participate actively, becoming prosumer and plays an active role in society?* This question would to assess how a user can shift from a passive role to an active role within the city, for example becoming prosumers and increasing his/her awareness about the effects of energy choice. The methodological approach is deepened in Chapter 4, where particular emphasis and space is devoted to the social component. Starting from an analysis of the stakeholders, subsequently informative events, workshops are used to bring citizens closer to the topic and, finally, a questionnaire to investigate in detail thoughts, attitudes and personal characteristics is used.
- *"It is possible to define citizens homogeneous groups based on the same characteristics?"* The data collected with the questionnaire are analysed through a cluster analysis in order to understand if it is possible to divide the population into homogeneous groups, constituted by users who share similar characteristics. It is, also, important to understand the weight of each item taken in

consideration. In this case, the output is model able to describe, through a questionnaire and data analysis, the incidence of these variables. The definition of different users clusters, based on the behaviours and factors investigated through the questionnaire, leads to a reflection on the environmental and energy policies strategies to be implemented in society. These policies must be, precisely due to the different human nature characterized by different possibilities, tailored to each identified cluster in order to reach, jointly, the environmental purposes.

1.5 The Score project

In the current context, in September 2015, 193 UN member countries signed an Action Program, named Agenda 2030 (United Nations, 2015b), in order to contribute to global development, to promote the human wellbeing and to protect the environment, through the achievement of the 17 Sustainable Development Goals (SDGs). In this framework and considering the new legislative framework (as mentioned in Paragraph 1.2 and detailed in Chapter 2) that, in recent times, is emerging, several projects, focused on the energy transition and energy communities, are financed by the European Community.

SCORE
Co-own. Prosume. Renew.
Supporting Consumer Ownership in Renewable Energies

Figure 5. SCORE project logo.

The SCORE project - "Supporting Consumer co-Ownership in Renewable Energies" ("SCORE Project," 2018) fits into this type of projects. It is a 3-years project financially supported by the European Commission (Grant Agreement 784960) under the Horizon 2020 program for research and innovation and it focus mainly on SDG 11 "Sustainable cities and communities", which "makes cities and human settlements inclusive, safe, resilient and sustainable" (United Nations, 2015b). Inevitably, as highlighted in the paragraph concerning the project objectives, the actions have, also, repercussions on other goals such as SDG 3 "Good health and well-being", SDG 7 "Affordable and clean energy", SDG 10 "Reduce inequalities", SDG 13 "Climate action" and SDG 15 "Life on land". The project has a duration of 36 months, from April 1, 2018 to March 31, 2021 (in reality, the closure is postponed, due to the COVID-19 health emergency, to December 31, 2021). In general, the purposes of the SCORE project are (i) the engagement of private and/or public consumers towards sustainable energy and (ii) the study and the implementation of energy communities in three different pilot countries.

1.5.1 Score objectives

The energy transition, from fossil fuels sources to renewable energy sources (RES), requires motivating consumers and, just towards consumers, particular attention is paid. Consumers are encouraged to play an active role within their community by becoming "prosumers" and changing their energy consumption behaviour/habits in order to accept new technologies, to balance the energy demand considering the volatile energy supply determined by renewable energy and finance RES plant system. According to the Grant Agreement n° 784960 (European Commission, 2018b), the main objectives of SCORE project could be summarized as follows:

- to overcome the usage of energy from fossil fuels by promoting and facilitating the production of energy from renewable energy sources and to increase energy efficiency (EE) of the building systems (e.g. the envelope and/or the energy systems);
- to reduce energy consumption through behavioural change of the users of the building/neighbourhood;
- to promote the creation of energy communities, lending, above all, attention to the dynamics that allow/not allow the birth of these communities;
- to shift the attention from the individual to the community, particularly getting closer to vulnerable population segments (single-women, low-income households, unemployed) that are interested or would like to be part of it but do not have the possibility (for different reasons: economic, social, etc.);
- to facilitate consumers to become prosumers and co-owner of renewable energy and to understand how different case studies (firstly, in three pilot regions (Italy, Czech Republic and Germany) and, secondly, in cities across Europe following the pilot projects) can be financed by the local citizen (or simply people interested in); in this context, an important role is played by a trusteeship in order to collect the funds of individual entity in the application of a Consumer Stock Ownership Plans (CSOPs);
- to formulate policy recommendations to promote prosumership and to study the feasibility of creating energy communities in order to discover potential and limits that arise when this type of projects is implemented.

The objectives of the European project are complementary and also superimposable to the objectives set by this dissertation and mentioned and described in Paragraph 1.3. The inclusion and participation in this project represented, on the one hand, the opportunity to refine the methodology developed for the thesis project (Chapter 4), and, on the other hand, it made possible to implement (Chapter 5) the theorized concepts, in the three pilot contexts of the Susa Valley (Italy), Litoměřice (Czech Republic) and Essen (Germany) in order to create energy communities.

1.5.2 Project Consortium

The achievement of the objectives was possible thanks to the unanimous commitment of the project partners. The following table (Table 2) lists the entities that make up the project consortium. Subsequently, a brief description of the Italian local partners is presented since, in the dissertation, they are cited several times for their contribution in the application phases; an in-depth study is important to define their role.

Table 2. Consortium partners.

n	Name	Short name	Country
1	STIFTUNG EUROPA-UNIVERSITAT VIADRINA FRANKFURT (ODER) (COORDINATOR)	EUV	Germany
2	EC BREC INSTYTUT ENERGETYKI ODNAWIALNEJ SP ZOO	IEO	Poland
3	CLIMATE ALLIANCE - KLIMA-BUENDNIS - ALIANZA DEL CLIMA e.V.	CA	Germany
4	CENTER FOR THE STUDY OF DEMOCRACY	CSD	Bulgaria
5	POLITECNICO DI TORINO	POLITO	Italy
6	CO2ONLINE GENUETZIGE BERATUNGSGESELLSCHAFT MBH	CO2ONLINE	Germany
7	PORSENNA O.P.S.	PORSENNA	Czech Republic
8	LA FORESTA SOCIETA' COOPERATIVA	FORESTA	Italy
9	MIASTO SLUPSK*	SLUPSK	Poland
10	MESTO LITOMERICE	LITOMERICE	Czech Republic
11	CONSORZIO FORESTALE ALTA VALLE SUSA	CFAVS	Italy
12	DEUTSCHER CARITASVERBAND EV	CARITAS	Germany
13	AMICO SOCIETA COOPERATIVA SOCIALE	AMICO s.c.s.	Italy
14	FEDERACJA KONSUMENTOW STOWARZYSZENIE	FEDKON	Poland

*The city of Slupsk (Poland) left the project in November 2019 and has been replaced with the City of Essen (Germany).

A brief description of Italian partners (based in Susa Valley) and their function within the project is presented below.

Consorzio Forestale Alta Valle Susa. It is a consortium that represents 14 municipalities in “Alta” Susa Valley. It coordinates public authorities and private firms in harvesting the woods, developing the project design. CFAVS manages the forestry and fluvial activities conjointly owned by the municipalities of the Valley.

La Foresta Società Cooperativa. La Foresta deals with the wood cutting in the alpine region, wood transportation, wood drying and chips cutting (obtaining the PEFC7 certification for wood and wood chips). In addition, it deals with the installation and management of heat power plants of small and medium-size. In SCORE project, it covers the role of plant and design consultant.

AMICO Social Cooperative. CoopAMICO is a no-profit organisation related to Catholic Church and it focuses on the reintegration of disadvantaged and marginalised workers (e.g. unemployed, dibbled, former detainees, etc.) through work. Specifically, CoopAMICO integrates disadvantages people providing general service of agricultural and forestry works. In SCORE, it is responsible for the reintegration of marginalized people, acting as an intermediary to reach the weak sections of the population.

1.5.3 Work packages (WPs)

The thesis research fits perfectly into the SCORE project thus becoming, in turn, an opportunity to respond to design requests. The Table 3 shows an overview of the division of activities through work packages (WPs); subsequently, each WP objectives are, briefly, described (as reported in Grant Agreement).

Table 3. Work package description.

N°	WP Title	Lead beneficiary	Start month	End month
WP1	Project management	EUV	1	36
WP2	Preparation of pilot projects and legal and financial due diligence	IEO	1	12
WP3	Implementation of pilot projects	CA	9	24
WP4	Empowering consumers and follower cities	CSD	15	30
WP5	Enabling policies on prosumership	POLITO	20	36
WP6	Dissemination, communication and networking	CO2ONLINE	1	36

Work Package 1. This work package guarantees the effective management and coordination of all project activities; indeed, it ensures that all tasks are performed according: (a) to the previously defined quality, (b) within the established budget, (c) to the European Commission (EC) rules and procedures and (d) are firmly on schedule. Another components of this WP activities are monitoring and risk management.

Work Package 2. In this work packages, the conditions for the successful implementation of renewable energy prosumer investments at the community level are identified and tailor-made prosumer investment models for the pilot projects are developed.

Work Package 3. The renewable energy prosumer investments are implemented in the regions applying the CSOP financing model. The pilot projects are at the core of SCORE as they demonstrate the practical feasibility of optimised joint prosumer investments with local municipalities. Specifically, WP 3 aims to: (a) assess and address knowledge, expertise and training needs among the key actors of the pilot projects, (b) develop a local engagement strategy with pilot municipalities, to activate vulnerable groups (e.g. low-income households, unemployed, women, etc.) to participate and become prosumers, (c) assess the risk of rebound effects, and implement measures to counteract and coordinate the prosumer investment with energy efficiency measures in the pilot pro-jects and (s) apply the legal and economic CSOP financing model to kick off pilot project implementation.

Work Package 4. The main objectives of WP4 are (a) to empower consumers in the follower cities to become prosumers and (b) to increase the involvement of vulnerable groups of consumers in CSOP-financing model. In particular, the objective is to evaluate the actual involvement of vulnerable groups affected by fuel poverty, in particular unemployed, as well as women to become prosumers and draw conclusions for the strategy for follower cities.

Work Package 5. Through this WP, the objectives to be achieved are (a) the identification of impact drivers and barriers of consumer co-ownership from the experience of the pilot projects and (b) the formulation of policy recommendation to promote renewable energy prosumer investments both at the national as well as at the EU level.

Work Package 6. This WP ensures that all activities and tools developed within SCORE are disseminated and communicated to the widest possible audience. The main objective is to set up and implement an effective dissemination and communication plan. Communication, dissemination and exploitation strategies should be put in place in order to reach the target audiences, including the general public, policy makers, local key actors (local governments, SMEs, civil society, etc.) in particular in the “follower cities” and the research community.

Thesis contributes in some work packages towards the achievement of the set objectives; specifically, it is explained how and to what extent this occurs. The research thesis mainly contributes to the achievement of the objectives of WP 2, WP 3 and WP 5. Within WP 2, two surveys (whose methodological approach is provided by project partners) are applied to the Italian case study, in order to describe buildings and energy systems, current and project phase (Phase I). The contribution to WP 3 and WP 5 fall within the methodological (Chapter 4) and applicative (Chapter 5) section of this thesis called "technical structure" and "social structure". The contribution, within WP 3, was possible through the definition of the workflow inserted in the document called "Dossier" to determine the set of energy retrofit alternatives and the best scenario selection (Phase II). In WP 5, on one hand, through informative events and workshops, citizens are informed and made aware of environmental and energy issues (Phase III); on the other hand, through the definition of a questionnaire and the analysis of the data collected, the population is described in order to define and encourage the promotion of specific inclusion strategies in energy community projects (Phase IV).

1.6 Thesis structure

The thesis is divided in 7 core chapters (Figure 6) with the aim of contributing by giving an answer to the research questions expressed in the previous paragraphs. All the chapters present the same structure: a brief introduction, a methodology description, main results and discussion about limitation and future works. Chapter 2 and Chapter 3 concern a double literature review. The Chapter 2 is focussed on aspects and issues on energy community. Instead, Chapter 3 describe the role of citizen in the energy transition, highlighting the main factors that determine the human choice. Chapter 4 illustrates the methodological approach; it is divided into 3 main sub-paragraphs which describe the methodology adopted for each of the technical, social and legal components. In Chapter 5, the case studies, the application of methodology and results are presented tracing the same subdivision highlighted in Chapter 4. Finally, the conclusions are addressed in the Chapter 5 while key findings, limitations and future challenges are explained in Chapter 7.

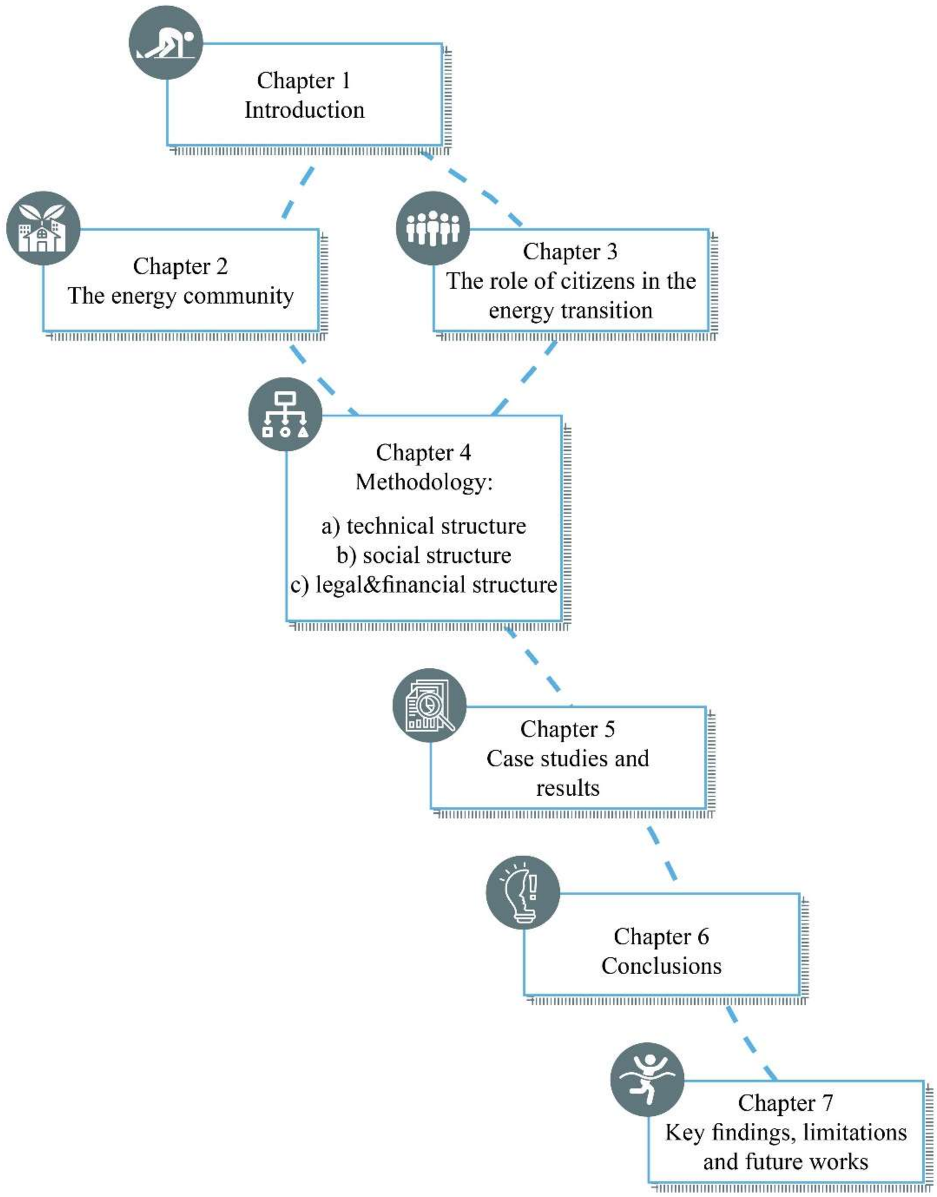

Figure 6. Thesis structure.

Chapter 2

Deepening the emerging concept of energy community

2.1 Introduction

To achieve a low carbon future and an energy transition, based on a clean, safe and reasoned use of energy, in order to address and mitigate the climate change and its consequences, is a need. The main greenhouse gas emissions come from the energy sector and, therefore, it becomes essential to accelerate the transition to renewables sources. At the same time, the energy efficiency principals, according to self-consumption and collaboration perspective, should not be underestimated. Starting from cities, where the majority of the population still lives, it is the right path to take; cities (and human activities) generate about 80% of global CO_2 emissions and they are, therefore, key players in achieving the global warming below 2°C. The desired transition is taking place in various form and, among these, this sort of revolution is called the Energy Community (EC). The concept of energy community carries various implications in sectors also outside the sphere of environmental sustainability: CO_2 emissions reduction (as improvement at global scale), pollutants (e.g. PM10) reduction (as improvement of local scale on external air quality), better living conditions for future generations, economic development, self-sufficiency, independence from public service providers or foreign states, independence from variable prices of energy, reduction of energy poverty, community cohesion, creation of new job, etc. The main change linked to the energy transition concerns the relationship between the user(s) and the produced and used energy. The user is no longer a passive beneficiaries of energy services, completely detached from energy governance processes (in other words, a simple consumer), but the user become an active assessment of consumer choices (in other words, a prosumer). The prosumer assume greater importance in the energy sector, through the reduction of demand and through the participation, in the first person, in the generation, storage and sale of energy. Hence, the transition path introduces the figure of the prosumer: an user that is, at the same time, an energy producer and consumer. In addition, the self-production and the self-consumption become collective since the user become part of an energy community. In an EC, users collaborate to produce, consume and manage energy with other stakeholders; in other words, in this way, a new decentralized and democratic energy system that encourages greater social involvement in the energy market is born.

In the following paragraphs, the legal framework that encouraged the birth of energy communities is examined in depth, then the definitions related to the concept of energy community are reviewed and, finally, some topics connected to it (as energy poverty, prosumership and co-ownership) are briefly described in order to clarify the concepts used in the methodological chapter (Chapter 4).

2.2 Legal framework

Currently, in Italy, the only permitted form of self-consumption is from a single system to a single end consumer (one-to-one) and the excess production has to be placed on the network. The case of a single-family house with a photovoltaic system installation for personal consumption or the case of a condominium with a photovoltaic system installation for the satisfaction of only common loads (e.g., elevator, lighting of common areas, etc.) fall in this typology. With the support of new legislative framework (Figure 7), the one-to-many configuration, from a single system to multiple end consumers (between different end uses) is allowed.

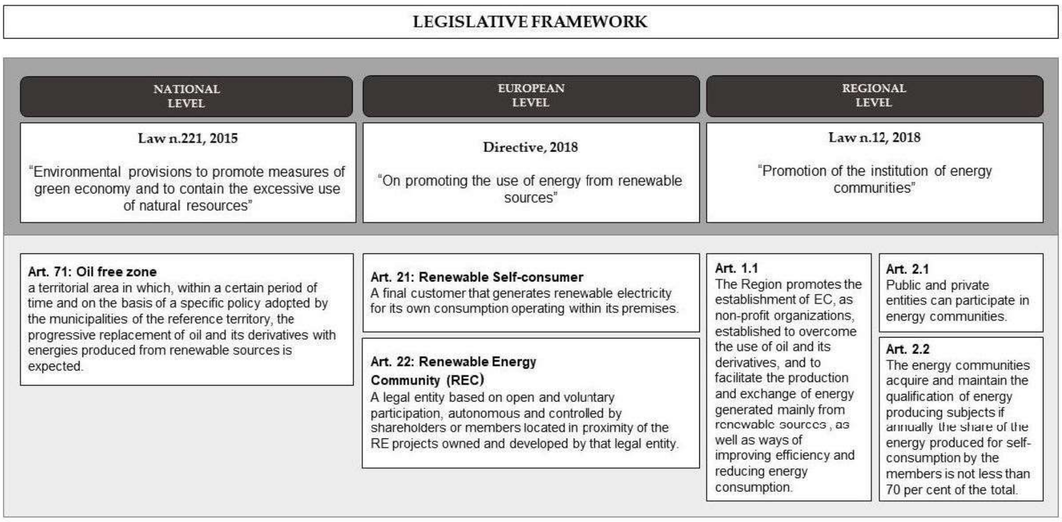

Figure 7. Legislative framework of energy community.

Indeed, to overcome these limitations, a legislative framework is taking shape. At national level, in the National Energy Strategy (SEN) of 2017, a reference to energy communities can be found. The ten-year plan of the Italian Government to manage the change in the energy system is contained within the SEN; in addition, it focuses on the consumer figure, considering it the "engine of the energy transition, to decline in a greater involvement of the demand to the markets through the activation of the demand response, the opening of the markets to the consumers and self-producers the regulated development of energy communities" (Ministero dello Sviluppo Economico (MISE), 2017).

At European level, energy self-consumption has been strongly boosted by the new directive on renewables RED II, Renewable Energy Directive, establishing the first legal recognition of self-consumption and energy communities. Under the Directive, Member States will ensure that renewable energy consumers, who are in the same building, are authorized to organize the exchange of renewable energy produced at their site, among themselves. This will allow the production, accumulation and sale of energy from one to many model. The Directive also provides that different stakeholders can join "renewable communities" based on self-consumption and sharing of the energy produced. Also in this case, the communities will be able to use the existing distribution networks, paying the relative charges, according to fair criteria based on the specific analysis of the cost-benefits also at the environmental level.

Furthermore, Law 221 of 2015 establishes, at national level, the possibility of creating areas free from the dependence of fossil fuels. In these territorial areas, the possibility of starting research and experiments, which also extend to new forms of association, is allowed. Indeed, according to Law 28/12/2015, n. 221 - Article 71 - Oil free zone, the "Oil free zone" means a territorial area in which, within a certain period of time and on the basis of a specific policy act adopted by the municipalities of the reference territory, the progressive replacement of oil and its derivatives, with energy produced from renewable sources, is envisaged. In order to promote the gradual exit from the carbon cycle economy, on an experimental and subsidiary basis, and to achieve European standards in environmental sustainability, the "Oil free zones" are established and promoted.

In this context, the Piedmont Region, with a Regional law in order to “promote the birth of energy communities as non-profit organizations”, act in this way. The Piedmont Region is the first Italian region to issue a law on Energy Communities (Regional Law of 3 August 2018, n. 12 "Promotion of the institution of energy communities") in order to promote this new paradigm. The Piedmont has, indeed, laid down the framework for the energy communities and, according to this law, the Municipalities that intend to set up an energy community have adopt a specific protocol of understanding, drawn up on the basis of criteria, indicating by a subsequent regional implementing provision. In addition, the Region accepts to financially support the establishment of energy communities, through specific incentives; furthermore, the EC may also stipulate agreements with ARERA (Regulatory Authority for Energy, Networks and Environment), in order to optimize the management and use of energy networks. The Regional law also provides for the establishment of a permanent technical panel between the energy communities and Region in order to acquire data on the reduction of energy consumption, on the amount of self-consumption and on the share of use of renewable energy and to identify the methods for more efficient management of energy networks. This action represents an important step in the direction of energy self-sufficiency and the construction of a new model of virtuous territorial cooperation.

2.3 Energy Community definition

The first form of community based on renewable energy have developed in 1970s in Sweden, Netherland and Denmark and subsequently they spread in other European countries, such as Germany and Great Britain. Currently, there are a lot of energy community initiatives. The term energy community is varied since it includes different types of actors, it is based on different organizational forms, pursues even multiple objectives (which are not necessarily linked to energy aspects) and, to achieve these objectives, it uses different strategies and technologies. As described previously, the paradigm shift, through the concept of energy community, is perceptible at the legislative level and it is defined in the revised Internal Electricity Market Directive (EU) 2019/944 (European Parliament & Council of the European Union, 2019) and the revised Renewable Energy Directive (EU) 2018/2001 (European Parliament & Council of the European Union, 2018), respectively through the terms of "citizen energy communities" and "renewable energy communities". These different expressions identify the same concept: an innovative model of energy supply, distribution and consumption with the aim of facilitating the production and exchange of energy generated mainly from renewable sources, as well as improving efficiency and reducing energy consumption. In addition an energy community refers to a wide range of collective action that involve citizens, at different levels and with several involvement degrees, in the decision-making related to the energy system with the primary purpose to get some community benefits (economic, environmental and social) for the involved people (Walker and Devine-Wright, 2008). The term "community" has an intrinsically positive connotation; indeed, it implies cohesion and solidarity in a very specific social context in which co-operation is favoured. It is, therefore, about people (stakeholders) who come together by choice and not by chance in order to guarantee their satisfaction through collective action; consequently, the participants' intentionality and will that allow the birth of an energy community are important and core elements. Energy community embodies stakeholders that voluntarily form a group and, in this context, certain rules are established in order to achieve common objectives, solely but not limited to energy, that are: generating energy, managing energy demand and supply and purchasing energy as collective group. Energy community proposes itself as an alternative in organization, management and governance of energy systems (Van Der Schoor et al., 2015). It is a new form of social movement that allows more participative and democratic energy processes; indeed, collective energy actions around open, democratic participation and governance are organized (Roberts et al., 2019). In this way, local citizens allow to take decisions and undertake actions that normally are reserved by regional or national agencies or by few private individuals.

Energy communities are experimental projects that are spreading across Europe in various forms. The JRC report (Caramizaru and Uihlein, 2020) analysed energy community projects in 9 countries across Europe and, as shown in Figure 8, Germany and Denmark are two countries with the highest number of community energy organization.

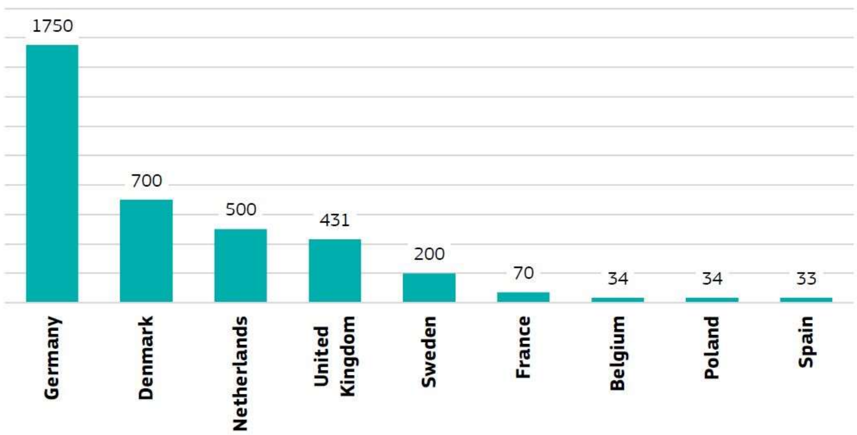

Figure 8. Approximate number of community energy initiatives from the nine countries of the 24 case studies (source: (Caramizaru and Uihlein, 2020))

Energy communities have basic principles in common but arise in different way, for organisational models and legal forms. Below, the conceptual elements, characteristics and differences of an energy community are listed.

Purpose. The main purpose of an EC is to produce environmental and social benefits rather than financial profits. Indeed, the directives frame defines users of energy communities as non-commercial actors that use profits to provide services and benefits for members and/or for the local community (Roberts et al., 2019).

Activities. The EC activities concern energy generation, consumption, distribution and sharing. Some EC implementations concern roofs equipped with solar panels, small biomass installations, windmills installed by residents in a village, district heating networks, etc.

Governance. The participation in EC should be 'open and voluntary'. The revised Renewable Energy Directive states that the participation in RE projects is open to all potential local members based on non-discriminatory criteria (European Parliament & Council of the European Union, 2018). Also the revised Electricity Market Directive (European Parliament & Council of the European Union, 2019) share the same principle: all segments of entities could become membership in EC. In addition, the household customers should be allowed to participate voluntarily in EC initiatives and, likewise, have the freedom to leave them, without losing access to the network managed by the community.

Ownership and control. The revised Renewable Energy Directive and revised Electricity Market Directive promote the participation and effective control by citizens, local authorities and SMEs whose primary economic activity is not the energy sector (Roberts et al., 2019).

Participants. Any actor can participate in a citizen energy community (remembering that members or shareholders that are engaged in large-scale commercial activity and for which the energy sector constitute a primary area of economic activity do not exercise any decision-making power) (Roberts et al., 2019). Natural persons, local authorities and micro, small, medium and large enterprises are allowed as participants in an energy community. In addition, a separate provision requires Member States to ensure that participation in energy communities is accessible to consumers in low-income or vulnerable households. This provision allows the participation of all segments of the population, considering that today, due to bureaucracy, little knowledge and little investment power, the participants are mainly men, middle-aged, wealthy and with a high income (Lowitzsch, 2019).

Typology and structure. The EC typology and structure concern cooperatives, association, partnership, eco-villages, small-scale heating organisations and other projects led by citizen groups. The most common type are energy cooperatives that have been established since the introduction of renewables support schemes.

Energy technologies. The common technology implemented are solar, bioenergy, wind, hydro, district heating networks or electric vehicles.

Size. The EC does not have a specific and precise size; indeed, it could differ in spread and size from the local, regional or national context. Furthermore, the number of members is also variable, from a few to thousands.

Geographical scope. EC can be of two typology: place-based and non-placed-based and the difference refers to the correspondence or not between the community and a specific area. In the event of a lack of correspondence, individuals can participate in projects they do not include neighbourhoods in which they live or work. In this case, the ownership of energy equipment and infrastructure is not necessary. Instead, the place-based communities are made up of individuals who belong to a specific and common context in which they live or work. On one hand, the revised Renewable Energy Directive emphasizes the connection between the local communities and the renewable energy projects (that are owned and developed by that community); on the other hand, the revised Electricity Market Directive does not bind citizen energy communities to a RE project in the same geographical location; consequently, it favours projects in which the proximity criterion between generation and consumption does not apply.

Autonomy. According to the Renewable Energy Directive, a renewable energy community "should be capable of remaining autonomous from individual members and other traditional market actors that participate in the community as members or shareholders" (European Parliament & Council of the European Union, 2018). Indeed, in an energy community, the decision-making powers should be limited to those members or shareholders that are not engaged in large-scale commercial activity and for which the energy sector does not constitute a primary area or economic activity (Caramizaru and Uihlein, 2020).

2.4 Energy poverty

The energy poverty (EP) is a widespread problem across the Europe that is determined by the ongoing economic and social crisis. It affects between 50 and 125 million people (European Fuel Poverty and Energy Efficiency (EPEE) project, 2009) and it is defined as:

- the inability to afford proper indoor thermal comfort;
- the difficulty to reach the necessary energy to meet the basic need in order to reach adequate living condition;
- the difficulty to reach the adequate basis threshold of living condition but to be not able to address the economic expenditure for the energy.

The energy poverty is determined by two types of causes: direct and indirect causes. The direct causes regarding the poor energy efficiency condition of the dwelling of the building stock, the high-energy costs, the low household income, the job position (retirement) and the relationship between the dwelling dimension and the number of occupant. The indirect causes are represented, principally, by the rising cost of living and benefit cuts. In Europe the people affected by the energy poverty are mainly elderly, unemployed and underage (Bouzarovski and Thomson, 2020). In addition, the energy poverty leads to negative impact not only economic but also on the health and social aspect, for example the isolation condition. In order to address the energy poverty it is necessary to know and to understand problem and causes. The problem has arisen in recent years, mainly as a result of three factors: (i) the decrease of resource available to low-income households (even if an increase in the average income has been recorded, the distribution of wealth is not homogeneous, leading to an increase in citizens at risk of poverty), (ii) the lower energy efficiency conditions of the building envelope and of the energy plant systems and (iii) the energy price where taxes and system charges have high incidence.

In this context, the European countries are facing the issue in different way, and energy community represents a possible solution. The energy community is an open tool that can allow the weaker and less well-off people to participate in the construction and management of renewable energy plant system. Indeed, energy communities bring together citizens, small and medium-sized enterprises and local authorities to ensure the sharing of renewable energy produced among the members of the same community, in a very limited territorial area where the community installs its own systems. The main barrier, linked to the installation of a new energy system, is the investment cost; this should be made with the revenues of the community itself, so as to include people who would otherwise have no way of accessing it. The principals of energy community is the use of renewable energy, produced and consumed locally; this determines less costs for energy transport and fewer losses on the network. In addition, the energy consumption, in the time frame in which the renewable production is high, is important for optimizing the use of renewable energy and decreasing the need for fossil-based support to capacity needs. Finally, the energy community represents a way of development and attention to local situations of energy poverty.

In an energy community, members are associated in any form allowed by legislation that guarantees the community to assume rights and duties; the inclusion in the energy community have to be open; in other words, this requirement allows to any person residing in the neighbourhood to be able to join the community. Indeed, the open nature of the communities implies that the join conditions should be such as not to affect the potential membership, even if individuals are an energy poverty condition. Therefore, the energy community allow individuals in a state of energy poverty who could never invest in the construction of renewable source plants to share the benefits of installing a renewable source plant and, consequently, to obtain amounts that contribute to the reduction of their energy costs. From a practical perspective, to ensure that the energy community can make an effective contribution to energy poverty conditions, it is important to intervene (i) avoiding subordinating the association to the community to the payment of membership fees; (ii) providing in the Statute or in the agreements for the distribution of proceeds that a preferential part of the refunds to members is guaranteed to those in a state of energy poverty; (iii) reducing community management expenses as much as possible; (iv) reducing the energy expenditure reduction for some consumer groups through energy bonus (e.g. discount on energy bills); (v) trying as far as possible to maximize the convenience conditions of joining the community through the use of the tax benefit of the tax deduction, or through agreements with plants made available by the municipalities. Concerning the promotion of energy efficiency and renewable energy generation through fiscal deduction of refurbishment costs, usually do not represent a winning solution since renters could receive tax deductions but not have the consent from the building owners to intervene.

The energy poverty affects the whole social community and solutions towards active participation by all segments of the population should include contributions from several stakeholders, such as institutions, charities, associations, researches and common citizens. Generating community aggregation around energy saving opportunities and encouraging local initiatives based on simple technical indication lead not only to energy and environmental benefits but also to community cohesion.

2.5 Prosumership

The term "prosumer" has a very wide use in energy transition and in the development scenarios of the various energy sources; in recent times, it is common, widespread and used in discussions as capable of summarizing and evoking the whole theme of the future individual, capable of living in harmony with the whole universe and the whole environment. The term "prosumer" is the synthesis of two words: "producer" and "consumer" and indicates an individual strongly independent from the classical economy. In energy communities the figure of the simple passive consumer is no longer present, but this is replaced by a user who invests, makes key decisions not only for himself/herself but at the community level. Indeed, a prosumer is a user with a more active role in the phases of production, distribution and consumption of energy, and for which monitoring, energy saving, and accumulation take on an ever-increasing significance. It follows that the fundamental element is not so much the technical components of an energy community but the prosumers, the citizens, who through their contributions and will makes the energy transition could be reach through a focus not on the individual but on the community, on the energy community.

2.6 Co-ownership

In the energy community, a relevant element is co-ownership. In fact, the classic one-to-one power supply model is turning into a one-to-many model. This means that the energy produced by a plant can not only reach the different housing units within a building but can serve different buildings, even different for their intended use. Moreover, thanks to the recently created legislative apparatus, exchanges of energy between the individuals involved, or prosumers, are allowed. As anticipated, the prosumers take an active role as they are involved in the phases of energy consumption, management and production as they are owners of the energy plant. In this specific case it opens as co-ownership; indeed, all interested people can take part in this community project, through an appropriate financial plan.

The Consumer Stock Ownership Plan (CSOP) is a financing technique that facilitates the involvement of investor through the figure of trustee (SCORE project, 2019). The CSOP model was applied in 1958, for the first time, by Louis O. Kelso, in United Stated with the aim at including American workers as co-owners or their employer companies (Lowitzsch, 2019). This structure is adaptable to the energy context; indeed, the CSOP model aims to reduce barriers and facilitate users' participation, allowing user to buy a share of an existing energy plant or invest in a new plant based on renewable energy. Specifically, the CSOP model allows consumers, especially those without savings or access to credit, to invest and become prosumers. It is a fiduciary investment model that provides participation not only financially but also in decision making. In addition, the CSOP facilitates investments between individuals with different interests such as municipalities, SMEs and other local authorities. Finally, an intermediate entity (the Operating Company) invests in the plant and manages it on behalf of the co-owners. The CSOP structure is detailed in Figure 9 and further described below.

Figure 9. Co-ownership financing model (source: (SCORE project, 2019)**).**

1. The establishment of a trustee as a fiduciary instrument. Trustee is usually a private company with limited liability (in small projects this can be a physical person) that manages consumer accounts.
2. Conclusion of fiduciary agreements (fiduciary-consumers) defining the value of the shares in the co-ownership plans (normally proportional to the energy consumption of each household, but the application of other types of principles is also possible). Contribution to the initial share capital by the participating families as their investment.
3. Creation of an intermediate entity (Operating Company) that invests in an existing or new energy plant. Acquisition of shares in the co-ownership Operating Company by co-investors such as the municipality and/or local SMEs.
4. Conclusion of standard energy supply agreements between consumers and the Operating Company;
5. the co-ownership operating company then signs a bank loan on behalf of the consumer shareholders and provides guarantees to the loan (value of the plant plus that of the shares), thus protecting the personal liability of consumers.
6. The RE plant supplies energy to consumer shareholders and sells surpluses of production; all revenues flow into the Operating Company.
7. Repayment of the loan: the interest and principal are managed with the revenues deriving from the sale of the excess energy produced by the plant and from the monthly payments relating to energy by each family.
8. After the equity acquisition loan has been repaid, the profits from the power plant are distributed to the consuming shareholders in the form of dividends based on the number of shares.

The innovative aspect of a RE plant co-ownership is a second source of income, from equity ownership in an investment that requires no prior savings, is shared between consuming shareholders. The project is financed by the future investment earnings, i.e. the revenue from energy sales. The participation in the CSOP financing model concerns some benefits for consumers (citizens).

a) Low investment and low individual responsibility. The requested investment requested to consumer is low. In addition, the Operating Company requests a loan to the bank. Finally, the individual consumer's liability is limited to the investment quota only.
b) Small source of income. The sale of produced energy creates a small profit, a small source of income. Once the bank loan is repaid, the profits are distributed among consumers in proportion to the amount invested.
c) The trustee helps and represents consumers. Consumers can participate in co-ownership even without having specific knowledge on the subject: it is the task of the trustee to inform, instruct and guide them. In addition, the involvement takes time and consumers determine to what extent they want to be involved in the decision-making process.
d) Independence from national energy supply through the energy community. Energy community is a possible way to address the energy and environmental problem through the increasingly active figure of the consumer (i.e. prosumer). Prosumers play an active role in the phases of self-production, self-consumption, exchange and energy management. In addition, greater independence from other public service providers are promoted and independence from variable energy price.
e) Environmental commitment. The implementation of the project leads to environmental benefits such as a better air quality, a reduction of CO_2 emissions and better living conditions for future generations.

2.7 Conclusion

The aim of this chapter was to answer the following research question: *"What elements are necessary for the birth of an energy community?"* and the emerging issue of energy communities was addressed in order to clarify the terminology used in Chapter 4, relating to the methodology. First of all, at European and Italian level, the regulatory framework in the context of community projects was described. The context formation is recent; although some experiments on the subject had already taken place, only in 2015 the Oil free zones were established; these are areas in which, by law, it was possible to carry out and implement actions in the field of energy. The production and exchange of energy (produced from renewable sources) among users, in order to overcome dependence on fossil fuels, is allowed. The definition of an energy community is not unique but, in general, there are shared elements. An energy community is created by the desire of different users to unite and cooperate in order to invest in a new or existing plant for the production of energy and to actively participate in its production, exchange and management phases. The user occupies a key and central position since it is not only an energy consumer but becomes a prosumer (producer and consumer) who, through his/her choices, engages in sustainable actions for the environment and for energy. Furthermore, energy communities can be very diverse; they can encompass a small portion of territory such as a neighbourhood or be as large as a city or region; they can use different technologies for energy production such as thermal solar panels, photovoltaic panels, biomass systems, etc.; they can include different users such as citizens, public entities, SMEs or, in any case, users who do not have the energy sector as their main source of income. In addition, the energy community is created to bring benefits also in other sectors: reduction of emissions and pollution, better living conditions for future generations, economic development, self-sufficiency, independence from public service providers or foreign states, independence from variable prices of energy, reduction of energy poverty, community cohesion, creation of new job, etc. As listed, the energy community aims to solve the problem of energy poverty that is present throughout Europe. The energy poverty leads to negative impact not only economic but also on the health and social aspect, for example the isolation condition. The causes related to the occurrence of the problem could be direct or indirect; the most frequent are the decrease of resource available to low-income households, the lower energy efficiency conditions of the building envelope and of the energy plant systems and the energy price where taxes and system charges have high incidence. Since sharing and inclusion is the cornerstone of the energy community, through targeted policies, it is necessary to include all segments of the population, especially the most fragile and vulnerable. Inclusion should not be limited to simple participation but it is desirable that it is also aimed at the (co-)ownership of the energy plant system: each user, represented by a trustee, invests economically as much as he/she can; initially with the earnings obtained from the sale of the surplus energy (appropriately distributed among the participants) the bank loan is repaid and only in a second phase the surplus become a small source of income.

Chapter 3

The role of citizens in the energy community

3.1 Introduction

The energy transition path is a way (i) to avoid the use of energy resources from fossil sources in favour of renewable ones, (ii) to improve the energy efficiency related to the energy production and, finally, (iii) to define a more conscious energy consumption by users/citizens. These purposes show how is necessary to consider not only the technical but also the social aspects and, therefore, speaking of socio-technical energy transition. In this way, as discussed in the previous chapter, the user/citizen is placed at the centre, becoming an element that assumes a fundamental role. The challenge is not just a fascinating proof on the scientific and technological level, but rather it should turn into a cultural and moral challenge that tends towards individual responsibility, in which all citizens are involved. Simple daily actions or decisions have an impact on energy consumption and the only use of new and more efficient technologies does not guarantee low consumption if it is present the unpredictability of user/citizen, given by his/her behaviour. In other words, for example, owning the Smart Meter does not reduce the energy consumption in buildings but, rather, reducing the set-point temperature is a behaviour that requires the installation of the Smart Meter to monitor, to make the user aware and, consequently, to save energy and money. In this way, studies at European level have shown how behavioural actions, linked to a conscious and optimal use of technologies, can allow energy savings of between 15% and 20% (Pothitou et al., 2016b). However, behaviour is not an easy topic: the deepening of the user behaviour theme and the recent interest, related to behavioural change, play a fundamental role in achieving the environmental purposes related to the energy transition. In addition, the administration of appropriate communication strategies can encourage people to adopt behaviours that reduce the negative impact on the environment and, at the same time, can increase user involvement leading to a behavioural change. Thus, the transmission of information plays a crucial role. Communication must be understood as a path of education (in this case an environmental and energy education) aimed at training and encouraging users to reduce consumption through greater awareness of the consequences of their habits or behaviour. Since the amount of information that users receive every day is high, it follows that not all messages are assimilated. Consequently, the information intended to be provided must attract attention and arouse interest, remembering that the clarity of the message is fundamental so that it can be received, understood and correctly interpreted by interlocutors with different backgrounds. In conclusion, “communication” does not mean the simple transmission of data but, rather, an interaction of different aspects in which the ability to attract attention, the ability to be correctly understood, the ability to give understandable information and the ability to be remembered play an important role. The communication strategies can direct towards more or less marked changes and more or less easy implementation depending on the methods used. A first level concerns the cognitive change which can be achieved through a simple transmission of adequate information in order to create awareness and knowledge (this does not necessarily imply a change in behaviour). More complex is the change in the action which consists in inducing users to change their action within a certain time through the supply of exhaustive information and effective motivations. Finally, the last level concerns the change of behaviour, of complex realization as it foresees a long-term variation of one's habits. The difficulties in reaching this last level lie in the complexity of the behaviours: to change a habit it is necessary to repeat the behaviour several times so that this becomes a new habit (taking the place of the previous one). For the achievement of other behaviours, incisive actions are necessary that provide, for example, profound choices in terms of economic expenditure, etc.

The main topic addressed in this chapter is the review of the elements that determine a user/citizen choice, action and/or behaviour. This study wants to make a contribution in better understanding the dynamics that lead a user to certain actions. Then, in the following paragraphs, the issue of behaviour is analysed in detail.

3.2 The human dimension

Analysing a behaviour, a goal achievement is given by the sum of different actions and is based on a very simple assumption: in the presence of a great commitment, great obstacles are faced; in case of low devotion, even the smallest difficulties are not overcome. More difficult actions require more personal commitment and a person who works a behaviour, that in a certain context results difficult to undertake, can be assessed as inclined to perform complex behaviour with respect to a person who performs, in the same context, only actions that are easy to implement. Consequently, more obstacles a person exceeds, greater is the effort that he/she spends in achieving goal and the commitment to that goal is stronger; on the other hand, when the presence of a small obstacle it is sufficient to prevent a person from acting behavioural measures, beyond those most simple, the commitment is probably low. Therefore, in light of the above, a behaviour is characterized by a personal effort (commitment or ability) and a behavioural price (difficulty) (Steg et al., 2013); the first refers to the personal provision, determined by the level of (for example) environmental and energy skill of a certain person, the second to the difficulty of a specific behaviour, determined by the "costs" that are implemented when that behaviour takes place. Indeed the behaviours are not all accessible in the same way but, entailing costs, they differ, for example, in effort or personal resources, time and money, etc. In addition, more obstacles and difficulties a person overcomes, the commitment placed in reaching a specific goal is greater; furthermore, it make sense to say that behaviours put in place by the most people are the easiest while those put into practice by few are difficult.

The human dimension, that is the behaviour of users and citizens, does not respect precise logic and is, consequently, still the subject of study. At the level of the individual building, it is widely demonstrated how the occupant determines differences between real and simulated energy consumption (Branco et al., 2004; International Energy Agency (IEA), 2018). This concept is equally valid if the scale of interest is wider, considering the urban one. In this case, not only the interactions of the user with his/her building will be considered, but also the interactions with other users and, moreover, the context in which the user/citizen lives. The purpose of this specific research is to cover the gap between proposed energy and environmental behaviour and the actual user possibility, remembering that the actions and behaviours are determined by some objective and subjective user's drivers. In other words, when a user has to take a decision, action or behaviour, various difficulties may arise due to the influence of users' features because they define the users' possibilities in engaging or not engaging this decision/action/behaviour. In this way, the factors that allow the user/citizen to perform or not perform a certain action are studied; a literature review was conducted in order to highlighting the main factors that determine the human choice and define a new classification of them.

3.3 The influencing factors

Building users and citizens can reduce their energy consumption and related emissions through three types of actions:

- the energy saving behaviours (ESB);
- the energy efficiency investment actions (EEI);
- the engagement in renewable energy projects (ERE).

Since human decision are complex and shaped by many factors (individual and contextual), in order to deepen the purposes, explained in the previous paragraphs, these actions are thorough.

The “energy saving behaviours” (ESB) consists in daily and habitual practices of household that focus on specific reductions in energy use related to the use of appliances in home and/or the use of home itself and no technological investment is foreseen. A behavioural example are switching off the light in occupied rooms, turning off the heating system when leaving the house for few hours, selecting the temperature of the water to wash clothes, etc. The ESBs are not characterized by an economic cost to achieve a not negligible reduction in energy consumption, but other types of costs or difficulties in engaging in these types of action could be arise.

The “energy efficiency investments” (EEI) consists in technologies adoption in order to reduce the energy consumption without an users behavioural change. The investments encompass a series of actions that concerns the appliances replacement (EEIA) and the envelope and/or energy system retrofit (EEIR). The first investments consist of purchasing appliances (“large” appliances: such as dishwashers, washing machines, refrigerators, etc.; or “small appliances”: such as TVs, computers, audio/video equipment, microwave ovens, etc.) with a high energy efficiency (class A or more). The second investments consist in major structural improvements related to physical changes of the building envelope, for example with the installation of an insulation layer or the replacements of the windows, or of the building system, for example with the installation of a new heating, domestic hot water and/or cooling system. These investments actions have different effects; in fact, the engagement in the appliances investment is characterized by a relatively low economic cost but this is associated to a proportional low reduction in energy consumption. On the other hand, the investments linked to an improvement in the envelope or the energy system are characterized by a greater cost, but the effects of these changes, compared to the others, have a decidedly greater impact. Furthermore, while changing equipment is an activity that can be done alone, without any particular expertise in energy matters (indeed, it is commonly defined a do-it-yourself (DIY) activity), retrofit activities require knowledge and skills and are mainly carried out by experienced professionals in the energy-technology sector. In addition, the retrofit solutions are inextricably linked to the building and cannot be "taken away" if the households decide to move, even if these measures probably produce an increase in the property value. Finally, the replacement of the equipment mainly affects the electrical consumption and it is determined by household composition; instead, the retrofit solution mainly refers to space and water consumption and it is determined by dwelling structure and its characteristics.

The “engagement in renewable energy projects” (ERE) consists in volunteering, in active participation and investment of financial resources, by citizens, in projects on a neighbourhood or urban scale that are based on renewable energy. Specifically, these projects represent collective action towards renewables; indeed, they consist of the self-production, exchange and self-consumption of energy from renewable sources such as sun, wind, wood, etc. Renewable energy projects are based on participation, defined as “a process in which individuals take part in decision making in the institutions, programs and environments that affect them" (Heller and Monahan, 1977). In general, citizen participation can be determined by investment actions of financial resources or through voluntary actions, defined as work without compensation for the community or non-profit organizations (Cnaan et al., 1996; Snyder and Omoto, 2008). In any case, these are emerging projects in which the lack of information, the initial investment costs and the difficulties inherent in the synergistic participation of different actors should be, gradually, studied, implemented and overcome.

Consequently a literature review research was conducted in order to identify, to determine and to understand the several main drivers that push a person to perform certain actions and to affect and to influence, directly, indirectly or in interaction way, the user decision. Academic literature (journal and conference articles) have been searched on bibliographic database in energy, social, behavioural and environmental sciences (e.g. Scopus, ScienceDirect, SpringerLink, Google Scholar platform), in a period up to 2019, using keywords and a combination of keywords such as: influencing factors, variables, drivers, energy behaviour, energy investment, renewable energy project. The research has yielded a great result in terms of scientific production. About 160 articles were analysed and the drivers from situational factors in the external environment to person-specific attribute of consumers that influence in an energy and environmental way decision-making and actions have been summarized, giving rise to a new drivers' classification. The new classification concerns 8 drivers' category:

- individual self-characteristics;
- personal characteristics;
- economic characteristics;
- household characteristics;
- building characteristics;
- community and neighbourhood characteristics;
- government, regulation and policies;
- external characteristics.

These categories are detailed in the following paragraphs in which the drivers, identified and studied, are listed for each macro-category. The definition and effects typology, with respect to the three actions considered, are given for each of them. The following figure (Figure 10) shows an overview of the factors influencing human decisions in the energy and environmental fields. Specifically, the drivers in the dashed box have been analysed in the following paragraphs.

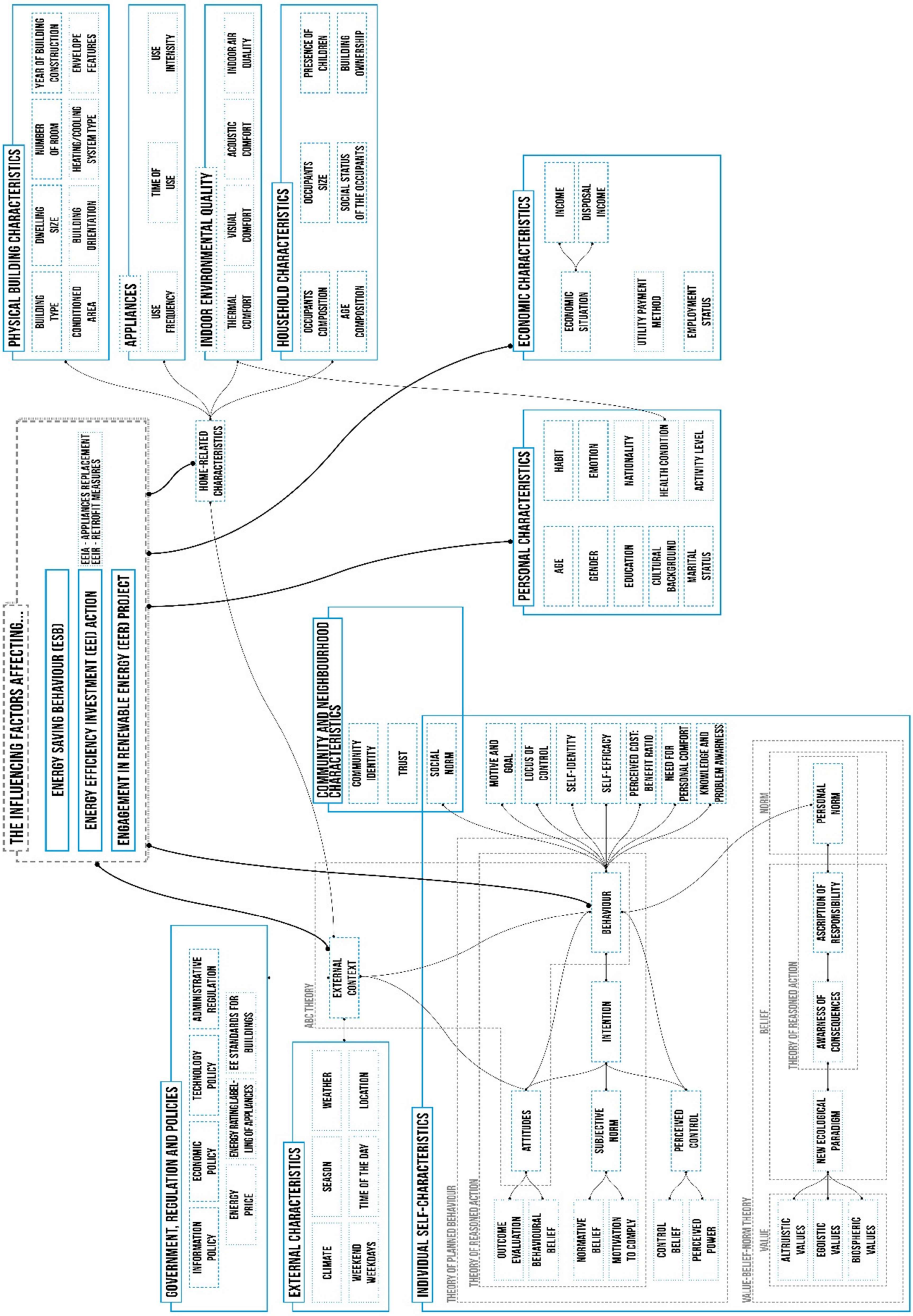

Figure 10. Conceptualization of influencing factors.

3.3.1 Individual self-characteristics

The most of literature research on drivers influencing the human behaviour and, consequently, the adoption of energy saving behaviours or the engagement in pro-environmental behaviour (such as the participation in renewable energy projects) is based on classical behavioural theories. Among all existing theories, three of these are in-depth and covered in this review: the Theory of Planned Behaviour (TPB), the Value-Belief-Norm (VBN) theory and the Attitude, Behaviour and Context (ABC) theory. It was chosen to investigate these three theories for the following reasons, listed below.

- All the selected theories are used to predict and explain the pro-environmental behaviour. The pro-environmental behaviour is a "behaviour that consciously seeks to minimize the negative impact of one's actions on the natural and built world" (Kollmuss and Agyeman, 2002) or "actions that contribute to the preservation and/or conservation of the environment" (Axelrod and Lehman, 1993).
- The Theory of Planned Behaviour is usually used to describe low-carbon consumption behaviour, specifically when the behaviour is related to self-interest (an example of this type of behaviour is when a household adopts environmental behaviours in his/her home obtaining an advantage for himself/herself).
- The Value-Belief-Norm theory is usually used to describe low-carbon consumption behaviour, specifically when the behaviour is related to public interest (an example of this type of behaviour is when a household adopts environmental behaviours, not only in his/her home, obtaining an advantage for the whole community, e.g. through the use of green energy).
- The ABC theory is thorough because it includes the effect of the external contextual factors, since Theory of Planned Behaviour and the Value-Belief-Norm theory are related only to individual's own factors.

The characteristics and founding elements of the three behavioural theories are described below, in order to understand the several drivers that push a person to perform certain actions and to affect and to influence the user decision, since there is a complex psychological process behind them.

The Theory of Planned Behaviour (TPB). The Theory of Planned Behaviour (Ajzen, 1985) is an extension of the Theory of Reasoned Action (TRA) to which the variable of perceived behavioural control was added. According to TRA, the central element that defines a behaviour is the behavioural intention that depends on the "extent of willingness of an individual to engage himself/herself in a particular action and on the extent of efforts he/she has planned to make" (Fishbein and Ajzen, 1975). In other words, the behavioural intention depends on behavioural attitude and subjective norm. The behavioural attitude concerns the extent of a person's support or not support a behaviour; the individual's attitude could have a positive or negative emotion towards that particular behaviour. In addition, attitude is also affected by outcome evaluation (i.e. the consequences of a particular behaviour based on reason) and by behavioural beliefs (i.e. the possibility that the consequences will arise). The subjective norm concerns the individual's perception of what the important people (relatives, close friends, etc.) think if he/she does a certain thing or action. In other words, the subjective norm is quite similar to a social pressure perceived when individual decides to perform or not perform a particular behaviour; consequently, it depends on normative beliefs (the individual's perception of what the important people think whether he/she performs a behaviour) and on motivation to comply (the individual's motivation to comply to his/her important people). When an individual puts a behaviour into practice, this also depends on other factors (such as time, money, etc.) and, for this reason, the variable of perceived behavioural control was added as an element influencing the behavioural intention. The perceived behavioural control concerns the difficulty degree that an individual perceives when he/she implements a particular behaviour; it depends on control beliefs (the perceived factors (such as price, time, convenience, etc.) promoting or hindering the performance of a particular behaviour) and on perceived power (the impact degree of these factors on behavioural performance).

The Value-Belief-Norm theory (VBN). The Value-Belief-Norm theory is an improvement and combination of Value Theory, Norm Activation Theory and New Ecological Paradigm, (NEP). As the name implies, the theory is composed by three elements: value, belief and norm (Stern et al., 1999). Concerning value, Stern proposed three typology: the altruistic value (that is centred on interest of others), the egoistic value (that is centred on self-interest) and the ecological value (that is centred on the interest of the biosphere). Concerning belief, this element is also composed of three parts. The first part is the New Ecological Paradigm and it measures "the people's general view on the relationship between humankind and biosphere" (in other words, a beliefs on humanity's ability to distress the balance of nature, on the presence of growth limits for human society and on humanity's right to rule over the rest of nature) (Dunlap et al., 2000). The NEP is influenced by values and, in turn, affects the awareness of consequences (the individual's belief according to which the environmental condition constitutes a threat to other people, other species and, therefore, the whole biosphere); consequently, the awareness of consequences affects the ascription of responsibility (the individual's belief that own behaviour can have negative repercussions on the environment). Finally, the ascription of responsibility affect personal norm, which can be defined as a feeling of personal obligation or as the belief that one's own behaviour follows personal values.

The Attitude, Behaviour and Context theory (ABC). According to the Attitudes-Behaviour-Context theory (Guagnano et al., 1995), attitude, behaviour and environment are dependent on their interactive influence. When the external contextual factors are extremely favourable or unfavourable, the environmental behaviour may be greatly promoted or prevented; in this case, the impact of environmental attitude on environmental behaviour is close to zero. Otherwise, when the external contextual factors are rather neutral, then there will be closer relationship between behaviour and attitude; indeed, when the external contextual factors are comparatively neutral can the personal behaviour be changed by changing personal attitudes. Finally, when a person's attitude towards behaviour is close to being neutral, then the impact of the external factors on behaviour will become very important; however, when a person has an attitude that is strong enough towards behaviour, behaviour's dependence on the external factors is going to weaken.

The individual self-drivers, identified through the three behavioural theories, are listed below; for each variables, the definition and the effects found in the literature review are described.

Behavioural intention. Behavioural intention concerns the motivational drivers that influence a behaviour; consequently, it is more likely to perform a behaviour if the intention is stronger. Therefore, low-carbon consumption behaviours are affected directly by behavioural intention (Ding et al., 2017; Mehedi Masud et al., 2015). Furthermore, the intention is not only affected by attitude, subjective norms and perceived behavioural control, as described above in the TPB, but also, directly or indirectly, by other psychological variables (Chen, 2014; Fornara et al., 2016).

Attitude. Attitude is defined as "a mental state of readiness learned and organized through experience, exerting a specific influence on a person's response to people, objects, and situations to which it is related" (Allport, 1935). Some analyses (Hines et al., 1987; Mancha and Yoder, 2015; Shi et al., 2017; Yang et al., 2016) have found a positive relationship between attitudes and pro-environmental behaviour, since people with a positive attitude are likely to engage in environmental and energy responsible behaviour. In addition, according to Becker et al. (Becker et al., 1981) householder's attitudes are the main predictors for decision concerning the energy and environmental issues and for the household energy use. Often the effects of positive attitudes have a low impact on pro-environmental behaviour (Flynn et al., 2009; Frederiks et al., 2015; Kollmuss and Agyeman, 2002); it is not to be overlooked that the people behave and make decisions in order to minimize cost and to maximize benefit to themselves, not paying attention to the effects that these benefits may have on others or the environment (Becker et al., 1981; Samuelson and Biek, 1991). Furthermore, the "attitude-action gap" is an element that can arise; despite attitudes may lead to positive intentions to ESB, EEI actions or ERE projects, various intervening factors (e.g. economic costs, lack of knowledge, social norms, etc.) can lead to the non-realization of a certain behaviour (Frederiks et al., 2015). Indeed, even if people manifest solid belief and attitudes about the negative consequences of environmental problems (e.g., global warming, climate change, etc.), or positive assessments for technologies, which can be defined as "green" and sustainable, (e.g., renewable energy sources), they fail to put into practical action.

Subjective norm. Subjective norm is defined as "the perceived social pressure to perform or not to perform a behaviour and it refers to an individual's feelings of social pressure from other people or groups" (Ajzen, 1985). In general, literature shows indirect effects of subjective norm were found on low-carbon behaviour (Mehedi Masud et al., 2015); in addition the subjective norm affects, significantly, the behavioural intention (Chen, 2016; Mancha and Yoder, 2015; Shi et al., 2017).

Perceived behavioural control. The perceived behavioural control is defined as "an individual's perceived ease or difficulty in performing a specific behaviour" (Ajzen, 1985). The perceived behavioural control usually affects, directly or indirectly, the low carbon behaviour (Mancha and Yoder, 2015; Mehedi Masud et al., 2015). In addition, if the sense of moral obligations intervenes in engaging in a behaviour, the role of perceived behaviour control is limited. Indeed, a research study (Chen, 2016) shows how the moral obligations could overwhelm the individual perceived behaviour control; consequently, a person with a strong sense of moral obligation can overcome the difficulties (e.g., lack of money, time, or skills, etc.) that he/she perceived before performing the behaviour.

Motives and goal. Motive concerns the reasons why a person acts in a certain way at any given time and encloses the driving forces which determine the goal-directed behaviour. Indeed, some theories define motivation as "the process that shapes the intensity, direction and persistence of effort that a person allocates toward achieving a particular goal or desired end state" (Steel and König, 2006). Concerning goal, a distinction should be done between self-transcendent and self-enhancing goals (Schwartz, 1994). Specifically, the self-transcendence goals support the interests of other people and the external world and they are positively related to pro-environmental behaviours. Instead, the self-enhancement goals focus on oneself and one's interests and action and the relationship with pro-environmental behaviours is negative or non-significant. Indeed, according to Schultz and Zelezny research (Schultz and Zelezny, 2003), greater attention and concern for environmental issues and engagement in pro-environmental behaviours are expressed by people characterized by high self-transcendent value. Conversely, egotistical concerns about environmental issues and a low commitment to pro-environmental behaviours are expressed by people characterized by high self-enhancing value. Furthermore, also intrinsic motives, defined as motivation related to personal interest and pleasure in an activity without external pressures or rewards, are linked to pro-environmental behaviour. In De Young research, four different intrinsic satisfactions and motives that support environmental sustainability are suggested (De Young, 2000): satisfaction determined by behavioural competence (e.g., gratification from solving problems and completing tasks), satisfaction from frugal, thoughtful consumption (e.g., gratification of careful management of limited resources), satisfaction from participating in the community (e.g., gratification from being involved in community activities), and, finally, satisfaction from luxuries (e.g., gratification to new/novel products). In addition, another research (Pelletier and Sharp, 2008) states that sustainable behaviour are applied by people who own intrinsic motivation. A motive could be primary or specific: primary motives influences a wide range of behaviour, instead, specific motives influence particular actions and often evolve around one’s own needs. Furthermore, the goal framing theory (Lindenberg et al., 2066) states that human behaviour arises from several motivations and goals guide how people think, feel and act. In order to foresee pro-environmental behaviour, three motives have been defined (Lindenberg and Steg, 2007): gain goal (the desire to protect and improve one’s resources, e.g. to save money), normative goal (the desire to behave properly in line with social and moral standards) and hedonic goal (the desire to achieve positive self-esteem and improve how one feels at a particular moment, e.g. to seek pleasure and avoid pain).

Personal norm. Personal norm is defined as “feelings of moral obligations to act in a pro-social, altruistic manner” (Schwartz, 1977) and, through the NEP, the awareness of consequences and the ascription of responsibility, it is influenced by values. Personal norm have a direct effect on low-carbon consumption behaviour (Fornara et al., 2016; Han et al., 2017; Lind et al., 2015). In addition, personal norm affect the altruistic behaviour and acting following personal norms generates positive feelings (e.g. satisfaction and pride) in people; otherwise, acting not following personal norms generates negative feelings (e.g. regret and guilt). The personal norm is activated by the consciousness that human behaviour affects the context (environment and other people) in which a person live (i.e. awareness of consequences) and by the sense of personal responsibility for such impacts (i.e. the ascription of responsibility). According to this, Abrahamse and Steg highlighted in their research (Abrahamse and Steg, 2009) that people feel a stronger commitment to apply ESB or invest in EE if they believe that their currently actions and decisions negatively affect the environment.

Sense of responsibility and perceived responsibility. Sense of responsibility is the conscious awareness of one’s obligations. The sense of responsibility has a significantly positive influence on ESB, EEI actions and ERE projects (Ding et al., 2017; Yang et al., 2016). Indeed, many studies argued that perceived responsibility, relating to environmental issues and problems (e.g. feeling obligated to reduce the carbon emissions in order to fight against the climate change), is positively associated to sustainable use of energy and to pro-environmental behaviour. Therefore, people, characterized by a feeling of responsibility towards a specific issues and since they feel a stronger commitment towards them, feel they have to mitigate and minimize the negative effects, activating personal norms (e.g., moral obligation to act) and increasing one’s willingness to act pro-environmentally (Abrahamse and Steg, 2009). On the other side, people may give fault to an external entity, denying personal responsibility; in this case, do not feel the need to take action or make decisions in order to change one’s lifestyle and behaviour. Consequently, the acceptance of personal responsibility in environmental and energy issues is, therefore, considered a predictor of ESB (Barr et al., 2005; Samuelson and Biek, 1991). In addition, according to (Hummel et al., 1978), the willingness to save energy is associated to perceived self-fault, instead a less willingness to save energy is associated to the fault imputation to someone else. Finally, in psychological literature a discrepancy between intentions, perceived responsibility and pro-environmental behaviour is present and the relationship is not always consistent or reliable.

Value. Value could be defined as a set of ideals, belief and standards that drive people principles, for example the individual's sense of right and wrong. Many research have examined the role of values, attitudes and beliefs in the context of pro-environmental behaviour, mainly related to the energy use (Abrahamse and Steg, 2011, 2009; Samuelson and Biek, 1991; Schultz and Zelezny, 2003). Specifically, pro-environmental behaviour are supported by pro-environmental values, attitudes and beliefs (Becker et al., 1981; Hines et al., 1987; Seligman et al., 1977). As expressed for attitudes, values are also characterized by "value-action gap" (Boulstridge and Carrigan, 2000; Flynn et al., 2009; Stern et al., 1999).

Environmental value. Environmental value is the individual's value towards the environment and it directly influence the low-carbon consumption behaviour (Ding et al., 2017; Estrada et al., 2017) or the low-carbon behavioural intention (Q. Li et al., 2017; Pals and Singer, 2015). An inconsistency between environmental values and environmental behaviour ("environmental values-action gap") (Frederiks et al., 2015) is present and, consequently, the environmental values is affected by other factors (e.g. pursuing happiness and wealth). In addition, the concept of environmental concern consists in apprehension for environment and, in literature, this is closely linked to greater environmental awareness and, consequently, to the implementation of behaviours in favour of the environment (Kilbourne and Pickett, 2008).

Locus of control. Locus of control reflects "a person's perception of whether they have the capability to enact change and/or control events that impact them" (Kaiser et al., 1999). People with a strong internal locus of control believe that the events are affected mainly by internal factors (e.g. personal motivation), thinking to control decisions, life circumstances and outcomes (Hines et al., 1987). Instead, people with a strong external locus of control believe that the events are affected mainly by external factors (e.g. government, other people or socio-economic drivers). This last people category considers pro-environmental behaviours useless and they believe to "cannot make a difference" (Kollmuss and Agyeman, 2002). Finally, psychology literature proposes that attitudes, individual's values and intention to ESB or EEI are connected to locus of control; in any case, the effective behaviour implementation does not always respond to linear matches or the relationship is not strong.

Self-identity. Self-identity concerns a specific role or general sense of role that an individual attributes to himself/herself with the significance, expectation, and series of standard associated to that role in order to guide his/her behaviour (Ding et al., 2018). Self-identity affect, significantly, the low carbon behaviour (Dermody et al., 2018). Furthermore, as evidenced by (Lacasse, 2016), the positive self-identity leads to an increase of personal attitude towards ESB.

Self-efficacy. Self-efficacy concerns the confidence level of completing some specific tasks by using own ability. According to some researchers (Broomell et al., 2015; Estrada et al., 2017; Huang, 2016), it has a significant positive impact on pro-environmental behaviour. In addition, self-efficacy affects directly (Estrada et al., 2017) or indirectly (e.g. through internet, newspaper) (Huang, 2016) the ESB, EEI actions or ERE projects.

Perceived cost: benefit ratio. People, when performing actions, are often motivated by self-interest and try to pursue the best alternatives characterized by high benefit and, at the same time, lowest cost (where "benefits" and "costs" may include scarce or valued resources such as time, effort, money, etc.). The economic and behavioural cost-benefit trade-offs may influence pro-environmental behaviour. For example, the perceived advantages and disadvantages of pro-environmental behaviour are explored in Midden and Ritsema research (Midden and Ritsema, 1983); they have identified: personal disadvantages (e.g., beliefs regarding loss of comfort imposed by an energy-saving lifestyle), societal advantages (e.g. beliefs regarding less environmental pollution, more energy for future generations, etc.) and personal responsibility (e.g., beliefs regarding a sense of duty/responsibility). From an economic perspective, financial costs (or benefits) concern the monetary expenses (or potential savings) that households incur from consuming energy (or conserving energy) (Barr et al., 2005; Seligman et al., 1979; Verhllen and Van Raaij, 1981). The probability of engaging in EEI initiatives shrinks due to financial costs related to initial investment and due to long-term monetary payoffs. Indeed, if on one hand, people may want to improve the EE in their home, purchasing appliances or investing in retrofit measures, on the other hand, the initial financial costs may discourage pro-environmental actions, since there are no immediate benefits. At the same time, the energy usage costs may affect people choice regarding the adoption of energy efficiency measures: if energy consumption costs and EE level are perceived as high, people might be more motivated to engage in order to increase the EE, to reduce energy consumption and, thus, to decrease the utility bill expenses (Black et al., 1985; Nair et al., 2010). Indeed, a recent study by Nair et al. (Nair et al., 2010) found that the increase of energy prices and expenses may actually encourage people to actively invest in EE measures in order to reach energy savings. Research show how people that perceived their household energy costs as high were more likely to adopt investment measures respect people who perceived their household energy costs as low. Furthermore, the concept of time inconsistency is important for understanding the potential impact of cost and benefit appraisals. In many situations, people postpone decisions or actions since these are viewed as costly in the short-term, even if they offer long-term benefits (environmental benefits, such as reduced carbon emissions, or economic benefits, such as monetary savings on energy bills). Many research supports this tendency for people to assess immediate rewards (and dislike immediate costs) far more than they assess future rewards (and dislike future costs) (Thaler, 1980).

Need for personal comfort. The energy-saving measures may lead to a perception of loss of comfort; this feeling can influence the household energy actions. Indeed, the probability to engage in energy conservation behaviour reduces when personal comfort or lifestyle quality reduction. In this regard, Barr et al., in their research (Barr et al., 2005), explored the level of comfort and the relationship that this has with the acceptance of ESB and EEI actions. The research output highlighted how over 60% of citizens defined "committed environmentalists" were willing to loss some comfort in order to pursue energy savings and environmental protection behaviour; but also the 25% of citizens defined "non-environmentalists" were willing to act in the same way. Furthermore, the feeling of "comfortable around the home" was considered an important issues by less than 20% of "committed environmentalists" and by almost 60% of "non-environmentalists".

Knowledge & problem awareness. Energy-related knowledge concerns the individual's level of knowledge and awareness related to behavioural potential and consequences (Van Raaij and Verhallen, 1983). In general, the relationship between knowledge and awareness and environmental and energy issues has different results: on one hand, greater level of knowledge and awareness are associated to pro-environmental behaviour (Brandon and Lewis, 1999; Herberlein and Warriner, 1983); one the other hand, knowledge and awareness does not always translate directly in pro-environmental behaviour, since a "knowledge-action gap", often, is present (Abrahamse et al., 2005; Barr et al., 2005; Courtenay-hall and Rogers, 2002; Kennedy et al., 2004; Sligo and Jameson, 2000). Indeed, due to the impact of several drivers, that may limit or facilitate energy-saving and environmental protection behaviour, the increase of knowledge and awareness does not usually translate into a consistent behavioural change. Furthermore, according to Kollmuss and Agyeman (Kollmuss and Agyeman, 2002), the environmental and energy knowledge and awareness affect the pro-environmental behaviour only in small extent, since (more or less) the 80% of the pro-environmental behaviour is defined by other internal and situational factors. Consequently, the relationships between knowledge and problem awareness and pro-environmental behaviours is not statistically significant (Abrahamse et al., 2005; Staats et al., 1996).

3.3.2 Personal characteristics

Age. Age is the time length that a person has lived or is living. In general, the relationship between age and ESBs, EEI actions and ERE projects concerns different and inconsistent empirical results; indeed, it does not consistently appear as a statistically significant predictor. As expressed by Barr et al. (Barr et al., 2005), the households belonging to "25-44" and "55-65" age groups are particularly inclined to adopt daily energy-savings behaviours. Instead, concerning the investment in low carbon or more energy efficiency solutions, researchers believe that age has a non-lineal relationship (Balcombe et al., 2013; Belaïd and Garcia, 2016; Karytsas and Theodoropoulou, 2014a, 2014b; Sardianou and Genoudi, 2013; Yang et al., 2016). Specifically, for the EER measures, the "25-65+" age group are likely to invest compared to the "16-24" age group. The investment by middle-aged people is certainly likely (Sardianou and Genoudi, 2013); instead, it should be emphasized as the willingness to invest from older occupants is a source of conflict. On the one hand, the very high investment costs, the negative perception of cost-benefit ratio and the long payback period represent a limitation due to their advanced age (Abrahamse and Steg, 2011; Ramos et al., 2015) but, on the other hand, often, with advancing age, the amount of money a person owns often increases before retirement. In addition, retired elderly people spend more time at home, consequently consuming much more energy (mainly for heating) than younger generations. Precisely for this expense, however, they are willing to invest in EER measures to increase thermal comfort. Furthermore, many old people, having lived when younger difficult times, and therefore as a result of past experiences, are very active in energy conservation (Yang et al., 2016).

Gender. Gender concerns the range of characteristics related to, and differentiating between, femininity and masculinity; in addition, it should not be underestimated that the concept of gender is subjective and depends on how a person perceives and experiences their body. In general, the relationship between gender and ESBs, EEI actions and ERE projects concerns different and inconsistent empirical results, indeed it could have effects (Pothitou et al., 2016a; Yu et al., 2018) or not (Ameli and Brandt, 2015; Martinsson et al., 2011; Yang et al., 2016). Concerning the investment in more efficiency appliances, according to (Gaspar and Antunes, 2011), the research shows as the 6% of women are more likely to implement this type of actions; indeed, they spend time to be informed about the energy classes of the products to be purchased, showing greater environmental awareness compared to men. It is no coincidence that several studies (Barr et al., 2005; Clark et al., 2003; Kollmuss and Agyeman, 2002; Zelezny et al., 2000) have highlighted pro-environmental attitudes and behaviours mainly in women, resulting more involved in wanting to improve environmental conditions (Belaïd and Garcia, 2016). Conversely, other studies (Abrahamse and Steg, 2011, 2009; Hines et al., 1987; Olsen, 1983; Poortinga et al., 2003) have not highlighted this evidence with the female gender.

Education. Education represents the process of receiving or giving systematic instruction, especially at a school or university. In general, education concerns different results. On one hand, education is not related to energy saving behaviours (Belaïd and Garcia, 2016; Curtis et al., 1984; Yang et al., 2016; Yu et al., 2018) and energy efficiency investments (Ameli and Brandt, 2015). On the other hand, according other studies (Mills and Schleich, 2012; Poortinga et al., 2004), a positive relationship between education level and ESB and EEI is shown; indeed, people with a high school education are likely to have a high income and, consequently, they are able to afford the economic expenses related to energy efficiency improvement measures. Furthermore, research highlights how positive effects on low-carbon consumption behaviour are associated with education improvement (Ding et al., 2017; Ye et al., 2017), for example, a case study (Bartiaux and Gram-Hanssen, 2005) shows that household electricity consumption decreased significantly as the level of education increased and the households with higher education degree consumed less electricity than households with low education level. Instead, even if education tends to be associated with increased knowledge, awareness and concern regarding environmental and energy issues, however, no positive effect between education level and low-carbon consumption behaviour are highlighted in other research. Indeed, sometimes higher levels of education do not imply certainly and directly to pro-environmental behaviour (Kollmuss and Agyeman, 2002). Finally, education in young generation (for example in school context) is not to be underestimated since it forms energy and environmental attitudes, lifestyle, habits and behaviour, that will be good for the whole society, and it has the most lasting impact on people. Indeed, according to a research investigating the students' perspective and attitude about the relationship between environment and energy (Ntona et al., 2015), education covers an important role towards a sustainable future pathway.

Cultural background. Cultural background is the context of individual's life experience as shaped by membership in groups based on ethnicity, race, socioeconomic status, gender, language, religion, sexual orientation, and geographical area. All beliefs, values, and rules, that characterize the members of a society and differentiate from other societies, shape the cultural background; in addition, it concerns the transmitted behaviour patterns, arts, beliefs, institutions, and all other products of human work and thought that a person has grown up in and belongs to. Culture has the most lasting impact on people and education is closely linked and represents a way to spread culture. In this regard, school and family are important place to learn and cultivate habits towards the energy saving and environment protection. Furthermore, Digital skills online social networking and socio-political interest are important predictors in energy and environmental behaviours. Rich and highly educated citizen, living in urban area, had significantly more access to internet than others. In addition, men were more inclined to participate online than woman, and that unemployed citizens were relatively more willing to participate.

Marital status. Marital status concerns a person's relationship with a significant other and some status could be married, single, divorced or widowed. According to Trotta (Trotta, 2018) the married condition is connected with the EEI (in appliances and retrofit measures) and with ESB. In addition, not being married but living with a partner has also been shown to be positively associated with the purchase of more energy efficient appliances than respondents characterized by single status.

Habit. Habit concerns a sequence of actions which have become automatic to specific cues and are implemented in order to reach certain goals or states (Verplanken and Aarts, 1999); from its definition, habits are semi-unconscious, repetitive, goal-oriented and environment dependent actions that become consolidated behaviours over time (Wood and Dennis, 2016). As expressed by Ding et al. (Ding et al., 2018) habits influence the citizens' energy consumption behaviour and these can have positive or negative consequences (on the environment and energy consumption). Indeed, habits like wearing more clothes rather than increasing the set point temperature of heating system in winter have apparent positive influences on energy conservation intentions (Girod et al., 2017; G. Li et al., 2017), while habits like keeping mobile phone charger plugged in to the socket when the phone is not charging represent obstacles for the change of energy conservation behaviour (Huebner et al., 2013). Finally, we should not forget that habits depend to other drivers, such as personal factors, environmental values, knowledge and income (Pothitou et al., 2016a).

Emotion. Emotions can be defined as a positive or negative experience that is associated with a particular pattern of activity; they are affective conditions that are the reaction to something and they influence an individual's motivation to act in certain ways (Ortony et al., 2005). In conclusion, emotions are an important contributor to human behaviour and health (Ortiz and Bluyssen, 2018). According to Ortony et al. (Ortony et al., 1988), emotion are divided in four main categories: general well-being emotions (emotions feel in response to possible actualization of desirable or undesirable events), expectation-based emotions (emotions feel in response to the conformation or disconfirmation of an expected event), social context emotions (emotions feel when events are attributed to people or object behaviour or in response to event to own behaviour) and material context emotion (emotions feel towards desirable, undesirable, distinctive and unexceptional objects).

3.3.3 Economic characteristics

Family economic situation. Family economic situation mainly concerns two aspects: the family income and the family disposable income. Literature highlights how the household energy consumption increased with income; a possible reason for this relationship arises from the probability that higher income households live in home with large area and own many appliances and, consequently, this led to more energy consumption. At the same time, wealthy families have capability to buy smart appliances and install home energy management systems, while poor families can incur small expenses, such as changing light bulbs that guarantee energy savings. The energy-saving equipment choice, according to Özkan (Özkan, 2016) allows to reduce electricity cost (of a share between 5-16%), improving energy efficiency and maintaining the desired comfort through the installation of smart home power management systems. The economic situation is closely related to others factors such as employment status, household composition and size; in addition the situation could change with the development of economic.

Income. Income represents money received, especially on a regular basis, for work or through investments. Household income appears to be one of the strongest socio-demographic predictors of ESBs, EEI actions and ERE projects and it is closely linked with factors such as employment status, education and household size. Considering households with medium and high-income, on the one hand, they are less inclined to save energy through daily behavioural activities and actions, compared to low-income households (Abrahamse and Steg, 2011, 2009; Barr et al., 2005; Gatersleben et al., 2002; Holloway and Bunker, 2006); on the other hand, however, the medium and high-income households have a high probability to invest in high-cost energy efficiency retrofit measures (Sardianou, 2012; Urban and Scasny, 2012), highlighting a relationship between the increase in income and the commitment to retrofit measures. Regarding the purchase of more efficient equipment, instead, the relationship between income and investment is unclear (Gaspar and Antunes, 2011). Considering households with low income, they are more likely to commit themselves in the habitual low-carbon consumption behaviour (e.g. completely turning off the equipment if they are not used) (Yang et al., 2016). In addition, some research demonstrated that the most likely income group to save energy is the middle-income households, since, on one hand, low-income households are unable to reduce their energy use, on the other hand, high-income households are unwilling to reduce their energy use (Verhage, 1980).

Employment status. The employment status is the relationship established between a person and his/her working position and it is related to the contract of work or duration of work done. Full-time, part-time, or employee on a casual basis are example of work position; in addition, a person could be retired or unemployed. The employment status affects the household income, socio-economic status, confidence in income security and/or financial capability which in turn can constrain the household's capacity to invest in efficiency measures. Some studies analyse people engage in full-time employment, highlighting how, on one side, they could have more disposable income to spend for daily energy use and for energy-intensive appliances but, on the other side, they could have also more money to invest in EE measures (e.g. insulation, windows replacement, solar panels, energy-efficient light bulbs, etc.). In addition, home improvements to conserve energy is significantly related to full-time employment condition (Powers et al., 1992), since in people it could increase confidence in their capacity to undertake home improvements. Furthermore, people with full-time employment are more willing to accept energy conservation strategies (Olsen, 1983). It is not to be underestimated that, working full time precisely, people spend fewer hours per day at home compared to part-time, retired or unemployed consumers and, consequently, they have less energy consumptions.

3.3.4 Household characteristics

Occupant composition. Occupant composition concerns the number of family members and the characteristics of them; for example the presence of children, the occupant age, etc. In general, among all, the phase of family life cycle seems to be an important predictor of household energy use since it is associated to family needs and activities. Indeed, household energy consumption records a peak during the stages of children growth, probably due to changes in household work (e.g., cleaning, cooking, laundry, etc.), childcare and family activities (e.g., in-home entertainment, recreation). In addition, the family composition changes, i.e. the presence or absence of family members from a household like new-born baby, older child leaving home, etc. may also influence household energy consumption and the energy-related decisions (Van Raaij and

Verhallen, 1983). Below, some aspects relating to the household composition are explored.

Family size. In general, the number of people in a family tends to be associated to energy consumption; consequently, in presence of large family, the consumed energy is greater (Abrahamse and Steg, 2011, 2009; Benders et al., 2006; Gatersleben et al., 2002; Wahlström and Hårsman, 2015), even if the use of energy per capita is probably lower than small households due to sharing of energy services among multiple residents. Larger families (i.e. parents with children) are the highest consuming households; instead, the highest amount of energy per capita is consumed by single-person households followed by couple, single-parent with child (Holloway and Bunker, 2006). The reason for the higher energy consumption by larger family could be summarized in: ownership and use of energy-intensive appliances, income availability to spend on energy and greater energy requirement to be met (e.g. heating/cooling, washing, cleaning, etc.). In addition, large family are more difficult to change the habits of all members and to pursue ESBs (Nicholls and Strengers, 2015).

Children. The presence of children in household leads to conflicting results. On one hand, families with children are more engage in low-carbon behaviour (Yang et al., 2016) since adults want to be a good example and want to educate children to follow good practices; on the other hand, adults want to provide a comfortable environment for children, neglecting energy consumption (Belaïd and Garcia, 2016; Brounen et al., 2012; Mcloughlin et al., 2012). In addition, women with school-age children are more likely to be included and participate in some schools and community organizations focus on energy and environment conservation (Nakamura, 2013).

Age composition. Age composition of family members affects the energy consumption in households; indeed, when the children grow up, the family will start to seek for energy conservation methods, and the energy conservation potential reaches the summit. With the increase of age, citizens start to care more about comfortableness rather than economical lifestyle (for instance, the elderly need to warm themselves more), and this is a period of time when the attention paid to energy conservation declines, thus the energy conservation potential drops) (Guo et al., 2018).

Social status of the family. Social status of the family has different influence on energy consumption. According to Mcloughlin et al. (Mcloughlin et al., 2012), socio-economic status of a family had a significant impact since the higher social status of household is linked to a more energy consumption. Instead, according to Leahy and Lyons (Leahy and Lyons, 2019), socio-economic status of a family had no significant impact on household energy demand and consumption.

Building ownership. Tenure concerns the ownership or rent of the house in which the household live. In general, literature highlights that household, that are owners of their own home, are more likely to make investments related in energy conservation measures (e.g., in order to increase EE of the envelope or energy system and/or to purchase of energy-saving and more efficient appliances) (Ameli and Brandt, 2015; Lange et al., 2014). EE measures are more likely to be implemented by homeowners than renters, since the former tend to have greater financial security, hold longer tenure and, consequently, receive greater return on EEIs. Furthermore, according to Barr et al. (Barr et al., 2005), a feel of belonging encourages owners to be more aware and conscious toward energy saving measures. Instead, rented families tend to be poorer, more transient with a no sense of belonging and less willing and/or capable of making home improvements (or simply they have no right to make such investments in order to modify the buildings components (Lange et al., 2014). Rather than engaging in EEI actions, renters are, instead, more likely to adopt low-cost behaviours of low-carbon consumption.

3.3.5 Building characteristics

Building type. Building type refers to property characteristics and/or dwelling configuration; the building type concerns: single-detached houses, semi-detached houses, row houses, condominium apartments, mobile homes, etc. Existing literature shows a relationship between building typology and other variables. A first correlation is present between the type of dwelling and its floor surface (in other words its size). Greater amounts of energy (considering the thermal energy for space heating) are used for larger homes; consequently, households living in a detached dwelling are more likely to invest in EER measures to reduce costs than households living, for example, in flats (Santin et al., 2009; Sardianou and Genoudi, 2013). Other relationships exist between building type and income (most of households that live in a flat have lower levels of income) and between building type and building ownership. The building type driver is, therefore, linked to other factors such as area, household income, average energy consumption, building ownership, physical building characteristics (degree of insulation, sun and wind exposure, double glazing, etc.) which can push or hinder people in pursuing ESBs and/or EEIR measures. In contrast, according to Trotta (Trotta, 2018) the probability of purchasing EE appliances does not depend on the building type.

Dwelling size. Dwelling size is related to floor area and, consequently, to number of rooms/floors, etc.; since larger dwellings typically use more energy, the dwelling size is positively related to household energy consumption. In addition, people residing in detached dwellings probably consume more energy than those live in multi apartments.

Dwelling age. Dwelling age is closely related to the building construction year; this gives information on the physical and technological characteristics that characterize the building. Consequently, due to the lower energy efficiency level of older dwellings, the dwelling age is often directly proportional associated with household energy consumption. For this reason, homeowners residing in older dwellings, characterized by poor efficient condition, could adopt energy-efficient measures than homeowners residing in newer dwellings. However, regarding the relationship between building age and consumer participation in energy conservation activities, studies do not show significant correlation.

Ownership of home technology and technical expertise. A relationship has been highlighted, in the literature, between owning high-tech products (e.g. computers), not necessarily in the energy field, and being attracted to technical innovations and energy-saving device (Costanzo et al., 1986). In addition, also the technical knowledge and skills in home maintenances are positively associated to energy saving and conservation. Specifically, these households are inclined to understand new technology (Costanzo et al., 1986) and to be more capable of performing installation and ongoing maintenance tasks for energy-saving technology (Nair et al., 2010). Despite this, a detailed technical knowledge does not facilitate or increase pro-environmental, as highlighted by Kollmuss and Agyeman (Kollmuss and Agyeman, 2002).

3.3.6 Community and neighbourhood characteristics

Community identity. Community identity, i.e. the identification and connection with the place and other people living in the same context, leads individuals (citizens) to implement actions that do not only pursue personal interests but are oriented towards the well-being of the whole community (Bomberg and Mcewen, 2012; Tyler and Degoey, 1995; Van Vugt, 2001). In other words, community identity can be defined as “Feelings of attachment to the community, taking pride in the community and having friends within the community” (Van Vugt, 2002). In addition, the shared desire to make the community a better place, in which live, can be an important element for community projects; moreover, on the other hand, solidarity and cohesion can be a result of community projects (Horst, 2008). It is precisely the community identity, as highlighted in the literature (Haggett and Aitken, 2015), which favours community action.

Trust. Trust is defined as “the mutual confidence that no party to an exchange will exploit the other’s vulnerability” (Sabel, 1993) or “a psychological state comprising the intention to accept vulnerability of other individuals” (Rousseau et al., 1998) and it is a feeling that, in recent times, researchers are deepening and dedicating growing interest (Crepaz et al., 2014; Hobbs and Goddard, 2015). In interpersonal relationships, trust is a key feeling; in fact, the presence of this feeling increases the commitment and participation of citizens in community projects (Tyler and Degoey, 1995). In addition, trust appears to be positively correlated to voluntary actions and is also crucial when a person has to make an economic decision, like an economic investment (Ding et al., 2014). Indeed, several authors (Walker et al., 2010; Wiersma and Devine-Wright, 2014) state that trust is essential in the implementation of community projects. Trust turns out to be closely connected with the concept of community identity, so much so that it influences each other. Indeed, a high level of community identity corresponds to a high level of trust. Community identity itself has effects on citizens' willingness to participate through a change in the feeling of trust. Regarding the trust of individuals in the financial field, this issue is currently being investigated; indeed, users engage in purchasing behaviour only if they place their trust (Testa et al., 2015). In this case, trust is defined by the level of promises, expectations and obligations that another person (the trustee) is able to keep. According to Blomqvist (Blomqvist, 1997), the variables that influence trust are the level of competence, honesty, altruism and goodwill. Finally, the concept of trust can be understood as public trust in science, institutional trust in technological choices and trust in information received from a government, local authorities, etc.

Social norm. Psychology literature shows how individual's decisions and actions could be significantly influenced by group membership and by social influence, since people are incline to behave in similar way to those around them (e.g. family, friends and neighbours). People often behave according to the context in which they find themselves, following the behaviour of other people. In other words, people are influenced by social norms, "the explicit and/or implicit rules, guidelines or behavioural expectations within a group or society that guide what is considered normal and/or desirable" (Cialdini et al., 1991; Feldman, 1984). Social norm, in general, can be driving forces of behaviour and can promote low-carbon consumption behaviour (Allcott, 2011; Q. Li et al., 2017; Priolo et al., 2016). Specifically, a research analysis conducted by Alcott (Allcott, 2011) describe how an energy company decided to send energy reports to domestic consumers, attaching the comparative situation between the household consumption and his/her neighbour's consumption. It has been highlighted as, after the implementation of this project, an average reduction of 2% in power consumption occurred. The type of social confrontation feedback, just described, is exactly based on the mechanism of descriptive social norms. In addition the social norms could be imperative and prohibitive. Researchers found that using prohibitive norms, in order to make people recall the inconsistent behaviours, would cause them psychological discomfort; this feeling leads to change the currently behaviours into environmental-friendly ones (Priolo et al., 2016). Finally, a positive effect of social norms on cooperative behaviour is highlighted by Biel and Thøgersen (Biel and Thøgersen, 2007); the impact of social norms on community energy project (Mulugetta et al., 2010), specifically the importance of social norms on decision making in energy field (Rathi and Chunekar, 2015) and on pro-environmental behaviour (Gifford and Nilsson, 2014) was thorough. Furthermore, some studies have focused on the role that some social actors have on the individual choice of implementing energy saving behaviours or investing in more efficient technologies. Family members and friends are the people who are most trusted and, therefore, who can influence in implementing pro-environmental behaviours; in fact, in the literature there are many studies that confirm an established influence in the choices and actions of the closest people and in which great trust and esteem is placed (Pickett-Baker and Ozaki, 2008; Sidiras and Koukios, 2004).

3.3.7 Government, regulations and policies

Information policy. Information feedback has a positive effect on household energy conservation (Du et al., 2017; Podgornik et al., 2016). Feedback equipment, designed with detailed information, such as function of comparing with communities and customized suggestions, are better at promoting the residents' low-carbon consumption behaviour (Buchanan et al., 2015; Burchell et al., 2016). Furthermore, it is important to highlight that although the effect of the information feedback is obvious soon after implemented, it will be weakened in the long run (Allcott and Rogers, 2014), since frequent reminders tend to have a hypnotic effect (Gilbert and Graff, 2014) and could be boring due to repetition (Asensio and Delmas, 2016; Lehner et al., 2016; Rogers and Frey, 2014). An example of information of a product is the carbon label that provide to end-consumers information on carbon emissions caused in its entire lifecycle process, in order to lead to environmental-friendly decisions. This information are important and meaningful, even if consumers still usually give priority to the quality and price of products (Liu et al., 2016; Shuai et al., 2014).

Economic policy. Economic policy has a positive effect on pro-environmental behaviour or energy-saving behaviour (Belaïd and Garcia, 2016; Geng et al., 2017; Maki et al., 2016; Nilsson et al., 2015). Maki et al. (Maki et al., 2016) states that irregular economic incentives have greater effects than periodic ones; in addition, the economic incentives regarding special behaviour have greater effects than general economic incentives. However, (Steinhorst and Matthies, 2016; Truelove et al., 2014) it should not be underestimated that it is difficult to maintain low-carbon consumption behaviour only through economic incentives.

Technology policy. Technology maturity is a situational variable that affects, in a positive way, the individuals' low-carbon consumption behaviour (G. Li et al., 2017). The achievement of low-carbon consumption depends on the mutual influence between technical progress and res idents' behaviour.

Administrative regulation. Administration regulations, for a limited time, have effects on individuals' low-carbon consumption behaviour in absence of stimulating motivation. Considering residents with strong motivations in low-carbon consumption behaviour, policies of Optional policies nature are more effective than administrative regulations in individuals' that show pro-environmental behaviour. Instead, individuals' that show low pro-environmental behaviour, administrative regulations are more effective (Karatas et al., 2016).

3.3.8 External characteristics

Geographical/climatic factors. Studies on energy consumption highlight how this is related climatic variable; the energy consumption of most cities can be explained by Heating Degree Day (HDD) (Creutzig et al., 2015) or by Cooling Degree Day (CDD) (Craig, 2016). Regional differences in climate, temperature and geography are closely related to energy use and consumers' preference towards energy conservation. Indeed, literature shows that households located in more southern regions (with warmer temperatures) tend to consume less energy than households in more northern regions (with colder temperatures) (Abrahamse and Steg, 2011; Van Raaij and Verhallen, 1983). Rural areas have also been found to have higher levels of energy use than urban areas (Van Raaij and Verhallen, 1983), with these regional differences purportedly arising due to variability in types of houses (e.g., freestanding dwellings vs. apartments), life-style characteristics, and house orientation to sunlight and wind. Geographical location may also impact homeowners' attitudes and preferences toward energy conservation for example, due to the effects of the local governments' actions to encourage and reward energy efficiency measures and behaviour (Nair et al., 2010).

3.4 Conclusion

The aim of this chapter was to answer the following research question: *"What are the factors that determine the human behaviour related to energy use/consumption and engagement in Renewable Energy (RE) projects?"*. Understanding these drivers has not been an easy task since behaviour is not an easy topic. The main topic addressed in this chapter is the review of the elements that determine a user/citizen choice, action and/or behaviour. In addition, simple daily actions or decisions have an impact on energy consumption and the only use of new and more efficient technologies does not guarantee low consumption if it is present the unpredictability of user/citizen, given by his/her behaviour. The research wanted to make a contribution in better understanding the dynamics that lead a user to certain actions in achieving the environmental and energy purposes related to the energy transition. Reaching a goal is given by the sum of different actions and is based on a very simple assumption: in the presence of a great commitment, great obstacles are faced; in case of low devotion, even the smallest difficulties are not overcome. Consequently, a behaviour is characterized by a personal effort (commitment or ability) and a behavioural price (difficulty). In addition, it is necessary to remember that the actions and behaviours are determined by some objective and subjective user's drivers. In other words, when a user has to take a decision, action or behaviour, various difficulties may arise due to the influence of users' features because they define the users' possibilities in engaging or not engaging this decision/action/behaviour. With this goal, a literature review was conducted in order to highlight and to identify the main factors that determine and affect, directly, indirectly or in interaction way, the human choice in order to understand the factors that allow the user/citizen to perform or not perform a certain action. The actions on which the research has focused are (i) the energy saving behaviours (ESB), (ii) the energy efficiency investment actions (EEI) and (iii) the engagement in renewable energy projects (ERE). Academic journal, conference articles and book chapters have been searched on bibliographic database in energy, social, behavioural and environmental sciences, using keywords and a combination of keywords such as: influencing factors, variables, drivers, energy behaviour, energy investment and renewable energy project. The research has yielded a great result in terms of scientific production. About 160 articles were analysed and 77 drivers from situational factors in the external environment to person-specific attribute of consumers that influence in an energy and environmental way decision-making and actions have been found and described. A new classification has been produced, grouping the drivers in different 8 categories: (1) individual self-characteristics, (2) personal characteristics, (3) economic characteristics, (4) household characteristics, (5) building characteristics, (6) community and neighbourhood characteristics, (7) government, regulation and policies and (8) external characteristics. The study of the literature allowed to define, in detail, the social component (user and citizen) of an energy community. Furthermore, the 8 categories was divided into 3 macro categories: the factors relating to the person (including individual self-characteristics, personal characteristics, and economic characteristics), the factor relating the external context (including building characteristics, government, regulation and policies and external characteristics) and the factor relating individuals who interface and create relationships with other individuals (including household characteristics and community and neighbourhood characteristics). The identification of the factors, that promote individuals' behaviours and the decision-making choice, is the preparatory and fundamental step preceding the characterization of the population in a given context. Indeed, as described in detail in Phase 4 (target group involvement) of Chapter 4 (methodology for an EC creation), the research allowed to define (using the personal factor and relationships with other individuals macro categories) the methodology for a questionnaire in order to jointly investigate the intentions and objective conditions of citizens and to characterize the population, understanding if it is possible to divide it into clusters and, consequently, to promote specific inclusion strategies to commit towards an energy community project.

Chapter 4

Methodology for an Energy Community creation

4.1 Introduction

The issue of energy community creation, as a potential solution to achieve the energy transition, is the core of this research dissertation. In the previous two chapters through a review of the literature, respectively on the concept of energy community (Chapter 2) and on the role of citizens in the energy transition (Chapter 3), it was possible to dissect the topic, giving some key points and definitions in order to understand "*what elements are necessary for the birth of an energy community*?" (RQ1). Besides, thanks also to the comparison and discussion with a panel of experts, the main elements of an energy community have been defined, without which it cannot be established. As shown in Figure 11, the main elements that make up an energy community are three: a material component (consisting of buildings and energy plant system), a social component (consisting of users and citizens, private and public entities) and, finally, a regulatory component (consisting of an agreement between the parties regulate its balance and functioning). Furthermore, the Figure 11 highlights how the social component is the fulcrum of everything; this is precisely the element that, through people involvement, participation and active contribution, allows to create an energy community. Indeed, the term community is used in order to mark how the union of citizens is the centre of the process without whose presence the energy community would not exist.

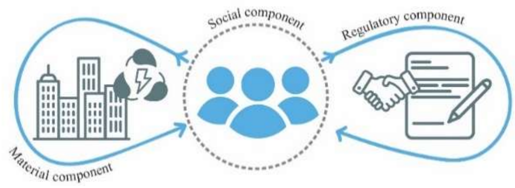

Figure 11. The three elements of energy community.

In this chapter, the definition of a structured workflow is explained through a separate description of the methodology adopted for each of the three elements (material, social and regulatory component). Even if these three elements are described separately (only for reasons of clarity in the writing of the thesis), it is important to remember that the energy community is born, in truth, from the synergy of them. A schematic overview of the workflow is shown in Figure 12 and each element is descripted in detail in the following paragraphs. Briefly, the first elements is the technical structure (Paragraph 4.2). This consists of two parts: a preparation phase, in which the buildings and the energy plant systems are described in their more technical aspects, and a preliminary and feasibility analysis phase, in which the best scenario is chosen from a set of possible energy retrofit solutions. The social structure is the second element (Paragraph 4.3) and, as also shown in Figure 11, it represents the core of the energy community; for this reason, this element is deepened with particular attention. The objective of this part is to inform and sensitize people and raise their awareness on energy and environmental issue through several events. Furthermore, during these actions, the distribution of a questionnaire is promoted in order to collect information on the characteristics of citizens. Subsequently, on the basis of the obtained answers, the population is described and citizens' clusters, that share the same features, are defined. The purpose is to outline tailor-made inclusion strategies in order to include more segments of the population in energy community project. Finally, the third element is the legal and financial structure (Paragraph 4.4) through which the contractual form (it represents an innovative issue and it is a result of a complex discussion with a panel of lawyers) is defined that binds and defines the balance between different stakeholders and the material elements in order to reach the co-ownership of renewable energy and, therefore, the birth of an energy community.

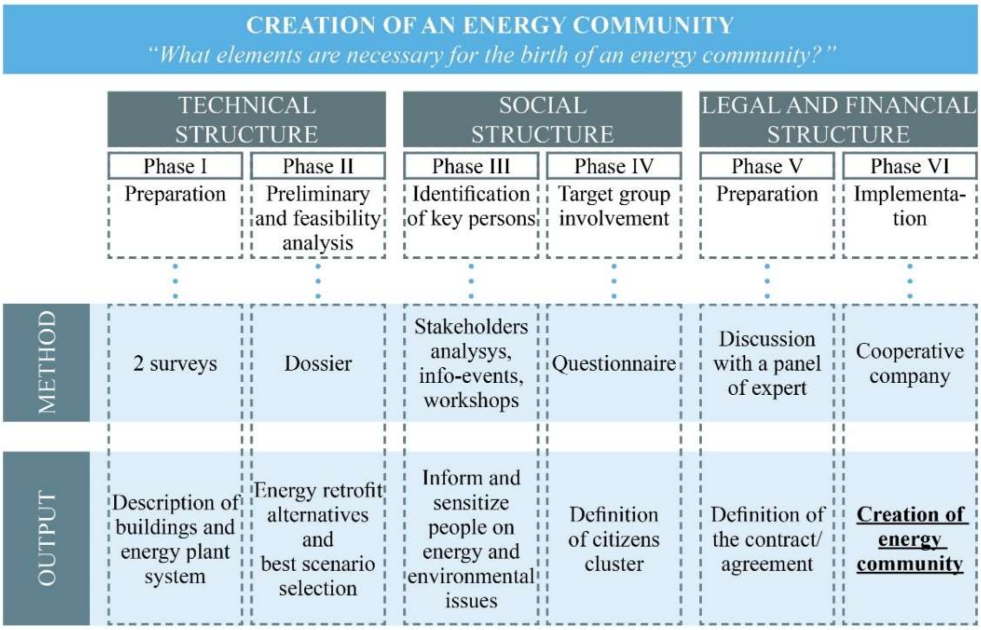

Figure 12. The methodology workflow. (Elaborated by author from (Torabi Moghadam et al., 2020))

Topics covered in this paragraph, mainly related to the technical and the social structures, were previously published in journals and conference proceedings and in SCORE project deliverables listed in the following Table 4; for each publication, the main addressed issues are highlighted. As a co-author, the publications provided the basis for the writing of this chapter.

Table 4. List of publication regarding the technical structure of energy community.

Type of publication	Publication	Addressed issue
Project deliverable	Lombardi, P.; Torabi Moghadam, S.; **Di Nicoli, M. V.**; Nonelli, A.; Figueiredo Eschholz, B.; Abastante, F.; Toniolo, J. (2021). D 5.1. Report on impacts of consumer co-ownership incl. recommendations on fine-tuning, Supporting Consumer co-Ownership in Renewable Energies (SCORE) project (GA 784960).	Phase III: informative-event, workshop. Phase IV: questionnaire
Journal article	Torabi Moghadam, S.; **Di Nicoli, M. V.**; Manzo S.; Lombardi, P. (2020). Mainstreaming Energy Communities in the Transition to a Low-Carbon Future: A Methodological Approach. Energies, 13 (7), 1597.	Phase I: surveys. Phase II: Dossier, MCA analysis. Phase III: informative-event, workshop.
Project deliverable	Lombardi, P.; Torabi Moghadam, S.; **Di Nicoli, M. V.**; Toniolo, J.; Lowitzsch, J.; Talachini, G.; Klusák, J.; Šafařík, M.; Pučelík, L.; Malý, V.; Černý, M.; Szwed, D. (2019). D3.1, Manual on Energy Refurbishing including Mitigation of Rebound Effects, Public Report, Supporting Consumer co-Ownership in Renewable Energies (SCORE) project (GA 784960), D3.1 Report on EE and Avoiding Rebound Effects - 1 VIII 2019.doc (score-h2020.eu).	Phase I: surveys. Phase II: Dossier, MCA analysis.
Conference article	Torabi Moghadam, S.; **Di Nicoli, M. V.**; Manzo S.; Lombardi, P. (2019). Supporting Consumer Co-Ownership in Renewable Energies: SCORE H2020 project. Sustainable Built Environment (SBE) International Conference, Sustainability and Resilience, 21-22 November 2019, Malta.	Phase I: surveys. Phase II: Dossier, Key Performance Indicators.
Conference article	**Di Nicoli, M. V.**; Torabi Moghadam, S.; Lombardi, P. (2019). A framework for selecting the best refurbishment alternative in renewable energies towards consumer stock ownership. 4th Energy for Sustainability (EfS) International Conference, Design a sustainable future, 24-26 July 2019, Turin, Italy.	Phase II: Dossier.
Conference article	Torabi Moghadam, S.; **Di Nicoli, M. V.**; Giacomini A.; Lombardi, P.; Toniolo J. (2019). The role of prosumers in supporting renewable energies sources. IOP Conference Series: Earth and Environmental Science Conference, 297. Article presented in Sustainable Built Environment, Emerging concept for Sustainable Built Environment, 22-24 May 2019, Helsinki, Finland.	Phase II: Key Performance Indicators.

4.2 Technical structure

In this paragraph, the methodology regarding the technical structure is described. Specifically, as anticipated in the introduction of this chapter, all the processes aimed at selecting and describing buildings and energy plant systems, defining various energy retrofit scenarios and, finally, choosing the best scenario are included and deepened in this dissertation. The technical structure is, in turn, divided into two phases: the preparation and the preliminary and feasibility analysis. The first phase (Phase I) is the preparation. In this phase, through two surveys, a buildings and energy plant systems identification, data collection and description are obtained. The second phase (Phase II) consists in a preliminary and feasibility analysis. The methodological approach of Phase II is described in a document called "Dossier" and the expected outputs are the proposal of different energy retrofit alternatives in order to shift from fossil fuels to renewable one, to increase the efficiency of the building envelope and the energy system and to reach a reduction of energy consumption. Then, through a multi-criteria analysis (MCA), the best alternative, considering different stakeholders' opinions, is identified.

4.2.1 Phase I: preparation

The purposes of this phase is a buildings and energy plant systems identification, a data collection and, consequently, a description of their current situation. The methodology consists in two pre-defined surveys (Torabi Moghadam et al., 2020, 2019b) in order to collect information and data about a) the investments identification of renewable energy sources and b) the energy costs and tariffs for the current situation, i.e. for the use of non-renewable energy sources. Through an in-situ analysis, technical documents and expert opinion, it was possible to find the information and complete the two surveys. The two surveys were provided by the SCORE project partner and their structure is described below.

a) Survey 1: the investments identification of renewable energy sources.

The survey is composed by five main parts and its purpose is to collect information about a general description of the buildings, to quantitatively describe the current situation of the building system and the energy plant system (i.e. geometry and typology of energy plant system) and the design situation for the implementation of an energy system fuelled by RES (i.e. information in terms of RES and financial aspects). Hence, the first survey is structured in five sections as follows:

i) the first section aims at identifying the building characteristics: the building typology, the building ownership, the building construction year, the year of the last refurbishment measures, the heat and domestic hot water (DHW) distribution system operator, the average of consumptions expenses, the total number of dwellings or offices (if it is a residential or tertiary building respectively), the total official number of inhabitants/employees, the number of floors, the total usable area and total roof area;

ii) the second section concerns the existing conventional energy sources or external supplier; specifically, the type of energy sources, the installed power or purchased power (if the district heating (DH) network is present) are investigated;

iii) the third section aims at describing, if present, the existing RES plant system; consequently, the type of energy sources and the installed power and the active surface (if photovoltaic (PV) and/or solar thermal panels are present) are examined;

iv) the fourth part, instead, investigates the planned RES: the type of energy sources, the installed power and the active surface (if photovoltaic (PV) and/or solar thermal panels are present);

v) the fifth section identifies the planned structure of financial sources for the RES investment: the type of financial sources and the percentage of overall costs are explicated.

b) Survey 2: the energy costs and tariffs for the current situation.

The survey aim at collecting economic information about the actual situation related to the use of non-renewable energy sources. The survey investigates two elements:

i) the average consumption fee (expressed in €/GJ), i.e. the annual energy consumption (in GJ) and the historical data for non-renewable energy (e.g. oil, natural gas, etc.) cost (in €/GJ);

ii) the average fixed fee (expressed in €/month).

4.2.2 Phase II: preliminary and feasibility analysis

The second phase consists of preliminary and feasibility analysis. In order to describe different refurbishment measures due to increase the energy efficiency of the buildings and energy plant system and to select the best retrofit scenario, the methodology followed refers to a document, called "Dossier" (Di Nicoli et al., 2019; Torabi Moghadam et al., 2020). Dossier represents a guideline in order to prepare a standard document/workflow in which the collected information in Phase I are structured and implemented. Briefly, through the Dossier, the purposes are: (i) the evaluation of the energy efficiency (EE) of the current situation of the pilot buildings, (ii) the design, at least, of two alternatives for each pilot case study, intervening on energy system, envelope system and control system (in order to shift from fossil fuels to renewable one, to increase the efficiency of the building envelope and the energy system and to reach a reduction of energy consumption) and, finally, (iii) the identification of the best alternative retrofit scenario through the Multi-Criteria Analysis (MCA) methods, considering different criteria: technical, economic, social and environmental aspects. In addition, the inclusion of a legal and financial analysis (business plan) highlights if the selected alternative is feasible in an economic perspective. As shown in Figure 13, Dossier is composed by five steps (grouped into 3 macro-categories) and each element is described below.

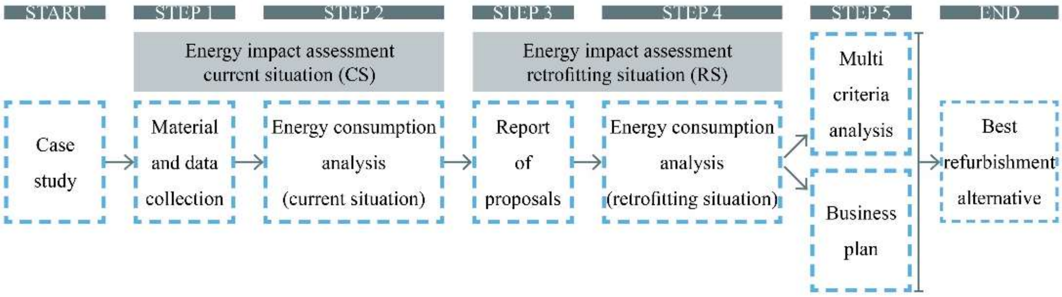

Figure 13. Steps of the Dossier workflow methodology.

a) The energy impact assessment - current situation (CS).

Step 1. After the case study is chosen (Start Point), the first step concerns the materials and data collection of the current situation of the building(s) and energy plant system(s). Specifically, a report on the administrative permissions and an analysis of the context and buildings systems are required. As regards this last analysis, the reference documents are: masterplan (1:500), photographic survey, floor plans, sections and elevations of the building (1:200), constructive details (useful for the understanding of the used materials, architectural elements, etc.), scheme, diagrams and plans of heating and/or electricity plant system (according to the retrofit proposals).

Step 2. The energy consumption analysis, related to the current situation (CS), is the objective of the second step. The elements of which it is composed are two: first, the energy model of the building(s), including the energy needs and the energy uses for space heating, domestic hot water (DWH) and lighting and equipment and the efficiency of the building systems (heating, DHW); second, the historical energy consumption data (e.g. the energy bills).

b) The energy impact assessment - retrofitting situation (RS).

Step 3. The third step regards a report of retrofit alternative proposals. It is constituted, first, by an analysis of the constraints and critical issues that characterize the case study in the current situation, for example, a report describing the buildings' weaknesses from the energy point of view. In addition, on the basis of the criticalities found, an illustrative report in which at last two retrofitting alternatives is drawn up in order to improve the envelope building system, the heating and/or electricity plant system design (in order to foster RES through, for example, wood chip boiler, solar thermal collectors, PV solar panels, etc.) and the control system. Finally, the report is constituted by an analysis of the context and buildings systems (concerning the retrofitting situation). As described in Step 1, the required documents are floor plans, sections and elevations of the building (1:200), constructive details (useful for the understanding of the used materials, architectural elements, etc.), scheme, diagrams, plans of heating and/or electricity plant system.

Step 4. The fourth step concerns the energy consumption analysis of the retrofitting alternatives. As described in Step 2, for each retrofit proposal, the energy model of the building are necessary. Thus, the energy model allows to determine the energy needs and the energy uses for space heating, domestic hot water (DWH) and lighting and equipment and the efficiency of the building systems (heating, DHW). Finally, the comparison between the current situation, described in the second step, and the retrofitting situation, described in the fourth step, allows to understand the improvement rate of each alternative.

c) Environmental, economic and financial assessment.

Step 5. Two main analysis are included in the fifth step: the Multi-Criteria Analysis (MCA) and the Business Plan definition. The MCA is used to define the best alternative scenario, identifying the most feasible and sustainable alternative considering different criteria for Key Performance Indicators (KPIs). The KPIs iter definition is addressed in a previous publication (Torabi Moghadam et al., 2019a) and is described in three steps: a first selection through a comprehensive existing literature (Lombardi et al., 2017; Strantzali and Aravossis, 2016; Wang et al., 2009), several discussion with the teamwork and, finally, the final selection through a participatory workshop (Torabi Moghadam et al., 2019a) (involving expertise in energy engineering, plant system designer, multi-criteria analyst and socio-energetic planner), applying the playing card method (Simos, 1990). In the following Table 5, the selected criteria are shown and descripted; the selection of the indicators made possible to build the evaluation matrix. This evaluation matrix allows to compare the different refurbishment alternatives taking into account several project aspects, such as environmental, economic, technical, social and administrative features.

Table 5. Key performance indicators matrix.

	Criteria [u.m.]	Description
Environmental	Environmental constraints [-]	Environmental restrictions (park or protected area) and constraints such hydrogeological, seismic, etc.
	Land use [m^2]	Surface occupied by the plant.
	Primary energy saving [$kWh_{primary\ energy}/y$]	Primary energy that would be saved if the new plant was built (it is linked to the renewable nature of the investment and to the interventions on the building envelope).
	Global emissions CO_2 [kg/y]	Reduction of CO_2 emissions guaranteed by the project plant compared to the current one
	Local emissions NO_X, PM_{10} [kg/y]	Reduction of NO_X and PM_{10} emissions guaranteed by the project plant compared to the current one.
Economic	Payback period (PBP) [years]	Time in which negative and positive cash flows are equal. It represents the moment after which the expenses are amortized and there is the actual gain.

	Investment cost [euro]	Investment costs related to refurbishment of the building (efficiency investment) and/or new heating system (infrastructure investment).
	Public incentives [%]	Percentage of savings linked to the share of investment cost covered by administrative incentives.
	Savings on energy expenditure [euro/year]	Savings on annual expenditure.
	Saving on investment cost [%]	The percentage of saving on investment costs.
	Economic impact-installation [euro]	Money that remains on the territory because of installation.
	Economic impact-operation and maintenance [euro/year]	Money that remains on the territory because of operation and maintenance.
	Duration of the intervention contract [month]	Money that remains on the territory because of operation and maintenance.
Technical	The increase of plant system efficiency [%]	The increase in the efficiency of the new system plant compared to the existing one.
	Installed power reduction [kW]	The reduction of installed power.
	Work importance [-]	The importance of refurbishment.
	Availability of primary resource [-]	The availability of the resources for refurbishment.
	Operational difficulty of installation [-]	Presence of physical constraints or impediments that make difficult the installation of the system. It takes into account difficulties related to the size of the components or particular work for a buried plant.
Social	Number of users [-]	Number of people who use the structure.
	Ownership [-]	The property of the building can be public, private or mixed. Depending on the ownership, it may be more or less easy to obtain consent to proceed with the refurbishments work.
	Architectural impact [-]	The visual and architectural impact of refurbishments in the existing built environment.
Administrative	Interest of public administration and opportunities [-]	Level of interest project and participation for the project. Opportunities are linked to the proximity of the elections, historical situation, citizens' interest, etc.

In addition, several meetings and workshops introduce modifications in KPI set, according to project progress. The main changes were made in the economic category with the introduction of the following indicators: the labour cost (i.e. the employees' salary that are directly involved, expressed in €/y); the labour costs performed by local social cooperative (i.e. the labour costs share covered by a social cooperative, expressed in €/y); material cost purchased in the territory (i.e. the share of investment costs that remain in the local territory or, in other words, the share of costs products at km 0, expressed in €). Consequently, the outranking MCA (named PROMETHEE) is used to rank the set of retrofit proposal and provide an overview of the best alternative; in addition, the sensitivity analysis is performed (through a weight change) to check the robustness of the model and observe changes in the ranking.

Once the best alternative is defined, in order to proceed to the effective realization of the project, it is necessary to define a business plan. The Business Plan is used to describe the project profitability in an economic perspective and, consequently, some elements have to take in consideration: first, the assessment of the investment costs (e.g. the investment cost description regarding the purchase of building material, connection to the supplier, technological installation and manpower); second, a description of the expected resources for the activity intervention support (the financial resources can be differentiated between internal and external sources); finally, a calculation of three financial indicators, the Net Present Value (NPV is the difference between the present value of cash inflows and the present value of cash outflows over a period of time), the Internal Rate of Return (IRR is a discount rate that makes NPV of all cash flows from a particular project equal to zero) and the Payback Period (PBP refers to the period of time required to recoup the funds expended in an investment or to reach the break-even point).

Once all assessments, described above, have been completed, the end of the workflow (End point) is the definition of the best refurbishment alternative. In other words, the scenario that considering several aspects was outlined as the best and must be implemented.

4.3 Social structure

In this paragraph, the methodology regarding the social structure is described. This structure represents the research core since, within the energy community, users should play a key role, participating actively in the phases of decision, dissemination, production, distribution and use of energy. In other words, they are not simple energy consumers but, as described in Chapter 2, prosumers. Specifically, as anticipated in the introduction of this chapter, all the processes aimed at making users aware of energy and environmental issues and to encourage their inclusion/participation in community projects or promoting a behaviour change are included and deepened in this dissertation. The actions described in the social structure are aimed at all types of users. The literature has shown, as described extensively in Chapter 2, even if community projects are widespread, the importance of inclusion of all stakeholders is not taken into consideration. In detail, currently, the energy community projects are aimed at (and take into account) only segments of population composed of men, middle-aged people, people with high income and a high level of education, etc. (Lowitzsch, 2019). The challenge faced by this thesis is to analyse and to include, also, the segments of the population defined as “underrepresented” and/or “vulnerable”, affected by different types of difficulties (e.g. energy poverty, low income, unemployment, single parents with child/children, etc.). In order to achieve the active participation goals in community projects, different methodologies are used.

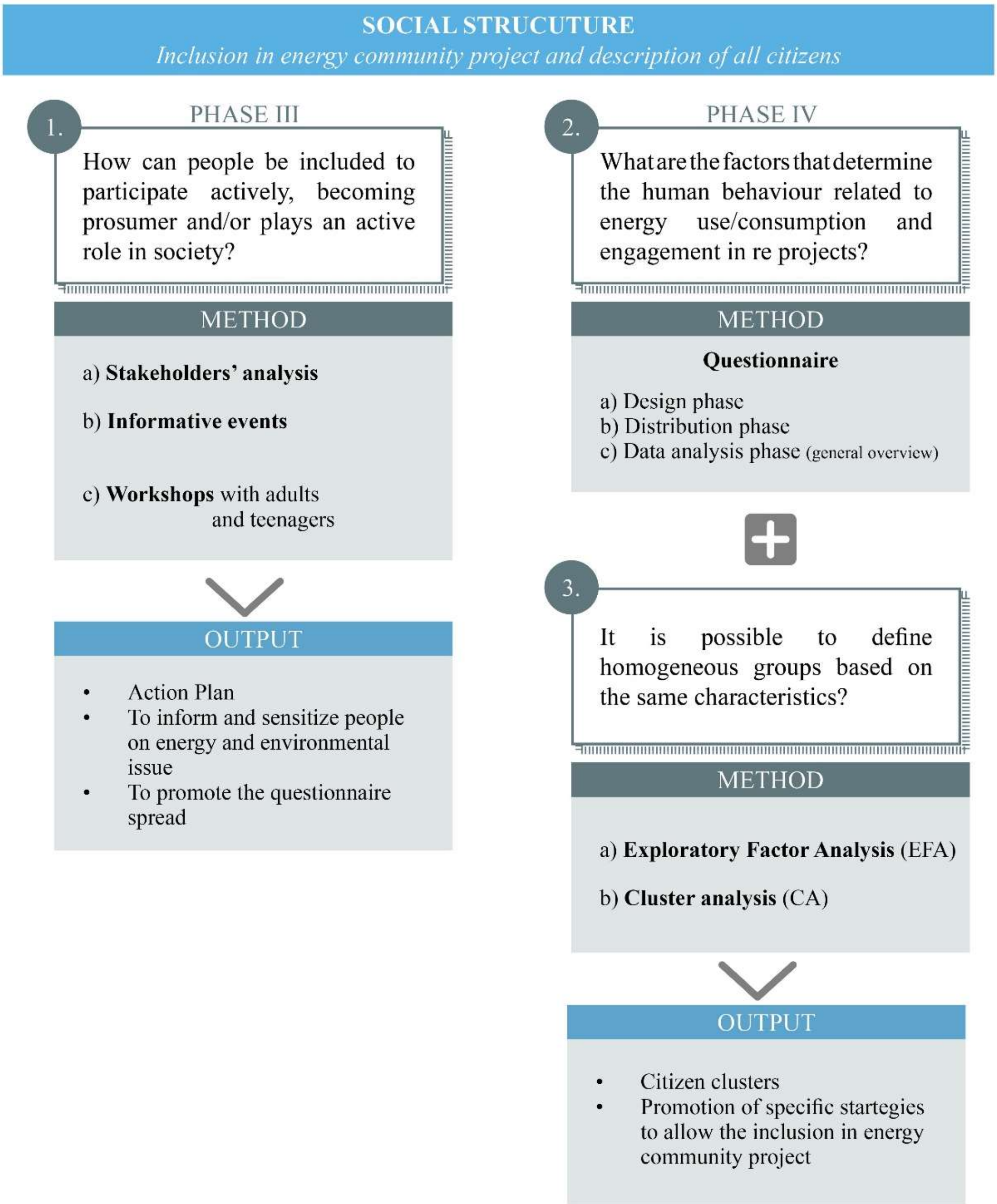

Figure 14. The social structure methodology.

The social structure is, in turn, divided into two phases: the identification of key persons and the target group involvement (as shown in Figure 14). The first is related to Phase III of methodology, the second to Phase IV. In Phase III, first through a stakeholders analysis to define the target group and then through informative events and workshops, the process in order to inform, sensitize and make people aware to community projects is described. Instead, the purpose of Phase IV is to characterize the population and to understand if it is possible to divide them into clusters, in order to promote specific inclusion strategies to commit towards an energy community project.

4.3.1 Phase III: identification of key persons

Since user participation is the core topic of energy community creation, the purpose of the third phase is to inform and make aware people towards energy and environmental issue. Therefore, "*how can people be included to participate actively, becoming prosumer and/or plays an active role in society?*" (RQ2). Through this research question, the understanding of citizens' subjective willingness to engage in local energy initiatives is studied. This analysis is conducted through three specific actions and related methodologies: a) stakeholders' analysis, b) the informative events and c) the workshops.

a) Stakeholders' analysis.

The creation of an energy community, in which all segments of the population are considered, is the main objective. Consequently, in this paragraph, the strategies to reach and identify stakeholders, specifically, above all, the vulnerable and the underrepresented groups, are described. Throughout the dissertation, when talking about these groups, reference is made to a Focus Group (FG) composed by:

- low-income households, people who are unable to deal with current and/or unexpected expenses;
- long-term unemployed, people who have not worked for at least 12 months;
- women, in general but, especially, single mothers with child/children;
- teenagers.

The identification process is divided into two steps. The first step is characterized by a survey in order to have a situation overview, collecting general information on Focus Group (on low-income households, long-term unemployed and women) and local actors who have access to or a relation with the Focus Group. In the second step, the interest/influence matrix methodology is applied in order to map the local actors and produce an Action Plan to reach the Focus Group.

a) Step 1: survey on Focus Group general information.

The survey methodology is defined jointly with the SCORE project partner Deutscher Caritasverbrand (CARITAS) and it is divided into six sections. The objectives and the details of each section are explained below.

<u>Section 1: Focus Group definition.</u> In this section, at a national level, the definition of "low-income household" is investigated. Being the category that does not present an accurately shared definition, this allows to lay a common basis, as objective as possible, in the identification of those who fall into this group ("*Is there a shared definition of low-income household? Is there a minimum threshold for belonging to this group?*").

Section 2: authorities with a general overview of the local context/territory. In this section, through local actors, mainly the mayors, the number of citizens belonging to these three Target Groups is investigated ("*How many low-incomes household, unemployed people are in the Municipality? How many of them are women or women with child/children?*").

Section 3: organizations/entities. This section investigates the organizations and entities that can provide information on the presence of target groups. For example: energy suppliers ("*Is there any private or municipal supplier who could provide information linked to energy poverty? E.g. a number of customers who have difficulties to pay bills or who have had a power cut.*), employment centre/offices ("*Is there any employment centre who could provide information on unemployed people?"*), social cooperative ("*Is there any social cooperative who provide work to people with difficulties?"*). In addition, the community group and/or no-profit associations concerning (a) the empowering women or single mother (e.g. women cafes), (b) the low-income (e.g. volunteer social workers, self-organized money saving club), (c) the unemployed people, (d) the environmental protection or nature projects (e.g. recycling group, gardening project), (e) the health (e.g. sport association), (f) the elderly people, (g) the church (e.g. food/clothes banks), (h) housing association, (i) educational institution (e.g. schools, kindergarten, public library) and (l) market (e.g. second-hand market).

Section 4: Focus Group location. The purpose of this section is to understand if there are certain areas in which people belonging to the Target Group are more likely to live ("*Is there any social housing area or district where TG live? Is there any residential area/street where the buildings/houses condition is a very poor level of envelope/energy system efficiency?"*).

Section 5: benefits. Several benefits provided by the State or by the Municipality are examined in this section. The investigated advantages are: social benefit ("*How does the State or Municipality subsidize low-income household?*") and energy benefits ("*How does the State or Municipality subsidize electricity and heating costs for low-income household?*"). An example of these benefits can be: job-seekers' allowance/unemployed benefits, household energy benefits (heating/electricity fuel allowance, support for energy efficiency improvements), maternity and child benefits (benefits for multiple children, childcare support, school meals and transportation vouchers). In addition, the requirements for obtaining these benefits and the possibility of accumulating them are examined ("*Which requirements are necessary to claim these benefit? For people who receive social benefits, can they keep generated income?*).

Section 6: dissemination. Finally, this section probes the presence of local/advertising newspapers in order to spread news and information on energy communities.

b) Step 2: influence-interest matrix.

Building participation in a given area, aimed at becoming an energy community, is important. The community is made up of a complex system of entities, defined as stakeholders (since they stake holders), who play an important role within the system, in this case the city and/or the neighbourhood system. Stakeholders are all those who can influence or who are interested or can, in a specific project, play a more or less active role. It is of particular importance to identify and analyse the interest of the organizations and individuals who have a stake in, or can influence, urban development projects, trying to focus on the key issues in urban development (Jing Yang, 2013). For this reason, the identification of the categories of interest and their analysis with respect to the ability to influence the success of the project is essential. Many definitions have been given on the stakeholder analysis (as reported in (Jing Yang, 2013)), which have small differences. Briefly, it is possible to state that stakeholder analysis can be defined as "as a series of activities aimed at identifying the groups of stakeholders that are most relevant to an organization at a given time and with respect to one or more topics of specific interest". The stakeholder analysis consists in mapping stakeholders/actors in a reasoned way with the aim of identifying the interlocutors to be considered (according to an order of priority) in the engagement activity. There are several methods for stakeholders' analysis; in this dissertation the influence/interest matrix methodology is used. Specifically, the influence/interest matrix takes into account:

- the level of influence, i.e. how much the actor can or could be able to influence the achievement of the objectives of a project/process, how much power the stakeholder has over the setting, execution and results and how much the actions that an actor can put in place they can strengthen or impede the process;
- the level of interest, i.e. how much the project/process can affect the actor's objectives/activities.

The model consists of a grid where influence and interest are relevant factors. Indeed, these two factors are represented and placed graphically through a matrix (Figure 15); both the influence and the interest ranges from low to high. Consequently, four quadrants are defined and in each of these, the stakeholders are placed.

1. Stakeholders with high influence and high interest are classified as "essential" or key players. They should be handled with the utmost care; it is necessary to involve them as they have a strong capacity for intervention.
2. Stakeholders with high influence and low interest are classified as "attractive". They simply have to be satisfied with their expectations. It is appropriate to involve them because pressure element or opinion leader are able to influence.

3. Stakeholders with low influence and low interest can be classified as "marginal". They simply need to be monitored to see if their attitude changes during the time.
4. Stakeholders with low influence and high interest can be classified as "weak". They must be kept informed on the progress of the project. It is right to involve them because entities who do not have the means to strongly express their interests.

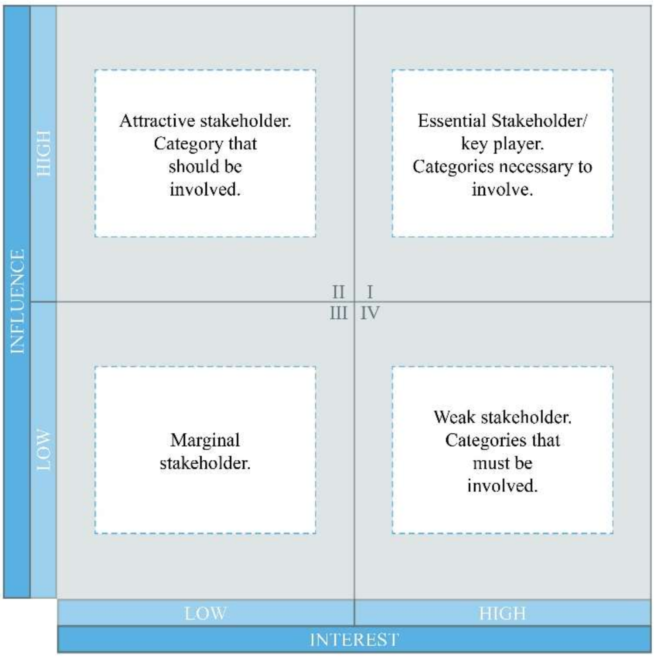

Figure 15. Influence/interest matrix.

At this point, having defined the list of local actors who have connections with the Focus Group (Step 1) and inserting each stakeholder within the matrix, respecting the factors of influence and interest (Step 2), an intervention strategy can be defined, named Action Plan. The Action Plan aims at establishing a priority contact strategy (through informative events and workshops) with these entities to reach the final purposes concerning the engagement of citizens, including, specifically, the vulnerable and the underrepresented segments of the population.

b) The informative events.

These events include the organization of meetings with local institutions, with the aim at disseminating the energy community principals and defining how to involve all citizens, and the participation in already organized events on the territory. Regarding the organization of meetings with local institutions, the contribution of the local SCORE project partners is fundamental in identifying (through a stakeholders analysis) and establishing contact (though email) with key persons. Once the institutions through which it is assumed that citizens can be reached is identified and mapped, the email contacts is recovered and a pre-structured email is sent containing the following information: a personal and research introduction, the purposes of the research, the email objective (i.e. to survey the availability to help in this project in order to get in contact with the citizen and disseminating information towards the local population and, if interested, the person with whom to discuss about). Once contact is established, then, the final step is the event organization or the participation in events already scheduled. Since the main focus of this kind of event is information, the supporting materials used for these meetings are flyers and brochures, concerning the energy community's topics.

c) The workshops.

Getting in touch with local institutions and participating in events led to workshop activities. The workshop is aimed not only at informing the invited stakeholders about a specific topic (the environmental and energy issues and the community energy topic) but also at creating a semi-structured debate with them. Specifically, thanks to the support of local authorities and the relationships established during the information events, several groups of citizens are invited to take part to these activities. The workshop follows a determined structure: there is shifting between educational moments and practical ones. During the educational moments, some fundamental notions (about the research topic, such as the meaning of energy transition, the advantages related to the use of energy from renewable sources, the energy community principles and the active role of citizens) are given. Instead, during the practical moments, various activities are carried out, studied *ad hoc* according to the invited stakeholders, in order to verify the learning, express their thoughts and opinions and create a constructive debate, ensuring that people feel free to express themselves. The workshop made possible to interact and understand the different stakeholders' positions. The actors' typology who participated in the workshops is listed below and the activities implemented for each group are described, in more detail, in the next chapter (Chapter 5).

- <u>Workshop with vulnerable citizens.</u> A specific activity is proposed in which the participants are asked to give their preferences, in order to understand obstacles and problems in participating in energy community project, and to understand which aspects of the CSOP are perceived as important.
- <u>Workshop with citizens in general and mayors.</u> The proposed activity is based on a storytelling methodology (Fog et al., 2005). The storytelling is a communication methodology used in several social disciplines and as the word says, its principle is "to tell a story". This method is used for different purposes: (i) to attract the attention of a specific audience, (ii) to convey to that audience the message that the story wants to transfer, (iii) to stimulate a specific desire in readers or spectators, (iv) to persuade them performing a specific action and so on (Jefferson, 1978). The methodology allows to the explicit concept in a narrative form (plot, characters, story) including multiple voices

and points of views; it, in an inclusive process, facilitates stimulates the emergence of stakeholders' opinions and experiences which are conveyed through simple and understandable stories. Indeed, the method allows communicating thoughts through language and writing. In this specific context, the methodology is used to allow people with different backgrounds to be able (a) to define the current energy scenario on the basis of individual experiences related to personal energy use and (b) to co-create the future energy community scenario.

- Workshop with students. The aim of the workshop is the description of the future energy community through a process of comparison and co-creation. In this case, the proposed activity preferred to favour the graphic story; indeed, the students had to self-identify themselves as urban planners/architects and tell their ideas through drawings, masterplans and photographs. In addition, the activity included a survey on their and their acquaintances' attitude towards energy-environmental issues.

In addition, the informative events and workshops not only represented an opportunity to introduce the concept of the energy community topic to the local population, but also a way (first) to refine some aspects of the questionnaire (described in the next paragraph 4.3.2) and (then) to distribute it, in order to obtain information on citizens characteristics.

4.3.2 Phase IV: target group involvement

At the same time, the aim of the social analyses is to obtain objective data about users' characteristics in order to identify the main drivers that favour/hinder their participation in energy community projects ("*what are the factors that determine the human behaviour related to energy use/consumption and engagement in renewable energy (RE) projects?*" (RQ3)) and, consequently, clustering the population on the basis of one's possibilities (*"it is possible to define homogeneous groups based on same characteristics?*" (RQ4)). Therefore, in order to answer the research questions, a) the questionnaire methodology and b) the cluster analysis are adopted.

a) The questionnaire methodology.

A questionnaire, according to literature (Zammuner, 1996), is a survey tool for collecting data through a defined and structured set of questions through which the interviewee is asked to answer. Different types of questions exist; briefly, if the questions are "closed", the interviewee is asked to identify, among the available answer options, the one/those closest to his/her position; in the case of "open" questions, there is no predetermined answer and the interviewee can answer by reporting his/her experience. The questionnaire allows to involve a selected sample in order to gather information, to know opinions and to understand attitudes and intentions; in addition, in this way, the interaction between researcher and interviewees is facilitated. Certainly, affordability, simplicity and speed are the advantages, even if it sin in rigidity and insensitivity. In particular, the proposed survey purpose is (a) to collect the different opinions of citizens on the issue of energy communities, (b) to understand the relationships with the community/territory in which they live and (c) to collect building's technical data and economic, social and demographic characteristics related to interviewee. The definition of the survey follows a three-part structured workflow: i) the design phase, ii) the distribution phase and iii) the data analysis phase.

i) Design phase.

First of all, a study of the literature was conducted. This research aims to answer the following research questions *"what are the factors that determine the human behaviour?"* (RQ3). The topic has been extensively covered in Chapter 3, in which various drivers have been identified and classified in 8 categories: (1) individual self-characteristics, (2) personal characteristics, (3) economic characteristics, (4) household characteristics, (5) building characteristics, (6) community and neighbourhood characteristics, (7) government, regulation and policies and (8) external characteristics. Subsequently, a first draft of the questionnaire is defined and the structure, questions and answer options are discussed separately with several experts, including energy experts, social experts, academic and institutions close to vulnerable people. Besides, the debate created with citizens, during the workshops, made it possible to define, in detail, some questions in order to adapt the literature studies to the real application in the specific context. Finally, a pre-test carried out with 10 citizens (citizens not necessarily with training in the energy field and knowledge on the topic of energy communities) allows to define the final version of the questionnaire. The questionnaire package is composed in this way: a flyer, the General Data Protection Regulation (GDPR) policy and the questionnaire.

The flyer.

The flyer is designed as a support for both direct and indirect administration of the questionnaire. In the case of direct administration, in which it is possible to explain the research and the survey, the flyer is used as an element to be left to citizens so that they can have a trace of what was discussed and can share it with friends/acquaintances/family. Besides, the presence of the QR code allows the questionnaire to be opened on any support provided with a camera and internet connection. However, in the case of indirect distribution, the flyer is the means that allowed to explain the purpose of the research and the questionnaire without the physical presence of an interlocutor. For this reason, its structure, its organization and its contents have been thought out with attention to detail. The flyer format is A4 front and back but is folded to assume a size of 10.5cm x 6.7cm (Figure 16).

Figure 16. Front and back of the folded flyer.

This choice derives from wanting to have a space to be able to give all the necessary information but, at the same time, being able to fold the flyer so that it can occupy the minimum space and fit, for example, in pocket or bag, avoiding it being thrown away immediately after having delivered it. Furthermore, the fact that its folding is particular could be a reason for curiosity and attract the attention of citizens. Thus, if, on the one hand, folding the flyer is dictated by reasons of practicality and comfort, on the other hand, this allowed the reader to approach the subject step by step, following a specific order. Indeed, by opening the flyer the reader is guided towards the research discovery, as if there is a person to tell the contents.

Step 1. The first information shown concerns a personal and research activity presentation; in addition, email and telephone contacts are left for those wishing to have more information (Figure 17).

Step 2. A) In the second part, since this doctoral dissertation is an integral part of the European project, a description of the SCORE project is shown. Specifically, the objectives of the European project are briefly described and the case studies localized. *B)* In addition, in the second part, the definitions of three words have been inserted (energy transition, energy community and prosumer). Since these words are used in the research and SCORE project description and recur in the questionnaire, it was necessary to give a simple definition for some words that are not used daily and to give a common knowledge baseline (Figure 18). The simple definitions are explained below.

- Energy transition: "*the term energy transition means, not only, to avoid the use of energy resources from fossil sources in favour of renewable but, also, to improve efficiency related to energy production of and to define an energy consumption, by the people, more aware*".

- Energy community: "*energy community means the union of users (municipalities, small and medium-sized enterprises (SMEs) and citizens), located in a specific area, who share the willingness to self-produce and self-consume energy from renewable sources. It is an innovative model of supply, distribution and consumption of energy with the aim at facilitating its production and exchange between several users. Social acceptance and a sense of community play a key role in the creation of these communities*".
- Prosumer: "*the word prosumer is the synthesis of two words: "producer" and "consumer". This is an individual who not only plays the passive role of consumer, but actively participates in the production and distribution phases of energy*".

Figure 17. Flyer, step 1.

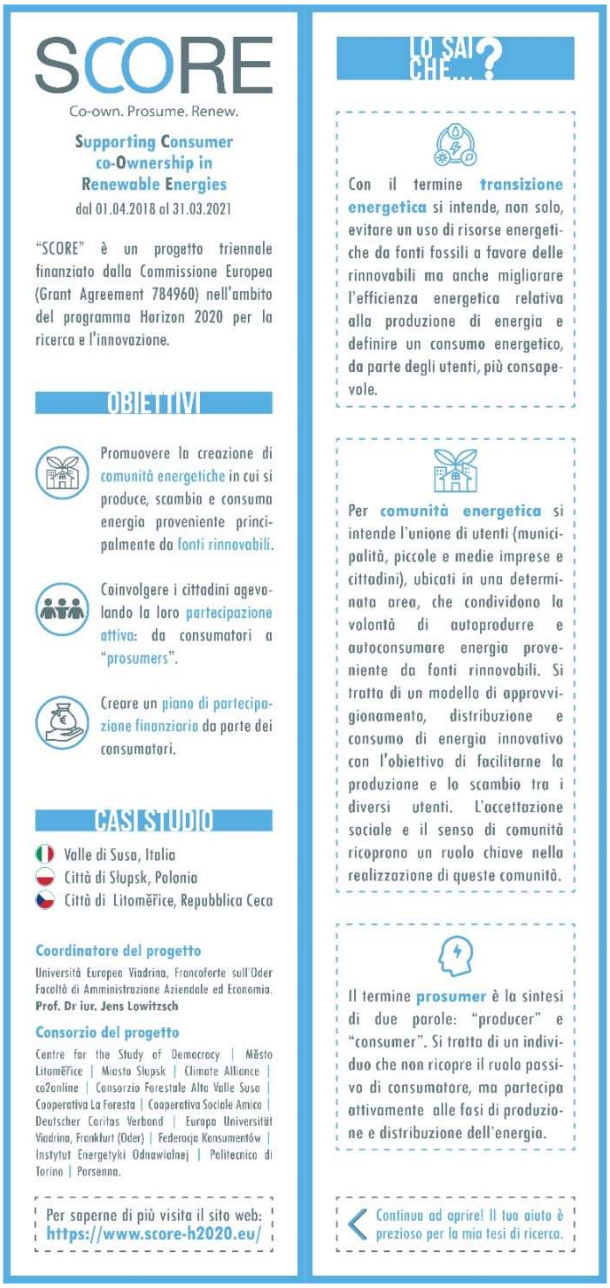

Figure 18. Flyer, step 2A and 2B.

Step 3. In this last part (Figure 19), the theory exposed is placed in the real context of application. For this reason, the application in the Susa Valley case study is briefly described through three following questions.

- With which strategy is the SCORE project applied in Susa Valley? "*Piedmont Region, with the regional law n.12 of 03/08/2018, is the first Italian Region to promote and institute the training of energy communities on their territory. The creation of these communities in Susa Valley represents, in an energy transition perspective, the opportunity to produce and use energy from local renewable sources. The project strategy consists in replacing the old and inefficient heating plant system, fuelled by oil or natural gas, serving a single building, with centralized systems, which serve at least two neighbouring buildings, powered by renewable sources. Furthermore, another purpose concerns the reduction of energy consumption both through an improvement of the building envelope and through a more conscious users' behaviour."*
- How can citizens play an active role? "*Within the energy community, citizens will play, according to their possibilities, an increasingly active role by participating in the decision-making, dissemination, production and distribution energy phases. At the same time, the creation of an operating company would lead several entities (e.g. municipalities, small and medium-sized enterprises and citizens) to become co-owners of the new energy plant system.*"
- What is your opinion about the energy communities? "*For my PhD research it is important to collect the different opinions on the topic of energy communities. For this reason, a questionnaire, developed by me, will allow to collect information about the interest of citizens to engage in local energy initiatives and to understand what factors favour/hinder their participation.*"

Figure 19. Flyer, step 3.

The General Data Protection Regulation (GDPR).

The GDPR is a regulation with which the European Commission intends to strengthen and make the protection of citizens' personal data more homogeneous. The purpose of the GDPR is to protect the individuals' right to have total control of the information concerning them. In fact, even if there is no question that explicitly asks for the respondents' name and surname, the administration of the questionnaire in small contexts could still lead to the identification, indirectly, of the interviewees. For this reason, as should be the norm, particular attention and caution has been paid to the processing and storage of data, despite data were used solely for institutional purposes connected to progress in scientific research and higher education. Interviewees, in order to proceed with the compilation of the questionnaire, have to read and accept the Regulation, in which the contact details, the purposes of the processing and legal basis, the transfer of data, the retention period of the data, the provision of data, the rights of the interested party and the complaint are explicit.

The questionnaire.

The questionnaire purpose is to gather different citizens' opinions regarding the energy community topic and their engagement in local energy initiatives. In addition, another questionnaire goal is to collect information in order to understand the relationships between respondents and the community/territory in which they live. The attitude to community projects and to energy behaviour and the study of the perception of the surrounding community/territory represent the core issues of the questionnaire. These information are important for understanding which factors favour/hinder their participation in this type of community project and clustering citizens. Finally, the data related the building's envelope and energy systems characteristics and data related economic, social and demographic characteristics are investigated.

Long version. Considering the aforementioned purposes of the survey, the questionnaire (written in Italian language and attached to Appendix B of this thesis) is composed of a brief introduction (in which the purpose, structure and time for completing the questionnaire is expressed) and 40 questions, divided into four parts. The structure of the questionnaires is described below.

First part: information on attitude and willingness. This first section consists of thirteen main questions that can be divided into three categories:

A. questions aimed at exploring the interest and willingness towards a renewable energy community project (RECP); first, investigating a general interest, then, the interest in actively participating and, finally, the willingness and interest in investing economically;
B. questions aimed at exploring the willingness to reduce the energy consumption in buildings, investigating users' actions to increase the efficiency of the building envelope components and of the energy plant system, investigating users' behavioural change and, finally, investigating the energy use adaptation to the renewable energy production model characterized by volatility;
C. questions aimed at exploring social influence and personal environmental judgment.

Figure 20 schematically shows, through key concepts, the composition of the questions (and sub-questions) that make up the first part.

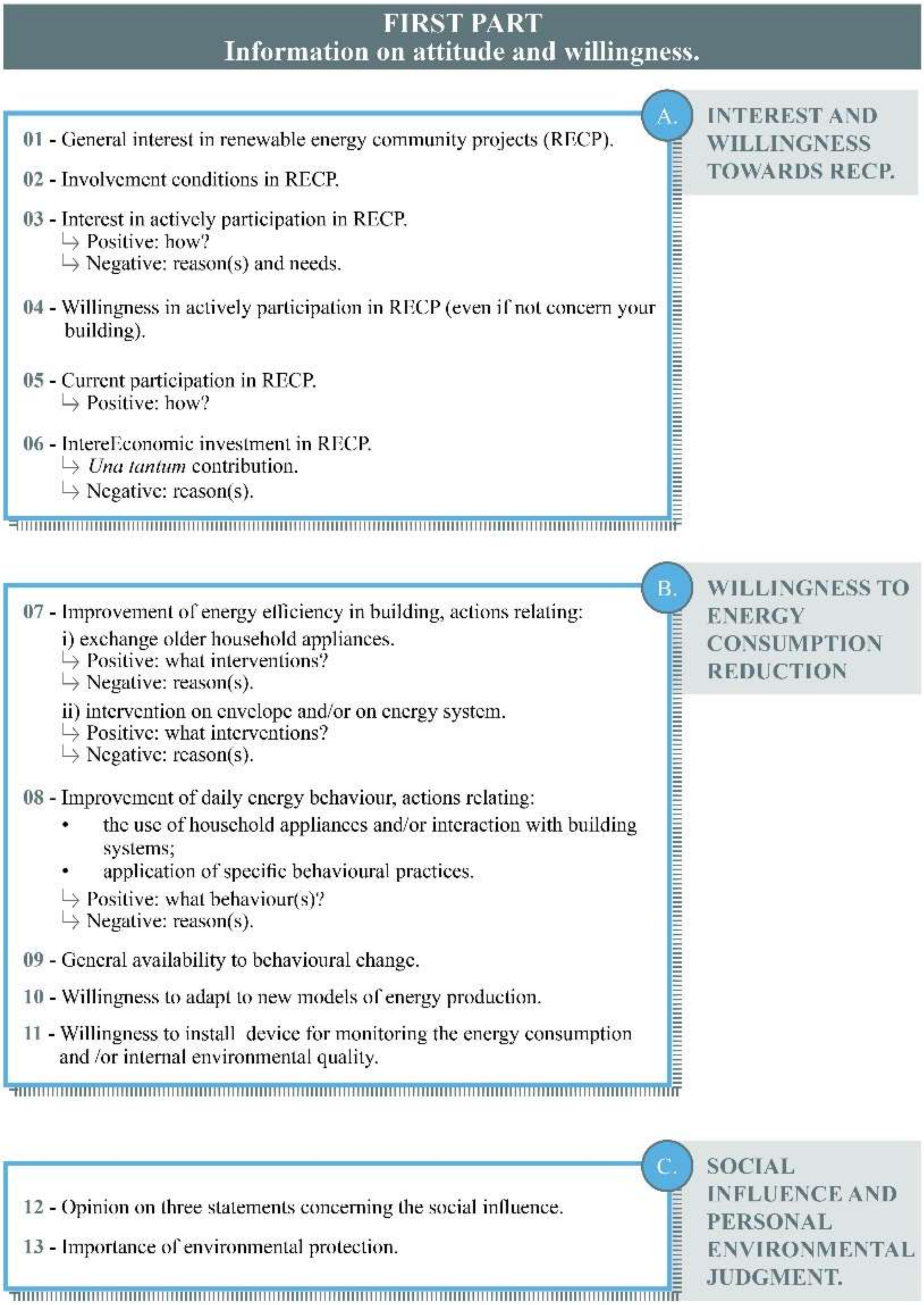

Figure 20. Scheme of questions concerning attitude and willingness information.

Second part: information on feelings and community identity. This second section consists of four main questions that can be divided into three categories:

D. questions aimed at exploring the citizens' level of feelings and emotion towards their community/territory. The feelings investigated are six: three positive (trust, pride and hope) and three negative (shame, fear and boredom);

E.	questions aimed at exploring the opinion about personal community/territory perception;

F.	questions aimed at exploring trust and relationships with other people.

Figure 21 schematically shows, through key concepts, the composition of the questions (and sub-questions) that make up the second part.

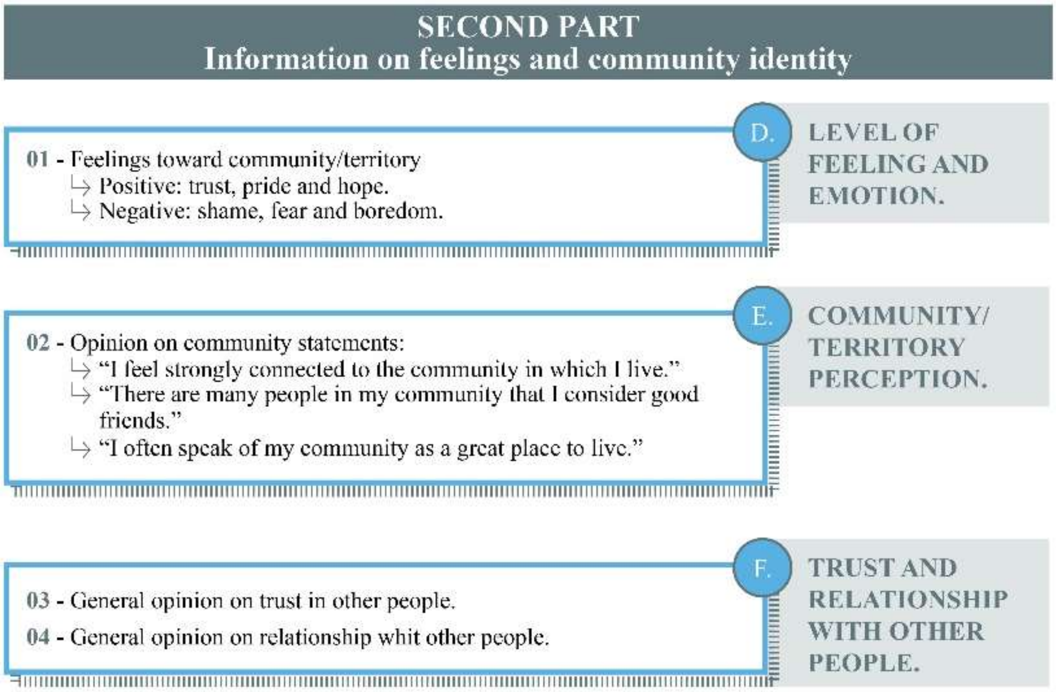

Figure 21. Scheme of questions concerning feelings and community identity information.

Third part: technical information. This third section consists of eleven main questions that can be divided into three categories:

G.	questions aimed at exploring general building's characteristics, specifically the building's typology and the building's construction year;

H.	questions aimed at exploring the energy system characteristics and the energy expenditure information;

I.	questions aimed at exploring the relationship between user and building and context.

Figure 22 schematically shows, through key concepts, the composition of the questions (and sub-questions) that make up the third part.

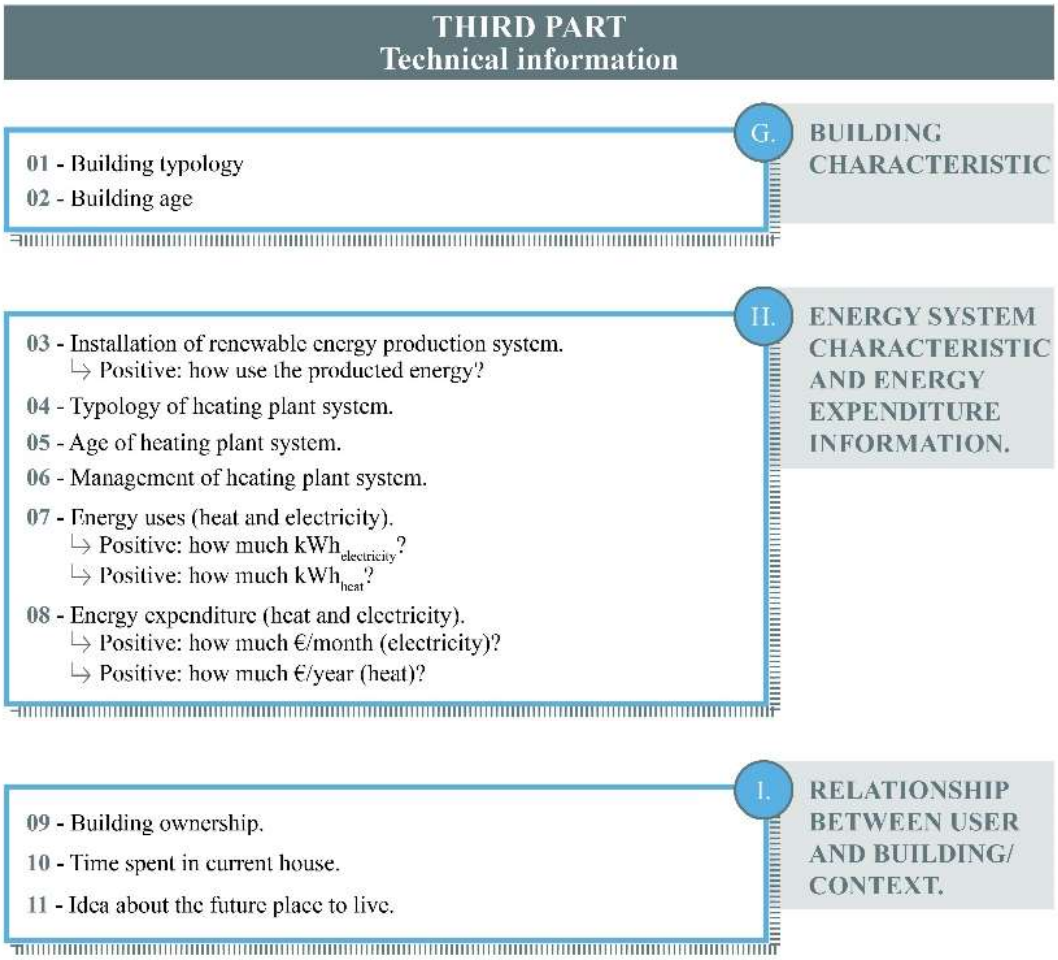

Figure 22. Scheme of questions concerning the technical information.

Fourth part: socio-demographic information. This fourth section consists of thirteen main questions that can be divided into three categories:

J. questions aimed at exploring the economic situation/condition of building occupants;
K. questions aimed at exploring the socio-demographic respondents characteristics;
L. question aimed at controlling the questionnaire spread on the territory.

Figure 23 schematically shows, through key concepts, the composition of the questions that make up the fourth part.

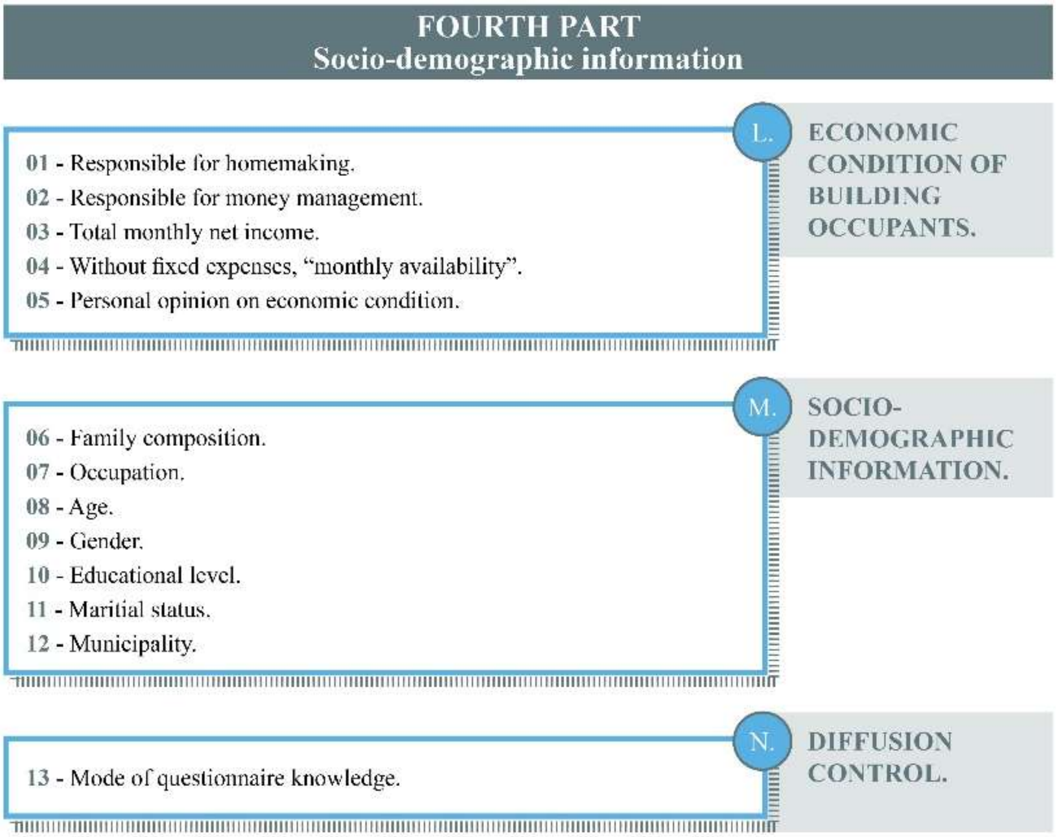

Figure 23. Scheme of questions concerning the socio-demographic information.

Reduced version. This questionnaire has the same composition as the longest one, therefore it is divided into an introduction and four parts but the difference is in the number of questions; indeed, it consists of 30 main questions. The questionnaire is defined, in its latest version, through multiple discussion with academic experts and considering a pre-test with a panel of citizens. The questionnaire is written in Germany and Czech language and is attached (in English languages) to Appendix C of this thesis.

As regards, instead, the questions’ form, this has defined considering the objectives to be achieved. In general, mostly closed questions are employed. These questions’ typology provides, as an answer options, fixed alternatives, predefined by the researcher; in this case, the respondent is asked to answer by choosing the option (or more than one option) that most closely matches his/her opinion or condition. Closed questions have some advantages; indeed, they are standardized and allow for comparisons, the presence of multiple answer option could help the respondent in better understanding the question, in reference to sensitive questions are more adequate to have truthful answers (e.g. question about income and presence of answer options expressed in range) and, finally, the interviewee is facilitated in answering. Consequently, the disadvantages, such as the random answer of the interviewee, the risk of response influence by the proposed alternatives, the different meaning given by each respondent for the same set of response options and the long length of the answers list, should not be underestimated. To overcome these aspects, mixed-choice questions have been used in some cases. In particular, this type of question includes both fixed alternative answers, always defined by the researcher, and an open answer. The latter was declined in the questionnaire with the following wording *"Other, please, specify ______"*. In this way, a greater freedom of expression and spontaneity is favoured for the respondent and, at the same time, it allows to include possible answer options not foreseen by the researcher in the questionnaire design phase. Certainly, also in this case, it is necessary to pay attention to the limitations, for example caused by generic or imprecise answers (determined by the absence of a "trail"). Since all survey's questions have defined as mandatory, the *"I prefer not to answer"* option has always added to the list of answers; this choice is determined by not collecting questionnaires with missing (blank) answers and wanting to understand when the respondent preferred not to give information because he/she is not in comfort with the request. Additionally, in some questions, the *"I don't know"* option has been inserted; in this way, those interviewed with the will to give an answer but who do not find the option that represents them or who cannot choose a single option are represented.

The response modality depends on the type of variable investigated in each question. In general, in the first and second part of the questionnaire ("information on attitude and willingness" and "information on feelings and community identity") most questions regarding opinions or attitudes, and therefore the ordinal variables are investigated. In this case, the 5-point Likert scale is chosen as answer mode ("*Not interested at all/Very interested*", "*Not available at all/Very available*", "*I strongly disagree/I strongly agree*", "*I don't feel this feeling at all/I feel this feeling strongly*", "*I absolutely must not trust/I can trust completely*"). The remaining questions investigate nominal variables (through non-numerical response modality) and cardinal ones (through discrete or continuous numerical response modality).

ii) Distribution phase.

The questionnaire is administrated between citizens in a specific contexts (in Susa Valley, in Essen and Litoměřice, see Chapter 5).

The reduced version of the questionnaire is distributed only online (https://www.soscisurvey.de/scorepilots/); instead for the long version of the questionnaire, two versions are defined: the paper-based version (Appendix B) and the online one (http://survey.polito.it/34418/lang-it). The online versions were written using the Limesurvey (LimeSurvey, 2020) platform, for the long version, and SoSci survey platform, for the reduced version, since these tools allows to implement the question/answer logic and allows the possibility to save and to resume in a second moment. In addition, the existence of the two different supports (only for the long version) is determined by the desire (and need) to use different distribution channels, considering both the distribution context and the national health condition because of COVID-19. The definition of an Action Plan allows to choose and plan through which channels and how to distribute the questionnaire. The distribution methods are listed below.

- Email invitation (long and reduced versions). Sending questionnaire link and flyer link to a default contact list; in addition, the sending of reminders has scheduled.
- Event participation (long version). For in-person events, the survey package is left to the participants; for online events, the link and the QR code have shared using the platform used for the meeting and sent through email.
- Intermediaries (long version). Copies of the survey package and flyers are delivered to key intermediaries in order to spread them across their territory.
- Social media (long version). Sharing on social channels of two images (with the contents of the flyer), of the link and of the QR code of the questionnaire.

The variety of the different distribution channels, used for the long version, leds to include the following question *"How did you find out this questionnaire?"* (Part 4, Question 13) in order to trace its diffusion.

Finally, the boundary conditions for distribution should be highlighted. All the questionnaires are aimed at investigating a specific context and citizens who live in a specific territory. The question *"In which municipality do you live?"* allows to discern which answers are to be considered valid and which are not since they are out of the research interest. In addition, a further condition is desired: given the complexity of the questionnaire, it is addresses to an adult target (minimum the legal age) who is, therefore, aware of their declarations.

iii) Data pre-processing and analysis.

As mentioned before, the purpose of the survey is to collect citizens' information in order to analyse the extent of their willingness to engage in local energy initiative, understanding which drivers favour and which barriers inhibit their participation. In addition, through the correlation of data relating to availability and feelings towards the community with socio-economic and demographic characteristics it is possible to define and describe the citizens' cluster. In this paragraph, the actions for a first general analysis on the data are described.

The first action is the dataset cleaning. Data cleaning refers to a generic process capable of guaranteeing, with a certain level of reliability, the correctness of a large amount of data. This procedure precedes data mining phase, in which quantities of information are extracted from the dataset, in order to produce knowledge. In this way, before any operation, it is necessary to prepare the dataset through the following data cleaning processes: the removal of unwanted observations, the adjustment of structural errors and the filtering of unwanted outliers.

- <u>Removal of unwanted observations.</u> This first action is aimed at both the removal of duplicate observations and the removal of irrelevant observations. As regards the presence of identical observations recorded more than once, these are searched within the dataset and the duplicates are eliminated, consequently leaving a single recording. The irrelevant observations, on the other hand, are those that do not actually fit the specific research issue, records outside the sample of interest. The sample of interest is framed through the definition of survey boundary condition. Since the survey is aimed at a specific context and at a sample who is aware of their statements, only the answers from respondents who live in Susa Valley, Essen and Litoměřice and have minimum 18 years old are considered valid. Records not satisfying these conditions have deleted.

- Adjustment of structural errors. Structural errors arise during measurement and data transfer. Since the questionnaire consists mainly of questions that require the choice of one or more answers among those proposed, this operation only concerned the compilation of the *"Other, please, specify _____"* field and the few open questions/answers. Specifically, the consistency of these responses is promptly verified and, in the event of inconsistent answers, the best strategy to pursue is punctually decided. For example, in the case of typos, these have corrected; in the case of a difficult interpretation, the single answer has deleted.
- Filtering of unwanted outliers. An outlier is an anomalous data, a data that lies an abnormal distance from other values in the dataset. To appreciate the presence of this type of data, the following values have calculated in order to define the data distribution.
  - *First quartile (25th percentile or Q_1)*. It gathers the first quarter of the data; it represents the middle number between the smallest number and the median of the dataset.
  - *Second quartile (50th percentile or Q_2 or median)*. It represents the middle value of the dataset.
  - *Third quartile (75th percentile or Q_3)*. It gathers the first quarter of the population; it represents the middle value between the median and the highest value of the dataset.
  - *Interquartile range (IQR)*. $IQR=Q_3-Q1$, it is the difference between 75th percentile and 25th percentiles.
  - *Lower whisker*. It is calculated in this way: $Q_1-1.5*IQR$.
  - *Upper whisker*. It is calculated in this way: $Q_3+1.5*IQR$.
  - The *minimum value* of the dataset.
  - The *maximum value* of the dataset.

  The presence of anomalous data is evaluated by comparing (a) the minimum value of the dataset with the lower whisker value and (b) comparing the maximum value of the dataset with the upper whisker value. Specifically, anomalous data are present if: (a) the minimum value of the dataset is minor the lower whisker value, (b) the maximum value of the dataset is greater the upper whisker value. The presence verification of outliers is carried out only for continuous data.

The second action concerns a first analysis relating to the statistical description of the responses, highlighting maximums, minimums, mode and median values. For each question, the distribution of the answers is shown, mainly through histograms and pie charts.

b) Citizens cluster analysis.

Based on the data collected with the questionnaire, the aim of this section is to answer the following research question: *"It is possible to define homogeneous groups based on the same characteristics?"* (RQ4), through the definition of homogeneous groups of citizens, through the Cluster Analysis (CA), based on the variables of attitude, availability and feelings. Furthermore, the purpose is to understand which social variables characterize each group. Clustering refers to the process of grouping a set of physical or abstract objects into classes of similar objects (Han et al., 2012). The cluster, therefore, is a collection of objects that are similar to each other and that are dissimilar to objects from other clusters. There are several clustering techniques, based on measures related to the similarity between elements. In many approaches this similarity (or dissimilarity) is conceived in terms of distance in a multidimensional spaces. As regards the Cluster Analysis family, the k-means algorithm is used (applying it thanks to the R software, see Chapter 5). K-means is a popular data partition method widely used in many fields; it is defined an unsupervised learning technique since, in order to dictate how the pattern is formed, it examines for patterns among the input variables without using an outcome variable. In this way, data are used to discover natural groupings within a heterogeneous population. Therefore, the population under investigation is divided into groups, depending on the presence or absence of a certain similarity and these groups are chosen *a piori*, before the algorithm is executed. When the K-means algorithm, a centroid is defined for each cluster, i. e. a point (imaginary or real) at the centre of a cluster. The k-means algorithm is an iterative algorithm; indeed, it performs (some of them repeatedly) the following steps: initialization, cluster assignment and centroid position update.

1. Initialization. The input parameters (the dataset and the number of centroids (k)) are defined. Consequently, by choosing the number of centroids, the number of clusters to be obtained is determined. Initially, the centroids position is arranged randomly.
2. Cluster assignment. In this phase, the algorithm analyses each of the data points and assigns them to the nearest cluster (or centroid). Indeed, the Euclidean distance between each data points and each centroid is calculated: then, each data points is assigned to the centroid whose distance is minimum. The following formula mathematically explains the concept:

$$\arg\min \, dist\,(c_i, x)^2$$

In the formula: c_i is a centroid in the set C (set that includes all centroids); x are the datapoints and $dist(c_i, x)$ is the standard Euclidean distance.

3. Centroid position update. In this phase, the exact point of the centroid is determined. The new value of a centroid is the average of all data points that have been assigned to the new cluster, described through the following formula:

$$c_i = \frac{1}{|s_i|}\sum_{x_i \in S_i} x_i$$

In the formula, S_i represents the sum of the datapoints assigned to the *i-th* cluster. The new position of the centroid is obtained from the average of all the data points assigned to the cluster in the previous step.

The algorithm continues to repeat Steps 2 and 3 until the centroids change, until a point of convergence is reached such that there are no more changes to the clusters. The final condition occurs when one of the following options intervenes: no data points change clusters, the sum of the distances is reduced to a minimum or a maximum number of iterations is reached. The traditional method for calculating k is empirical and consists of a graphical comparison between the number of clusters and the total sum of each point and its nearest centroid.

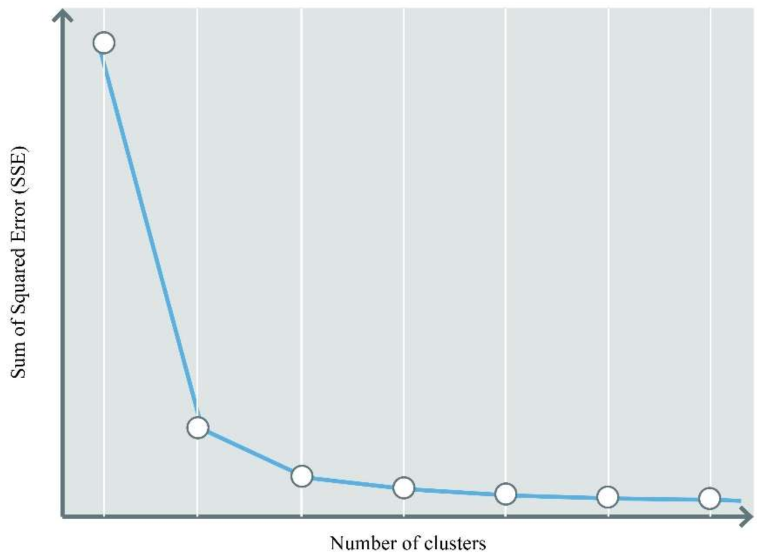

Figure 24. "Elbow" graph.

Figure 24 shows the graph used to determine the optimal number of clusters. In the graph, the number of clusters is represented on the *x-axis*, the Sum of Squared Error (SSE) on the *y-axis*. An increase in clusters is related to smaller clusters and distances, this sum decrease when k increases and, vice versa, increases when k decreases. Indeed, with a k value equal to the number of data points, the sum is zero, because the centroid coincide with each point and the total distance is zero. The goal of this process is to find the point where the increase in

k cause a very small decrease in the sum, while the decrease in k sharply increase the sum. This point represents the optimal number of clusters to consider.

Finally, the definition of groups of citizens who share similar characteristics allows understanding the attitudes and the needs of each cluster in order to suggest and to promote specific and tailored inclusion strategies so that each citizen can commit towards an energy community project.

4.4 Legal and financial structure

In this paragraph, the methodology regarding the legal and financial structure is described. As anticipated in the introduction of this chapter, this is the last element for the energy community creation. Indeed, through the contractual form the balance between different stakeholders and the material elements in order to reach the co-ownership of renewable energy is defined and bounded. The legal and financial structure is, in turn, divided into two phases: the preparation and the implementation. The first phase (Phase V) is the preparation. In this phase, through a discussion with a panel of expert, the definition of a contract/agreement is obtained. The second phase (Phase VI), the implementation, consists in a membership campaign to sanction, with the signing of the contract, the inclusion and participation of citizens and, therefore, the creation and the birth of the energy community.

4.4.1 Phase V: preparation

Once the material (buildings and energy plant system) and social (users and citizens, private and public entities) components are described, the attention is paid on the regulatory component, in other words, on the agreement between the parties regulate its balance and functioning. A discussion and comparison with legal experts is carried out in order to define the contractual form that best allows the birth of the energy community. The resulting legal and financial plan is the CSOP (Consumer Stock Ownership Plan), an innovative model (as described in Chapter 2). The CSOP contribute to the energy transition and climate change mitigation by facilitating local, decentralized production by investing in renewable energy installations. The agreement have to consider that several actors are the ownership of the new energy plant system, that supplies energy to consumers at fixed price and generates revenues from excess production sold to the grid. Specifically, the elements listed below should be taken into consideration in the agreement definition.

- The participation in decision-making is possible through the trustee, who represents the citizens interested in CSOP, while individual consumer-shareholders may execute control rights on a supervisory board or advisory council. Therefore, the model is consumer-cantered investment for general services providing participation both financially and in regards to management decisions.

- Municipalities, small and medium-sized enterprises (SMEs) and other local stakeholders are permitted as co-investors. CSOP avoid personal liability of the consumer-shareholders.
- The Operating Society invests in new or existing RE plants and operates it on behalf of different actors as co-owners.
- The banks, from which it is possible to demand loan.

4.4.2 Phase VI: implementation

Once the contract is defined, it is necessary that all stakeholders take part in it. On the one hand, contacts, events and workshops are exploited to bring citizens closer to this new model of (co-)ownership; on the other hand, the cluster analysis on the population make it possible to identify the needs of each group and define *ad hoc* involvement policies. The aim is to allow and encourage the participation of all segments of the population. The active participation of the population allows the signing of the agreement and therefore sanctions the birth and the official and legal creation of the energy community.

4.5 Conclusion

The aim of this chapter was to define a workflow, concerning the methodology underlying the energy community creation, in which the relationships and synergies of the three elements, that compose it, are highlighted: the technical structure (building identification, data collection, definition of energy retrofit alternatives and best scenario selection), the social structure (identification of key persons, informative event and workshop organization and questionnaire administration) and the legal and financial structure (definition of financial contract / agreement and co-ownership implementation).

Technical structure concerns all the processes aimed at selecting and describing buildings and energy plant systems, defining various energy retrofit scenarios and, finally, choosing the best scenario. The technical structure is divided into two phases: the preparation (Phase I) and the preliminary and feasibility analysis (Phase II). The preparation phase concerns the buildings and energy plant systems identification and description and data collection, through two surveys regarding a) the investments identification of renewable energy sources and b) the energy costs and tariffs for the current situation, i.e. for the use of non-renewable energy sources. The preliminary and feasibility analysis concerns the action aimed at describing the different refurbishment measures due to increase the energy efficiency of the buildings and energy plant system and at selecting the best retrofit scenario. The underlying methodology is a document called “Dossier”; it represents a guideline in order to (i) evaluate the energy efficiency (EE) of the current situation of the pilot buildings, (ii) to design, at least, two alternatives for each pilot case study, intervening on energy system, envelope system and control system (in order to shift from fossil fuels to renewable one, to increase the efficiency of the building envelope and the energy system and to reach a reduction of energy consumption) and, finally, (iii) to identify the best alternative retrofit scenario through the Multi-Criteria Analysis (MCA) methods, considering different criteria: technical, economic, social and environmental aspects. In addition, the inclusion of a legal and financial analysis (business plan) highlights if the selected alternative is feasible in an economic perspective.

Social structure concerns all the processes aimed at making users aware of energy and environmental issues and at encouraging their inclusion/participation in community projects or promoting a behaviour change. The social structure is divided into two phases: the identification of key persons (Phase III) and the target group involvement (Phase IV). The purpose of the identification of key persons phase is to define the target group, through a stakeholders' analysis, and to inform, sensitize and make aware people towards energy and environmental issue, through informative events and workshops. Specifically, informative events are meetings with local institutions aimed at disseminating the energy community principals and defining how to involve all citizens segments; instead, workshops are tailored activities aimed not only at informing the invited stakeholders about a specific topic (the environmental and energy issues and the community energy topic) but also at creating a semi-structured debate with them. The purpose of the target group involvement phase is to characterize the population, through a questionnaire based on existing scientific literature (Chapter 3), concerning the drivers that affect the energy saving behaviours, the energy efficiency investment actions and the engagement in renewable energy projects, and to understand if it is possible to divide citizens into clusters (characterized by level of attitude and willingness towards community projects based on renewable energy and towards energy saving practices and by feelings and level of identity towards the community/territory to which they belong), in order to promote specific inclusion strategies and tailor-made environmental, energy and social policies aimed at involvement in energy community project and to address the current issues.

Legal and financial structure concerns the last part before the energy community creation. The legal and financial structure is divided into two phases: the preparation (Phase V) and the implementation (Phase VI). The preparation phase aimed at defining, through a discussion with a panel of expert, the contract which regulates the agreements between citizens and the relationship between the social component and the material component. The implementation phase consists in a membership campaign to sanction, with the signing of the contract, the inclusion and participation of citizens and, therefore, the creation and the birth of the energy community.

Chapter 5

Case studies and results

5.1 Introduction

In the previous Chapter 4, the methodology related to the creation of the energy community, as a potential solution to address the energy and environmental problem and issues, is exposed in detail. The research outline proposes and defines three main elements: the material component (buildings and energy plant system), the social component (users and citizens, private and public entities) and, finally, the regulatory component (agreement between the parties that regulates its balance and functioning). Consequently, the energy community takes shape, respectively, from the synergy between the technical, social and legal and financial structure.

The participation in the SCORE project has represented an important and interesting opportunity for comparison and discussion, in order to refine the methodology, but, above all, it constituted the possibility of applying the methodology in three different case studies belonging to different contexts. As extensively detailed in Chapter 1, the SCORE project aims (i) to promote and create energy communities in which energy is produced, exchanged and consumed mainly from renewable sources, (ii) the involvement of citizens (public, private and small and medium-sized enterprises), promoting and facilitating their active participation and establishing the figure for prosumer and, finally, (iii) the creation of a financial participation plan shared by the energy community participants. Project implementation focuses first in the three case studies of Susa Valley (Italy), Litoměřice (Czech Republic) and Essen (Germany) then, subsequently having demonstrated the project feasibility, in other follower cities across Europe. Specifically, in this chapter, the application and results are, respectively, exposed:

- Susa Valley (Italy): technical (Part I and Part II) and social (Part III and Part IV) structure;

- Litoměřice (Czech Republic): social structure (Part IV);
- Essen (Germany): social structure (Part IV).

Furthermore, since the SCORE project includes the participation of different partners, the different contributions are indicated for each part.

5.2 Susa Valley (Italy)

The Susa Valley is a wide and deep Italian alpine valley and it located in the western part of Piedmont region, between the city of Torino and the border with France; the Valley takes its name from the ancient city of Susa, because it is located in a central position. Susa Valley is the largest and populated valley in Piedmont region and it extends for about 80 Km in length, belonging to the hydrographic basin of the Po river. The Susa Valley is crossed by the Dora Riparia river; it is delimited by the Cozie Alps (on the right of the Dora and Cenischia rivers) and by the Graie Alps (on the left of the same rivers). Dora and Cenischia streams form two important valleys that branch off from the main one (Figure 25). The geographical location of the Valley has marked its history and its social and economic evolution, with an urban and infrastructural development that, starting from the second post-war period, progressively moved from the mountain slopes to the valley bottom, marked by the Dora Riparia, trails, of the railway, of the two state roads and, in more recent years, also of the international highway. Around these transit and connection networks grew the municipalities of which the valley is composed. The Susa Valley includes thirty-nine municipalities, very different in location, territorial extension and demographic size. Indeed, from the more than twelve thousand inhabitants of the Municipality of Avigliana, to the few dozen residents of the Municipality of Moncenisio which, for some years, held the record of the smallest municipality in Italy. In addition, the different morphological, altitudinal and climatic characteristics have contributed to further differentiate the development of the territory.

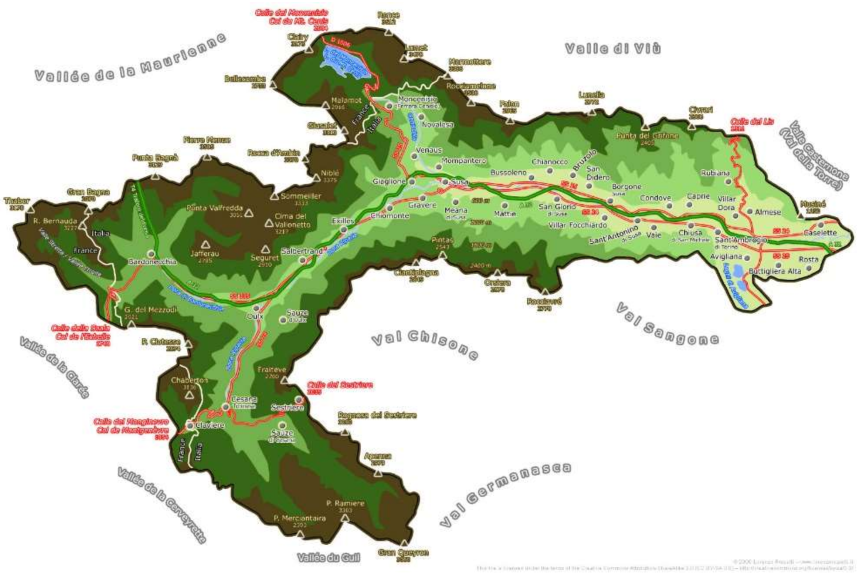

Figure 25. Susa Valley.

As shown in Table 6, municipalities are aggregated into the four geographical areas, referring to the largest municipality present in the surrounding area. In this case, the reference municipalities are Oulx, Susa, Condove and Avigliana. Moreover, the presence of three mountain Unions in the area leads to a further subdivision of the municipalities in Bassa Valle, Alta Valle and Olympic Municipalities of Via Lattea.

Table 6. Municipality in Susa Valley.

N°	Municipality	Geographical area	Unione Montana typology
01	Almese	Avigliana area	Unione Montana Bassa Valle Susa
02	Avigliana	Avigliana area	Unione Montana Bassa Valle Susa
03	Bardonecchia	Oulx area	Unione Montana Alta Valle Susa
04	Borgone Susa	Condove area	Unione Montana Bassa Valle Susa
05	Bruzolo	Susa area	Unione Montana Bassa Valle Susa
06	Bussoleno	Susa area	Unione Montana Bassa Valle Susa
07	Buttigliera Alta	Avigliana area	Unione Montana Bassa Valle Susa
08	Caprie	Condove area	Unione Montana Bassa Valle Susa
09	Caselette	Avigliana area	Unione Montana Bassa Valle Susa
10	Cesana Torinese	Oulx area	Unione Montana Comuni Olimpici Via Lattea
11	Chianocco	Susa area	Unione Montana Bassa Valle Susa
12	Chiomonte	Susa area	Unione Montana Alta Valle Susa
13	Chiusa di San Michele	Condove area	Unione Montana Bassa Valle Susa
14	Claviere	Oulx area	Unione Montana Comuni Olimpici Via Lattea
15	Condove	Condove area	Unione Montana Bassa Valle Susa
16	Exilles	Susa area	Unione Montana Alta Valle Susa
17	Gravere	Susa area	Unione Montana Alta Valle Susa
18	Giaglione	Susa area	Unione Montana Alta Valle Susa
19	Mattie	Susa area	Unione Montana Bassa Valle Susa
20	Meana di Susa	Susa area	Unione Montana Alta Valle Susa
21	Mompantero	Susa area	Unione Montana Bassa Valle Susa
22	Moncenisio	Susa area	Unione Montana Alta Valle Susa
23	Novalesa	Susa area	Unione Montana Bassa Valle Susa
24	Oulx	Oulx area	Unione Montana Alta Valle Susa
25	Rosta	Avigliana area	Unione Montana Bassa Valle Susa
26	Rubiana	Avigliana area	Unione Montana Bassa Valle Susa
27	Salbertrand	Oulx area	Unione Montana Alta Valle Susa
28	San Didiero	Condove area	Unione Montana Bassa Valle Susa
29	San Giorio di Susa	Susa area	Unione Montana Bassa Valle Susa
30	Sant'Ambrogio di Torino	Avigliana area	Unione Montana Bassa Valle Susa
31	Sant'Antonino di Susa	Condove area	Unione Montana Bassa Valle Susa
32	Sauze d'Oulx	Oulx area	Unione Montana Comuni Olimpici Via Lattea
33	Sauze di Cesana	Oulx area	Unione Montana Comuni Olimpici Via Lattea
34	Sestriere	Oulx area	Unione Montana Comuni Olimpici Via Lattea
35	Susa	Susa area	Unione Montana Bassa Valle Susa
36	Vaie	Condove area	Unione Montana Bassa Valle Susa
37	Venaus	Susa area	Unione Montana Bassa Valle Susa
38	Villar Dora	Avigliana area	Unione Montana Bassa Valle Susa
39	Villar Focchiardo	Condove area	Unione Montana Bassa Valle Susa

5.2.1 The energy community project

Considering the energy use in Susa Valley, currently (more or less) 75% of the energy produced originates from fossil fuels; the remaining part is produced by renewable energy sources, mostly from biomass. Even if these source represents a quite good percentage of penetration in the energy system, the main issues concerns the biomass origin: it is not sourced locally (it does not come from the local forests and, therefore, "km0") but imported from France and other European and Non-European countries. In addition, the main part of the imported biomass is not certified, a share that is not possible statistically quantify, since it is subjected to the grey market.

The main project actions jointly encourage the use of an energy mix from renewable sources (preferring local resources) and intervene on inefficient energy plant systems. Indeed, the strategy consists in replacing the old and inefficient heating plant system, fuelled by oil or natural gas, serving a single building, with centralized systems, which serve at least two neighbouring buildings (creating a small district-heating network), powered by local and certified biomass. From an operational point of view, the installation time of the new systems is estimated to be around one/two years. The time length depends also on the needed envelope system retrofitting for some of the buildings, considering that another project purpose concerns the reduction of energy consumption both through an improvement of the building envelope and through a more conscious users' behaviour. These interventions need to wait for an appropriate season for the installation of new systems and envelope system retrofitting, since, for example, it is not possible to intervene during the heating seasons since the systems work constantly. Summing up, the core idea is to substitute fossil fuels, imported by external countries (with not positive externalities on the territory neither internal, neither external) with local wood chips. In this way, the local forest (of which the valley is rich) can provide fuels in a sustainable way while generating positive economic externalities for the territory. In addition, the factors not to be underestimated in the design phase are: traceability of wood origin and high quality wood chips boilers to ensure low pollution. Consequently, the replacement of fossil sources with wood chips entails (i) lower costs for energy, (ii) a high share (>80%) of energy cost remaining on the territory as well as (iii) less CO_2 emission (close carbon cycle). In addition, other elements should not be underestimated since these actions, aimed at the decarbonization and transition process, can have several effects at different scales, which differ according to the metrics considered. Indeed, at global scale, the decarbonisation can be assessed by means of indicators that measure its environmental impact by assessing the emission of carbon dioxide and its contribution to the greenhouse effect. The same process, on a local scale, can be studied by evaluating the quality of the air and therefore the weight of particulate matter in the air.

It should not be overlooked that these actions are inserted in a context of decarbonization and energy transition in which it is necessary to take into consideration not only the technical aspects but, above all, the social aspects of citizen participation and (co)ownership of renewable energy plants. Indeed, the last purpose is the creation of a renewable energy community utilising the CSOP model in the whole Susa Valley, focussing on unemployed, low-income households and women with the intention of making underrepresented segments of the population co-owners and co-investors. For this reason, the Susa Valley action plan focuses specifically on the involvement of citizens and particularly vulnerable groups to invest in local RE CSOPs, as well as other residents, SMEs and municipalities.

In a first phase, 10 municipalities (Table 7), have been identified as interesting to implement energy communities. The goal is, however, to increase the number of municipalities involved in order to include the whole Susa Valley, to all 39 municipalities.

Table 7: Susa Valley pilot project

N°	Case study	Type of building	Existing conventional energy sources for heating	Planned RES sources project
01	Oulx	School and gym Nursey Gym Municipality Touristic office Social activity building Building (residential)	Oil and natural gas boiler (individual generators)	DH network (biomass)
02	Novalesa	Abbey Private building 1 Private building 2	Oil and LGP boiler (individual generators)	DH network (biomass)
03	Rueglio	Municipality Retirement house	Oil boiler (individual generators)	DH network (biomass)
04	San Giorio di Susa (building scale)	Multi–use room Bar	Natural gas boiler (individual generators)	DH network (biomass)
05	San Giorio di Susa (city scale)	Private residential building	Individual oil stove	DH network (biomass)
06	Almese	Sport (facilities) buildings Middle school Private buildings	Natural gas boiler (individual generators)	DH network (biomass)
07	Susa	District heating network	Oil and natural gas boiler (individual generators)	DH network (biomass)
08	Bardonecchia	District heating network	Oil and natural gas boiler (individual generators)	DH network (biomass)
09	Bussoleno	District heating network	Natural gas boiler (individual generators)	District heating network (biomass)
10	Villardora	School and gym Kindergarten	Natural gas boiler (individual generators)	District heating network (biomass) and solar thermal collectors

As shown in the table, most of the buildings are public; this determines economic security and commitment to this project since (for example) buildings like school or the town hall cannot "close". The sequential objective is the extension towards private buildings; in this way the citizen's involvement is more legitimized, not only as co-owner of an energy plant of a building that citizens uses only for service, but as co-owner of a building in which they lives and, consequently, spend more time, in which they pays his bills and, finally, can understand the benefits of a (co-)ownership and energy community.

In the next paragraphs, following the structure described in Chapter 4, the actions aimed at creating an energy community in the Susa Valley are described. For each structure and methodology the context of application will be explained; but, in general, it is possible to state that, in order not to fall into repetition, the technical structure is described only for the case study of Oulx; instead, the actions implemented in the social structure refers more broadly to the entire Susa Valley. The actions related the legal and financial structure are not treated since they are currently under discussion and work.

5.2.2 Technical structure

In this paragraph, the application regarding the technical structure is described. Specifically, all the processes aimed at selecting and describing buildings and energy plant systems, defining various energy retrofit scenarios and, finally, choosing the best scenario are exposed and the results are shown. The technical structure is divided into two phases: the preparation and the preliminary and feasibility analysis.

Part I: preparation

The first phase (Phase I) is the preparation phase and its aim is to identify and to obtain information regarding the buildings and the energy plant systems. Two pre-defined surveys, provided by the SCORE project partner, were compiled in order to collect information and data about a) the investments identification of renewable energy sources and b) the energy costs and tariffs for the current situation, for the use of non-renewable energy sources. The information were collected through an in-situ analysis, technical documents and discussion with local experts.

The Oulx case study, as shown in Figure 26, concerns some buildings that are located around the central square. These buildings are listed below:

1) Municipality (Piazza Aldo Garambois, 1);
2) Touristic office (Piazza Aldo Garambois, 2);
3) Middle school “P. P. Lambert” (Piazza Aldo Garambois, 6);
4) Baby parking (Piazza Aldo Garambois, 12);
5) Cutltural activity building (Via Vittorio Emanuele, 24).

Figure 26. Oulx case study.

a) Survey 1: the investments identification of renewable energy sources.

The first survey allowed to collect information on general description of the buildings, to quantitatively describe the current situation of the building system and the energy plant system and, finally, to explain the design situation for the implementation of an energy system fuelled by RES. Table 10 shows the results relating to the type of building the building typology, the building ownership, the building construction year, the year of the last refurbishment measures, the average heat and DHW consumptions expenses, the total number of offices, the total official number of inhabitants/employees, the total usable area and the total roof area.

Table 8: Oulx pilot project, survey 1.

	Municipality	**Touristic office**	**Middle school**	**Baby parking**	**Cultural activity building**
Ownership	Public building	Public building	Public building	Public building	Public building
Function	Non-residential - administration	Non-residential - service	Non-residential - educational	Non-residential - educational	Non-residential - service
Construction year	1980	1995	1958	1988	First year of 1900
Last refurbishment year	2016 (windows substitution)	none	2018 (seismic assessment)	none	2016 (structural and plant intervention)
Avarage heat and DHW expences [€/y]	13831	14699	57915	5585	3000
N of offices	10	3	27	1	3
N of users	26	6	250	2	2
Total usable area [m^2]	660	700	2800	270	300
Total roof area [m^2]	278	412	1041	280	158

In addition, the survey investigated the existing conventional energy sources. The buildings in question are equipped with an independent energy plant system. Specifically, the municipality, the touristic office and the cultural activity building have currently installed an energy plant systems supplied by natural gas (respectively with power boilers of 300 kW, 185 kW and 80 kW). Instead, the school complex is provided by an oil energy system characterized of an installed power of 440 kW.

Currently, the buildings considered do not have any type of RES system installed. On the other hand, the project involves the installation of a single centralized energy plant system, supplied with local biomass, which can serve all the buildings located around the square, thus creating a small network between the five buildings. Taking into account the interventions in order to improve the efficiency regarding the thermal performance of the building envelope, the expected installation power (for the new centralized energy system) is to be assumed about 500 kW. Finally, the estimated investment cost is around 320000 €; a portion of this share is placed by the citizens who will make up the CSOP financing plan.

b) Survey 2: the energy costs and tariffs for the current situation.

The second survey aim at collecting economic information about the actual situation related to the use of non-renewable energy sources. Consequently, the information collected is summarized in Table 9.

Table 9: average consumption fee, survey 2.

	Municipality	Touristic office	Middle school and baby parking	Cultural activity building
Av. Annual consumption (GJ)	540	540	1080	108
Av. Annual consumption (MWh)	150	150	300	30
Historical data 2013	25.069	25.069	52.982	25.863
Historical data 2014	21.644	21.644	51.886	22.393
Historical data 2015	21.706	21.706	46.489	22.457
Historical data 2016	19.363	19.363	43.736	20.219
Historical data 2017	19.363	19.363	46.321	20.741
Fuel	Natural gas	Natural gas	Oil	Natural gas

Part II: preliminary and feasibility analysis

The second phase consists of preliminary and feasibility analysis and the Dossier document is used as a guideline in which (i) the collected information in Phase I are structured and implemented, (ii) the energy efficiency (EE) of the current situation of the pilot buildings is evaluated, (iii) two alternatives for each pilot case study, intervening on energy system, envelope system and control system (in order to shift from fossil fuels to renewable one, to increase the efficiency of the building envelope and the energy system and to reach a reduction of energy consumption) are designed, (iv) the best alternative retrofit scenario through the Multi-Criteria Analysis (MCA) methods, considering different criteria: technical, economic, social and environmental aspects is identified.

In this application example, the Oulx Dossier investigated first the school complex (Figure 27). The school is currently undergoing a seismic adjustment and, contextually, the envelope retrofit strategies are implemented in order to improve energy efficiency and to reach the “Conto Termico” (that is a package of incentives and concessions set up with an Italian ministerial decree to promote measures to improve the EE of existing buildings and to encourage the production of RE). Later, a small DH network will be installed to cover also, in a second time, the adjacent buildings (municipality, touristic office and cultural activity building). The school area includes three different buildings:

- An elementary and middle school building, with a basement floor and three overlying floors in elevation;
- A gym that has only a ground floor with a common wall with the school (on the eastern side of the school);
- A prefabricated nursery building, that covers a single ground floor and is located beside the school.

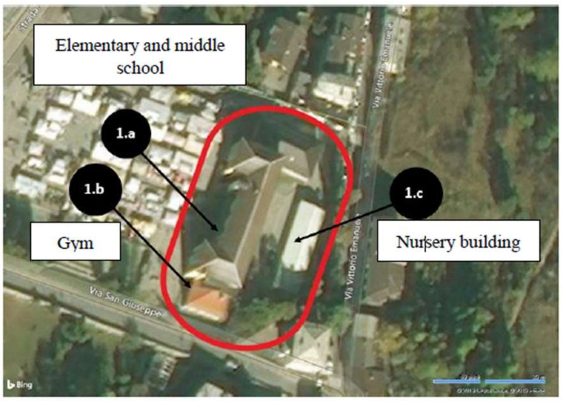

Figure 27. Building involved in Oulx (source: www.bing.com/maps).

The buildings are equipped by two oil boilers characterized by different circuits and by different kinds of heaters (radiators, fan heaters, and air nozzles) for the schools, the gym, and the nursery; consequently, the absence of integration between each building is one of the critical issues from the energy point of view. The thermal efficiency values of the two traditional oil boilers with blast burners are 81.5% (generator of 300 kW) and 78.9% (generator of 130 kW). Regarding the domestic hot water (DHW) production there is a centralized generation combined with the heating generation. Other critical issues of the building are listed as follows:

- significant energy leakage through the opaque casing;

- obsolete regulation and balance systems (simple regulation on-off with no internal temperature compensation);
- obsolete heat generation technology (oil boilers over 10 years old);
- not clean energy sources (diesel fuel) and consequent high emission levels of CO_2.

The energy model that shows the building and the energy system performances is created by an energy expert teamwork with a software certified by the Comitato Termotecnico Italiano (CTI). The primary energy indicator (total (Qp), and that normalized with respect to the floor area (EP)) for the two services of space heating and domestic hot water are shown in Table 10 below. Specifically, the non-renewable, renewable, and total values of consumption are calculated.

Table 10. Oulx energy indicators.

Service	$Q_{p,nren}$ (kWh)	$Q_{p,ren}$ (kWh)	$Q_{p,tot}$ (kWh)	EP_{nren} (kWh/m^2)	EP_{ren} (kWh/m^2)	EP_{tot} (kWh/m^2)
Heating	491,432	0	491,432	172.98	0	172.98
DHW	37,919	0	37,919	13.35	0	13.35
TOTAL	529,350	0	529,350	186.32	0	186.32

After an energy analysis and identification of weaknesses and critical issues of the actual situation of the buildings pilot, different retrofit alternatives (Table 11) were studied in order to improve the current energy situation and minimize the environmental impact. The first alternative (A1) concerns solely the replacement of the boilers with a unique biomass-fired one and regulation retrofitting, since the main purpose of the project was to facilitate consumers to become prosumers of RE and to become owners of RE energy plants (through the CSOP financing model).

Table 11. Retrofit alternatives for Oulx case study.

Code	Interventions
0.0	As-built simulation model.
0.1	As-built simulation model from real consumption (benchmark).
A1	Simulation 0 and replacement of the boilers with a unique biomass-fired one and regulation retrofitting.
A2	Simulation 1 and the upper-attic slab insulation (18 cm).
A3	Simulation 2 and external walls insulation for the school and the gym (18cm).
A4	Simulation 1 and nZEB conditions obtained with the upper-attic slab insulation (40 cm), external walls insulation for the school and the gym (30 cm), and the nursery’s external walls (25 cm).
A5	Simulation 1 and nZEB conditions obtained with the upper-attic slabs insulation (50 cm for the school and the gym, 40 cm for the nursery), external walls insulation for the school and the gym (40 cm), and the nursery’s external walls as built.
A6	Simulation 1 and nZEB conditions obtained with the replacement of the windows with more efficient components (transmittance: <1.0 W/m2K), upper-attic slab insulation (15 cm for the school and the gym, 12 cm for the nursery), external wall insulation for the school and the gym (15 cm), and the nursery’s external walls as built.

The subsequent alternatives intervene on the envelope of the buildings, insulating the external walls and roof with a growing thickness as the alternatives increase. Intervening only on the energy system is not enough; for a good result of the project it is, therefore, necessary to intervene on the envelope system, increasing its efficiency in order to reduce heat losses for transmission and ventilation. In this way the required winter load for the heating system will be lower. In addition, it is considered useful to reach nearly Zero Energy Building (nZEB) conditions and it is important to obtain the incentives offered by the "Conto Termico". Through the energy simulation, Table 12 shows the results obtained in comparison with the current situation, highlighting the energy consumption of the building system from non-renewable sources ($Q_{p,nren}$), the energy consumption of the building system from renewable sources ($Q_{p,ren}$), and the CO_2 emissions consequent to fuel consumption. In addition, the percentage of 80% of energy from renewable sources compared to the total energy used by the building is sets by a "minimum requirement" derived from the Ministerial Decree of 26 June 2015.

Table 12. Energy simulation results.

Simulation	$Q_{p,tot}$	$Q_{p,ren}$		$Q_{p,nren}$		CO_2 emissions	
	(kWh/y)	(kWh/y)	% (ren/tot)	(kWh/y)	% (nren/tot)	($kgCO_2eq/y$)	% (VS 0.1)
0.0	529,350	-	-	529,350	100%	137,551	85.84%
0.1	616,697	-	-	549,061	100%	160,248	100%
A1	457,140	365,712	80%	91,428	20%	22,857	14.26%
A2	335,284	268,228	80%	67,057	20%	16,764	10.46%
A3	197,529	158,023	80%	39,506	20%	9876	6.16%
A4	177,276	141,821	80%	35,455	20%	8864	5.53%
A5	177,213	141,771	80%	35,443	20%	8861	5.53%
A6	177,638	142,110	80%	35,528	20%	8882	5.54%

The evaluation matrix (Table 13) allows the comparison of each refurbishment alternative proposed, in the preliminary analysis, with the current situation. The selected indicators cover the different areas of the project, from the economic to the social, through the technical and environmental.

Table 13. Evaluation matrix.

Category	Indicator code	A1	A2	A3	A4	A5	A6
Environmental	ENV1	525,269	549,640	577,191	581,242	581,254	581,169
	ENV2	137,427	143,520	150,408	151,420	151,423	151,402
	ENV3	94.55	98.94	103.89	104.62	104.63	104.61
	ENV4	6.83	7.15	7.50	7.56	7.56	7.56
Economic	EC1	8.30	11.7	16.5	16.3	16.3	16.3
	EC2	284,750	417,250	617,250	617,250	617,250	617,250
	EC3	40%	40%	40%	65%	65%	65%
	EC4	34,142	35,727	37,517	37,781	37,782	37,776
	EC5	136,250	136,250	136,250	136,250	136,250	136,250
	EC6	34,063	34,063	34,063	34,063	34,063	34,063

	EC7	148,500	281,000	481,000	481,000	481,000	481,000
	EC8	51,975	98,350	168,350	168,350	168,350	168,350
	EC9	39,523	33,156	26,962	25,630	25,459	25,490
	EC10	TAA	TAA	TAA	TAA	TAA	TAA
Technical	T1	9.80%	9.80%	9.80%	9.80%	9.80%	9.80%
	T2	175	175	175	175	175	175
Social	S1	3	1	1	1	1	2

Finally, in order to choose the best refurbishment alternative, an outranking MCA, called PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluation), is chosen in order to sort the different energy retrofit interventions. In order to apply the PROMETHEE method, two specific types of information are necessary: the criteria weights and the decision-maker's preference function for comparing the contribution of the alternatives in terms of each separate criterion. The method is applied through Visual PROMETHEE" and the full application (including the sensitivity analysis) is described in detail in a previous publication (Torabi Moghadam et al., 2020). In addition, a sensitivity analysis was carried out, modifying the weights with respect to the Baseline alternative of each alternative (according to stakeholders' interests and opinions), in order to observe how their ranking varies and to test the robustness of the model. The assumptions relating to the three scenarios (Baseline, Change 1 and Change 2) are listed below.

- The Baseline model assigns same weight for each category (i.e., Environmental, Economic, Technical and Social), 25% each one, divided equally to the indicators. This means that the weight of each particular indicator will depend of the number of KPIs included on that category.
- Change 1 proposes the same weight for each indicator (e.g., ENV1, EC1, T2, etc.), 5.9 % each one.
- Change 2 focuses on the two categories that have more impact in the project, the Environmental and Economic. Taking into account the relevance of these two, a higher weight has been assigned (30 % each one), leaving the rest to social and technical aspects, divided equally.

The results for the three scenarios (Baseline (Figure 28), Change 1 (Figure 29) and Change 2 (Figure 30)) are shown below.

Alternative	A1	A2	A3	A4	A5	A6
Net phi	−0.3156	0.0020	0.0514	0.1042	0.1043	0.0538
Rank	6	5	4	2	1	3

Figure 28. Result of Baseline scenario.

Alternative	A1	A2	A3	A4	A5	A6
Net phi	−0.0516	0.0208	−0.0629	0.0353	0.0354	0.0230
Rank	5	4	6	2	1	3

A5 → A4 → A6 → A2 → A1 → A3

Figure 29. Result of Change 1 scenario.

Alternative	A1	A2	A3	A4	A5	A6
Net phi	−0.2923	−0.0158	0.0384	0.1032	0.1034	0.0631
Rank	6	5	4	2	1	3

A5 → A4 → A6 → A3 → A2 → A1

Figure 30. Result of Change 2 scenario.

From the model runs, by changing the weights, the best alternative is always A5 followed by A4 and A6; the main reason is the achievement of nZEB conditions since great public incentives are obtained. Simulation A5 and A4 only differ in the thickness of insulation, which is the reason since similar values of net phi are found. The lowest values are associated with A1, that is, the solution that provides only a biomass boiler addition.

5.2.3 Social structure

In this paragraph, the application regarding the social structure is described. Specifically, all the processes aimed at making users aware of energy and environmental issues and to encourage their inclusion/participation in community projects or promoting a behaviour change are exposed and the results are shown. The social structure is divided into two phases: the identification of key persons and the target group involvement. The application context is the entire Susa Valley.

Part III: identification of key persons

In Phase III, first, through a stakeholders' analysis, the target group is defined and, then, through informative events and workshops, the process in order to inform, sensitize and make people aware to community projects is described, through the application of different methodologies.

a) Stakeholders' analysis

As stated several times, the creation of an energy community is aimed at all segments of the population. In this first phase, the actions aimed at identifying citizens are described, with a particular focus on vulnerable and underrepresented citizens. First, a survey made it possible to collect general information on the Focus Group; second, this information made it possible to elaborate the interest-influence matrix to map the stakeholders in order to proceed, subsequently, with the phases relating to establishing a contact.

1. Step 1: survey on Focus Group - general information.

Table 14 shows the results obtained from the Focus Group's survey. The collected data refer, in general, to the entire Susa Valley and the information was collected through a personal research and comparison/discussion with local stakeholders close to vulnerable and underrepresented segments of the population.

Table 14. General information on Focus Group.

Section 1: Focus Group definition.

Q: *Is there a shared definition of low-income household? Is there a minimum threshold for belonging to this group?*

A: There is no shared definition of low-income household. However, there are some indicators that give an idea of the economic situation of a family. The absolute poverty threshold, the Reddito di Cittadinanza (Citizenship Income) and the "ISEE" indicator are some elements to understand the economic situation of a family in the whole Italian territory.

- The absolute poverty threshold represents the monetary value, considering the current prices, of the basket of goods and services considered essential for each family. The indicator takes in consideration three elements: the age and composition of the family members, the geographical position and the type of municipality of residence. The Istituto Nazionale di Statistica (ISTAT) provides a tool for calculating this threshold (Istituto Nazionale di Statistica (ISTAT), 2020). A family is absolutely poor if it incurs a monthly consumption expenditure equal to or less than this monetary value.
- The Reddito di Cittadinanza (Ministero del Lavoro e delle Politiche Sociali, 2020; Ministero dello Sviluppo Economico (MISE), 2020) is a monetary subsidy intended for all residents in Italy, workers or unemployed, for all people whose income (from work or retirement) is too low, below the poverty threshold of 780 €/month established by ISTAT or for all people with a ISEE indictor of the family unit less than 9360 €.
- The ISEE (Indicatore della Situazione Economica Equivalente (Equivalent Economic Situation Indicator)) is used to measure the overall level of economic condition of the family unit, considering all the items of "wealth", such as real estate, financial income, others incomes, etc. The indicator is the weighted result of a complex intertwining of mathematical and non-mathematical variables (e.g. the number of people within the family unit, the presence of disabled/invalids people, etc.). In Italy, the ISEE indicator is the main tool for accessing certain bonuses, subsidies and social benefits.

Section 2: authorities with a general overview of the local context/territory.

Q: *How many low-incomes household, unemployed people are in the Municipality? How many of them are women or women with child/children?*

A: The answer requires further research. Indeed, data can be found through the **mayors** of each municipality or through the **Centro per l'impiego*** (Employment Center).

Section 3: organizations/entities.

Q: *Is there any private or municipal supplier who could provide information linked to energy poverty? E.g. a number of customers who have difficulties to pay bills or who have had a power cut. Is there any employment centre who could provide information on unemployed people? Is there any social cooperative who provide work to people with difficulties? Are there any the community group and/or no-profit associations concerning (a) the empowering women or single mother, (b) the low-income, (c) the unemployed people, (d) the environmental protection or nature projects, (e) the health, (f) the elderly people, (g) the church, (h) housing association, (i) educational institution and (l) market?*

A: <u>Entities concerning the employment and job formation:</u> **Centro per l'impiego** in Susa, **Con.I.S.A.**** and **Casa di Carità Arti e Mestieri*****.

<u>Cooperatives:</u> in general, two types of cooperatives exists: type A and type B. Type A Cooperatives of type A deal with personal assistance; cooperatives of type B deal with job placement. In Susa valley there are two cooperatives **CoopAMICO** and **La Foresta**; other cooperatives, based in Turin and operating in Susa Valley territory exist.

<u>Associations concerning the empowering women or single mother:</u> **Centro per la Vita** (it cares about single moms and support families who are expecting children and are in disadvantaged situations) and **Il Mandorlo** (it gives hospitality to mothers and children who come from difficult family situations).

Associations concerning the low-income: **Caritas Susa** (Caritas is the pastoral entity of the CEI (Italian Episcopal Conference) for the promotion of charity), among the various missions, is involved in helping families with the shopping of foodstuffs, clothes and payment of bills.
Associations concerning the environmental protection or nature projects: **Acsel s.p.a.****** and **ClimaValsusa** (a social community of citizens of Susa Valley close to energy and environmental issues).
Associations concerning the health: in Susa Valley, many sport associations related to mountain walks are present, e.g. **Fit walking**, **Duma c'anduma**.
Associations concerning the elderly people: **Nonno vigile** (traffic warden grandfather), grandfathers that help children to cross the street to enter in the school.
Associations concerning the housing: in Susa Valley, some cooperatives rent houses for very low prices and, once a period of time (about 30 years) has elapsed, the houses become the property of the tenants; in other words, with that rent they redeem the apartment.
Associations concerning the education: in each municipality there are certainly elementary schools and public libraries, middle schools are present only in some municipalities.
Associations concerning the market: the market is organized once a week in each municipality; in addition flea markets and market for used stuff are organized in some municipalities. Furthermore, there are cheaper supermarkets (discount stores) and in all supermarkets there is a stand of things with low price because, for example, they expire early.

Section 4: Focus Group location.

Q: *Is there any social housing area or district where the Target Groups live? Is there any residential area/street where the buildings/houses condition is a very poor level of envelope/energy system efficiency?").*

A: In general, due to the geographical conformation of the Valley, there are some poorer areas. The valley is divided in two by the Dora Riparia river and the municipalities to the south, due to the presence of the mountains, receive the sun for a few hours during the day. In these areas the real estate value is very low as are the rents. For this reason, people with difficulties are more likely to decide to settle down. In addition, in the slightly larger municipalities there are some popular buildings (e.g. in Bussoleno, Avigliana, Sant'Ambrogio, Susa). Furthermore, in some municipality, there are some apartments that are temporarily assigned to people in an emergency situations; the assignment is usually managed by **Con.I.S.A.** (e.g. "Casa Gialla" in Almese).

Section 5: benefits.

Q: *How does the State or Municipality subsidize low-income household? How does the State or Municipality subsidize electricity and heating costs for low-income household?*

A: The Italian State, every year, issues the Legge di Bilancio (Budget Law), a law provided by Article 81 of the Italian Constitution, by which the government majority decides the public expenditure and the expected revenue for the following year. At the basis of this Law there is a document, the Economic and Finance Document (DEF). In this document the choices regarding economics and finance are explicated; specifically it is highlighted in which sectors the State has chosen to invest resources and in which not to invest or cut in order to restore the accounts, i.e. the economic and financial balance.
A benefit is certainly represented by the granting of a basic income, the Reddito di Cittadinanza (described above). In addition, some benefits refer to concessions and discounts on:

- school education (e.g. university fees);
- health (e.g. ticket for medical examinations);
- presentation of Dichiarazione dei Redditi;
- maternity;
- transport.

Furthermore, even the municipalities, based on their availability, provide some subsidies on:

- waste;
- school/education (e.g. meal ticket, after school);
- energy expenditure;
- dwelling (e.g. rent bonus)
- transport.

In the Susa Valley, as regards subsidies for energy costs (electricity and heat), the **Municipality** or **Con.I.S.A.** pays the bills in cases where a person is unable to meet the expense.

Q: *Which requirements are necessary to claim these benefit? For people who receive social benefits, can they keep generated income?*

A: Each family has to submit an application to be eligible for these State and Municipal benefits. The indicator to determine whether or not the benefit is granted is the ISEE; the concession

threshold varies according to the benefit. If a person receives an income, determined by a subsidy, usually he/she cannot receive anything else. An example, if a person receives Reddito di Cittadinanza, he/she do not receive any help to pay their bills. This can be explained in this way: the State tries to give a monetary quota to get his monthly economic condition to that established as a minimum for living (i.e. 780 €/month).	
Section 6: dissemination.	
Q: *Are there any local media for disseminating information?*	
A: In Susa Valley there are two local newspaper: Val Susa and Luna Nuova; these newspapers offer the possibility to write for free but, for citizens, newspapers have a cost.	

The table shows in bold the entities and organizations located in the territory of the Susa Valley and mapped in the influence-interest matrix.
*Centro per l'impiego is a public office, whose management is the responsibility of the province, with the aim of helping unemployed people to find a job).
**Con.I.S.A. (Consorzio Intercomunale Socio-Assistenziale Valle di Susa) is a consortium strongly linked to the territory which, through social workers, takes care of adults in difficulty, the elderly, the disabled, families and minors and foreigners.
***Casa di Carità Arti e Mestieri is a historic non-profit professional training institution, of Christian proposal; its purpose is the education, training and professional, human, cultural, social and spiritual promotion of people. It works by planning, coordinating and carrying out research, guidance, education and training, updating and accompaniment to work.
****Acsel s.p.a. is a public company owned by 39 municipalities in the Susa Valley that provides services to the same municipalities. In particular, it deals with the environment (waste collection and disposal), the management of the kennel, alternative energy, IT and telecommunications, education and awareness on waste collection and provides support to municipal offices).

This survey has led to some reflections which are explained below. First of all, the research conducted, relating to a shared definition of low-income household, has refined, in the questionnaire addressed to citizens (Social structure, Part IV, Questionnaire), the response options relating to economic questions (in the questionnaire fourth section). Specifically, in the question concerning the total net income of the family (P4-Q4), the option *"Less than 750 €"* refers, precisely, to the poverty threshold defined by ISTAT for access to Reddito di Cittadinanza. In addition, the question on family composition (P4-Q7), as indicated by ISTAT tool for absolute poverty threshold calculation, gives a more precise idea of the family economic condition. Secondly, the research has made possible to better understand the framework of the benefits and the entities and organizations present in the territory of the Susa Valley (highlighted in bold in Table 14). Their identification allowed to proceed with the next step of the stakeholder analysis, the influence-interest matrix.

2. Step 2: influence-interest matrix.

The authorities, entities and organizations, identified in the previous step, have been mapped and the output is represented in Figure 31. Their placement in the matrix highlights the role of each stakeholder and, therefore, allows the definition of an Action Plan, in order to define strategies for reaching citizens, in particular citizens belonging to vulnerable groups.

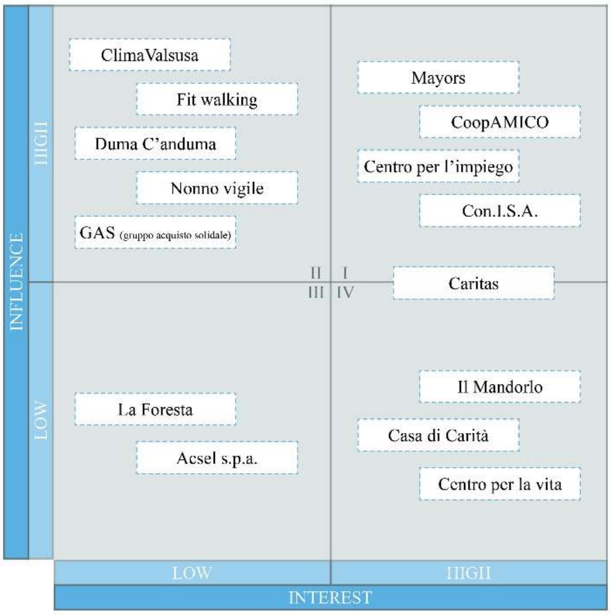

Figure 31. Influence-interest matrix.

In the first quadrant of influence-interest matrix, Mayors, CoopAMICO, Centro per l'impiego and Con.I.S.A. have been placed. Indeed, the stakeholders that are defined as "essential" or key players are placed in this quadrant. Mayors and the Con.I.S.A. play an important role since, by their nature, they have a global vision of the entire Susa Valley and interface with different people realities. Centro per l'impiego also plays a decisive role in reaching segments of the population affected by unemployment and looking for a job. Given their importance, it is necessary to involve them since they have a strong capacity for intervention; consequently, they are the first to be included in the Action Plan and with whom to establish contact. In the second quadrant, the stakeholders that it is appropriate to involve are placed. These are organizations that have a low interest as they do not have direct contact with vulnerable segments of the population but which can have a great influence. These are organizations with various interests (environmental protection, sport and the discovery of the Val Susa landscape, solidarity buying groups) that can indirectly contribute to reaching the target group. In the third quadrant are placed entities with low interest and low influence like The Forest and Acsel s.p.a. Finally, in the last quadrant there are organizations that have a high interest because they interface with vulnerable segments of the population but that have a low influence since they deal with difficult situations (such as abused women).

Finally, the information collected made possible to structure the Action Plan, as shown in Table 15. For each entity/organization, the implemented actions in order to identify the reference person, to establish contact and to present the research project are described. The actions (put in practice from March 2020, unfortunately in conjunction with the enactment of the state of emergency for the Covid-19 pandemic) are aimed at including citizens in the subsequent project phases and administering the citizens' questionnaire. In the last column, a chromatic indicator shows the achievement of this objectives: green, the objective is reached; yellow, the situation is in stand-by; red, the objective is not reached.

Table 15. Action Plan.

Entity/ organization	**Actions**	**Has the goal been achieved?**
Con.I.S.A	A contact had previously been established with the Con.I.S.A. Through an email, the number of people who ask for their help (e.g. people with economic difficulties who cannot pay their bills), the possibility of organizing events in which to meet citizens and the use of their informative channels spread material on the project. Three reminders were sent but no response was received.	O
Caritas	An exploratory email was sent to identify the reference person and understand the interest in the project issues. Once the contact was defined, the possibility of interfacing with people belonging to the Target Group was investigated. In the territory of the Susa Valley, groups of volunteers operate by offering social services; these are senior volunteers over 60/65 who prefer a face-to-face meeting rather than an exchange of emails or phone calls. The organization of the meeting has been suspended.	O
Centro per l'impiego	An exploratory email was sent to identify the reference person and understand the interest in the project issues. Following several forwarding until reaching the director, communications were interrupted with the desire to resume them as soon as the pressure due to the health emergency eased.	O
Mayors	Contact was established with mayors through different channels, such as sending emails or with intermediaries like project partners (CFAVS or La Foresta).	O
Active citizen	Contact was established with an active citizen who proved willing to participate in subsequent events and activities and to disseminate information and material on the project.	O
GAS (Group for solidary shopping)	Three solidarity buying groups were identified in Valle Susa, in Avigliana, Buttigliera and del Bass. Two emails were sent but no response was received.	O

The mayors prove to be the key stakeholders as they showed interest and, above all, because, being the municipalities of the Susa Valley small, they have a very precise and global vision of the reality and needs of their citizens. For this reason, a specific survey for the mayors was drawn up in order to obtain precise information on the Target Group. First of all, the mailing list of the mayors of the 39 municipalities of the Susa Valley was defined; subsequently, the questionnaire drawn up in Italian language with Google Survey was sent to each contact. Only 5 mayors (Bussoleno, Cesana, Gravere, Oulx and Sestriere) sent their response and Table 16 shows the results of the survey aimed at investigating the presence of vulnerable families who do not represent the "typical" investor in RE projects. This punctual information further enriches the data collected in Table 14.

Table 16. Results of Mayors' survey.

	Cesana	Gravere	Sestriere	Oulx	Bussoleno
Resident population	951	973	931	3319	5 806
Approximately, how many low-income families are in your municipality?	10	25	90	60	/
Of these families, how many are composed by single mothers?	1	5	3	7	/
What is the unemployment rate in your municipality?	2%	10%	85% (in this specific period)	7%	/
Are there specific areas or streets, in your municipality, where mainly low-income families/people live?	No, specific area, probably in public housing buildings, located on the edge of the municipality.				
Could you describe the characteristics of the building stock in which low-income families / people live, from an energy point of view? (For example insulation level, type of windows, etc.)	These are mainly buildings characterized by an inefficient envelope and with expensive energy systems.				
In your municipality, how many questions relating to the "Electricity and Gas Bonus" have been submitted?	3	10	/	8	/
Do you already have (inclusive) energy efficiency and/or energy saving programs in your municipality?	No	No	No	No	No
Are there any groups or organizations that deal with empowering women? (Examples: women's cafes, language/literacy/IT courses, money saving circles, etc.)	No	No	No	No	No
Are there any groups or organizations involved in environmental protection/ education?	No	No	Yes	Yes (days for the environment with schools)	No
Are there any health/exercise/nutrition groups or organizations in your municipality?	No	No	Yes	Yes (a sport clubs)	No
Are there some free local media (newspapers, newspapers, etc.) read frequently by many citizens?	No	Notiziarioi naltavalle	No	ValsusaOggi (online newspaper), InAltavalle (free newspaper), l'Agenda	ValsusaOggi (online newspaper) and La Luna Nuova (newspape

				News (online newspaper)	r)
Are there any educational institutions that might be interested in participating in the project?	No	No	No	"Des Ambrois" high school	No
Is there a public library where the SCORE project could be advertised?	Yes	Yes	No	Yes, it could be advertised in the tourist office	No
Are there any places where they might be more likely to be frequented by vulnerable families (second-hand, exchange, etc.)?	No	No	No	No	No
Are there any events / markets in which many citizens participate (including events organized by the municipality to meet the needs of the community)?	Yes	No	Yes	Yes, the weekly market on Wednesday	Yes, the weekly market on Monday

b) The informative events

The informative event concerns the organization of moment in which was possible disseminating materials on energy community principals and decide how to involve citizens. The purpose of these events is (i) to inform and share the research activities and the project results (mainly related to the technical analysis) with the Susa Valley community; (ii) to raising awareness among stakeholders about the energy community benefits and, finally, (iii) to co-create an action plan, to be implemented in the following months, shared by all stakeholders for the definition of an energy community in the Susa Valley. The organised informative events comprise two "levels" of stakeholders: public authorities (mayors, person in charge of municipality programs, etc.) and citizens and private and public enterprise stakeholders (local citizens, organization who deal vulnerable people, etc.). Thanks to the contribution of local partners (CoopAMico, La Foresta, CFAVS e l'Unione Montana) and the contacts established, the events organized are summarized in the following Table 17.

Table 17. Informative events.

Level	When?	Who?
Istitutional	November 07, 2019	Acsel s.p.a.
	November 22, 2019	Unione Montana Valle Susa
	November 26, 2019	Mattie meeting with local citizens
	November 26, 2019	Mayors in Susa Valley
Citizens	November 26, 2019	Con.I.S.A.
	November 27, 2019	CoopAmico
	November 27, 2019	Caritas Susa

c) The workshop

As mentioned in the methodology chapter, the workshop is a semi-structured method that allow people to free express themselves about a specific topic through a tailor-made activities. The workshop moment are always composed of two parts: the educational and the practical part. Specifically, in Susa Valley three workshops have been organized; each workshop focused on different users and, consequently, with very specific purposes. Briefly, vulnerable citizens, citizens in general and mayors and, finally, student are included. Below, the proposed activities are explained in detail.

1. Workshop on "Participation in local renewable energy projects".

On February 7, 2020, the first workshop was organized in Almese with the collaboration of Deutscher Caritas Verband and Cooperativa Sociale Amico. Their contribution was fundamental. CoopAmico, being a social cooperative focused on giving work to people with difficulties and who know their territory and citizens, invited 20 (vulnerable) citizens through personal communication, to attend the event (Figure 32). Instead, the discussion with Caritas made it possible to define the activity in detail. The purpose of the workshop was to understand obstacles and problems in participating in energy community project, specifically the reasons for their participation in a financing model. The workshop engaged citizens about half of the day; the educational moments were alternated with three moments of debate/discussion and activities, in which the participants were called to express their thoughts and opinions. In the first educational part, the aim of a community project (specifically, the SCORE project) and the meaning of some concepts as "energy transition", "renewable energy sources", "energy community", "prosumership" and "CSOP financing model" are described and explained.

Figure 32. Workshop educational moment.

Subsequently, the first discussion took place and this first exchange of information aimed to break the ice between speakers and participants and to know the participants (from an energy point of view). The first discussion was related to the characteristics of the heating system in their home and the predefined questions were asked (*What type of heating system do you have in your home? What are the costs? Are you satisfied with your system? Do you think your heating bill is too high? Are you having problems keeping your home adequately heated?*). The free discussion showed that most of citizens are not satisfied with the energy expenditure since the heating bills are too high. Obviously, the energy expenditure depends on several factors: the cost of the energy established by the supplier, the volume of the apartment to be heated, the house typology, etc. Anyway, the discussion revealed that the (poor) level of efficiency of the envelope (e.g. single-glazed windows, absence of wall/roof insulation, etc.) is the factor that has the greatest impact. Afterwards, the CSOP financing model was explained in detail, highlighting five key aspects of this concept: low investment and low individual responsibility, small source of income, the trustee helps and represents consumers, independence from the national energy supply through the energy community and environmental commitment. The workshop activity was focused on understanding which of the proposed aspects were perceived as important by the participants. Thus, each participant was asked to express their preference regarding only three elements of the CSOP ("*What are the CSOP benefits you are most interested in?*"). The key elements were written on sheets (1 element per sheet); participants were given at maximum 3 dots: one red dot, to stick on the sheet with the most important benefit for them, and two green dots, to put on the sheets with benefits for them. In this way, two elements are left without choice, that is, those not important to them.

Figure 33. Workshop activity: CSOP benefits.

The results (Figure 33) show that the "small source of income" benefit, contrary to what one might expect, obtained only the 11.4% of the consents. The failure of this aspect was justified in the following: on one hand, the source is small and, on the other hand, the participants are a little bit sceptical about obtaining money. Instead, the most successful benefits were “environmental commitment” and “low investment and low individual responsibility”, both with a preference of 28.5%. Regarding the last aspect, if a low investment is required, participants stated to be agree to contribute since the project can benefit the whole community. The “independence from the national energy supply” benefit received 23.1% of the votes. Finally, “the trusted administrator helps and represents consumers” (with 8.5% of preference) is the benefits that the participants were not interested in. The final discussion of the meeting was related to understand the participants’ opinion about obstacles in joining in a CSOP based on renewable energy (“*In your opinion, what are the obstacles/problems in participating in a CSOP based on renewable energy?*”). The debate highlighted three main obstacles (see Figure 34):

- the distrust, since being the energy community an innovative project, there is still no solid confirmation and feedback of its success;
- the control and verification actions in order to avoid that the investment disparity may lead to a different representation (the fear is that only the entities that invest a great amount of money are taken into account);
- bureaucracy, since the topic and the necessary documentation could be complicated for simple citizen not working in the legal, financial and energy fields.

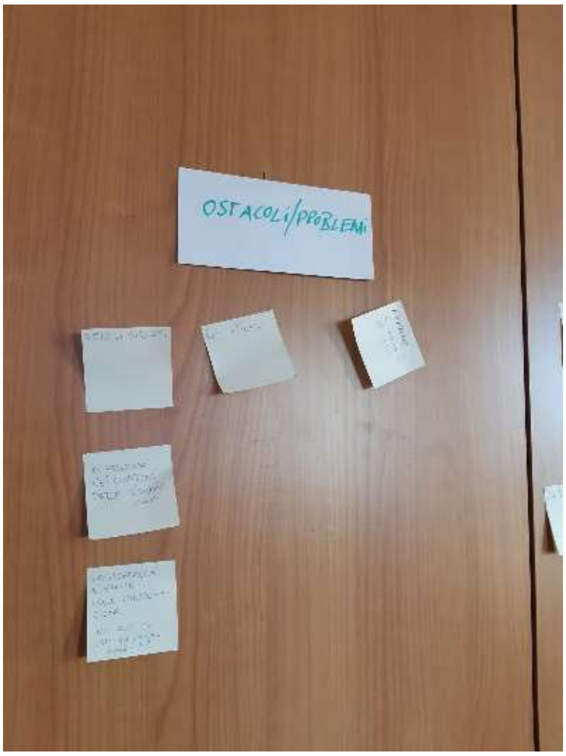

Figure 34. Workshop activity: CSOP problems.

In conclusion, this specific workshop allowed to understand the citizens' energy habits and to understand any problems related to the low efficiency of the building envelope and, consequently, to a high energy expenditure (for heating). In the main workshop activity, participants showed interest in the topic of energy communities, as a strategy to overcome their energy problems, and explained in which CSOP benefits they are interested in and the barriers they could encounter. The collection of these elements has been fundamental to refine the survey questions. Specifically, in the first part of the questionnaire relating to information on attitude and availability, the considerations collected made it possible to detail the response options relating to the unwillingness to invest economically in a community project based on the use of renewable energy on its territory (P1-Q5.1).

2. Workshop on "Creation of energy community in Susa Valley".

The second workshop was organized with the collaboration of La Foresta Società Cooperativa, Consorzio Forestale Alta Valle Susa, Unione Montana Valle Susa and Cooperativa Sociale Amico. Initially, in February 2020, the workshop was designed in presence but, due health emergency determined by the risk of infection from Covid-19 and the national lockdown (from March 9, 2020 until May 18, 2020), it has been adapted to an online version and was split in two moments: the first on April 17, 2020, in which the public sector (mayors and public entities) were invited, and the second on April 23, 2020, in which citizens were invited. The collaboration of local intermediaries was fundamental in contacting the participants through phone calls and e-mail. The main purposes of the workshop are (i) to illustrate the progress of the community project developed in Susa Valley, (ii) to raise awareness among stakeholders about the possible benefits of an energy communities and (iii) to co-create a future scenarios for the definition of an energy community in the Susa Valley shared by all stakeholders.

The workshops were divided into two main parts: an initial educational moment and, then, the application of a storytelling methodology. In the educational part, first, the meaning of some concepts as "energy transition", "renewable energy sources", "energy community", "prosumership" and "consumers' participation" were explained. Second, the community energy project SCORE was described, through an interactive WebGIS, and its purposes were highlighted. Then, the workshop structured according to the following listed steps.

a) *First work session - Individual storytelling (20 minutes).* The purpose was the definition of the current energy scenario on the basis of individual experiences related to personal energy use, aimed at creating an energy community in the Susa Valley. Through the storytelling, participants were asked to create briefly a character and describe their typical day regarding the thermal energy habits. Further, to list five main problems about the use and management of energy. Everyone, independently, wrote the history.

b) *Plenary session (20 minutes).* Each participant illustrates their story in a loud voice.
c) *Second work session - Individual storytelling (10 minutes).* The purpose was the creation of a future scenario for the definition of an energy community in the Susa Valley. Participants were asked to imagine their characters in an eventual scenario after the implementation of energy communities in the Susa Valley and after they become co-owners of the energy management. Everyone wrote together the history.
d) *Plenary session (30 minutes).* Illustration of participants' story and discussion of strengths and weaknesses.

It is meaningful to note that for the second workshop (with citizens) a small modification was made: while the creation of the future scenario through storytelling was collective for the public administration, for the citizens it was changed to an individual story spine. Collective here means that, through the coordination of the workshop's mediators, the public administration participants elaborated together their future scenario along with some discussions. Instead, in respect of the second workshop, the citizens elaborated separately their own story, submitted through the Google Forms survey and after it the discussion happened regarding each story. This change provided a better interactivity between the participants in the plenary session in respect to the illustration of the stories. Furthermore, in the elaboration of the weaknesses and strengths afterwards, the discussion was more enriched.

The whole activity engaged participants about a couple of hours and it were made through the ZOOM Video Conferencing platform since this platform allows the information transference through files, screen, voice, and webcam sharing. Along with it, an online survey (written with Google Survey) was used to compile on time responses from the participants and to make the workshops more active and participative. The online surveys were created previously, and a shared link was generated to facilitate the online and on time access for the participants. It were used each time as a tool to interact better with the participants:

- to familiarize with them, to collect personal information and their residence heating system;
- in the first working group section, during the application of the storytelling methodology about the current scenario in the Susa Valley;
- in the second working group section, during the storytelling of the future scenario;
- on a plenary session to discuss and define collectively some strengths and weaknesses of the energy communities' project.

Furthermore, to help the end users and, essentially, the participants of the workshops, a visual tool was developed to support the identification of the preferred energy efficiency solutions. In this way, an interactive WebGIS for the pilot of Susa Valley was developed by giving the impact estimation on buildings' energy efficiency in the pilot projects and the main information about them. It helped the participants to visualize the research activities and the SCORE project results (Figure 35). So that they could visualize the current and future energy scenario, after the installation of RECs in their community. Therefore, it was a simple way to share with the stakeholders what has been done so far and to boost their perception of the possible benefits of the project.

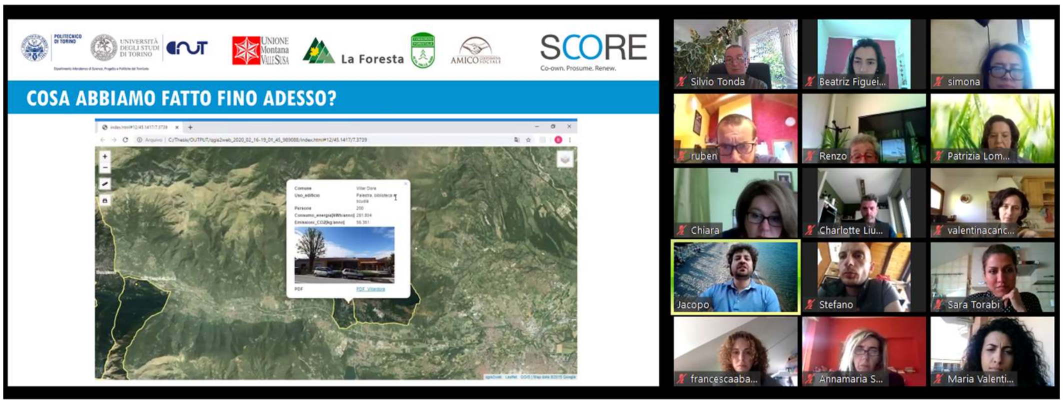

Figure 35. The WEBGIS visualization tool during the workshop with citizens.

The PDF documents for each pilot municipality were elaborated following the dossiers' assessment and the results evaluation through the PROMETHEE method (addressed in the technical structure). It contains the following information, divided in three columns (see Figure 36):

- the main current problems regarding the energy efficiency and retrofitting of the pilot (e.g., emission of fossil fuels combustion for energy generation, obsolete heat generation technology, loss of energy due to opaque housing materials, etc.).
- the suitable retrofit proposals for the pilot (e.g., replacement of the boilers with a unique biomass-fired one, regulation retrofitting, insulation of walls/ slabs and replacement of windows) and the selected retrofit for the project;
- the main benefits of the selected retrofit in relation of: decrease of the primary energy consumption (kWh/year); decrease of the global emission of CO2 ($kgCO_2eq$); and finance benefits such as payback, public incentives, investment costs, material costs, labour cost, and labour cost by a social cooperative.

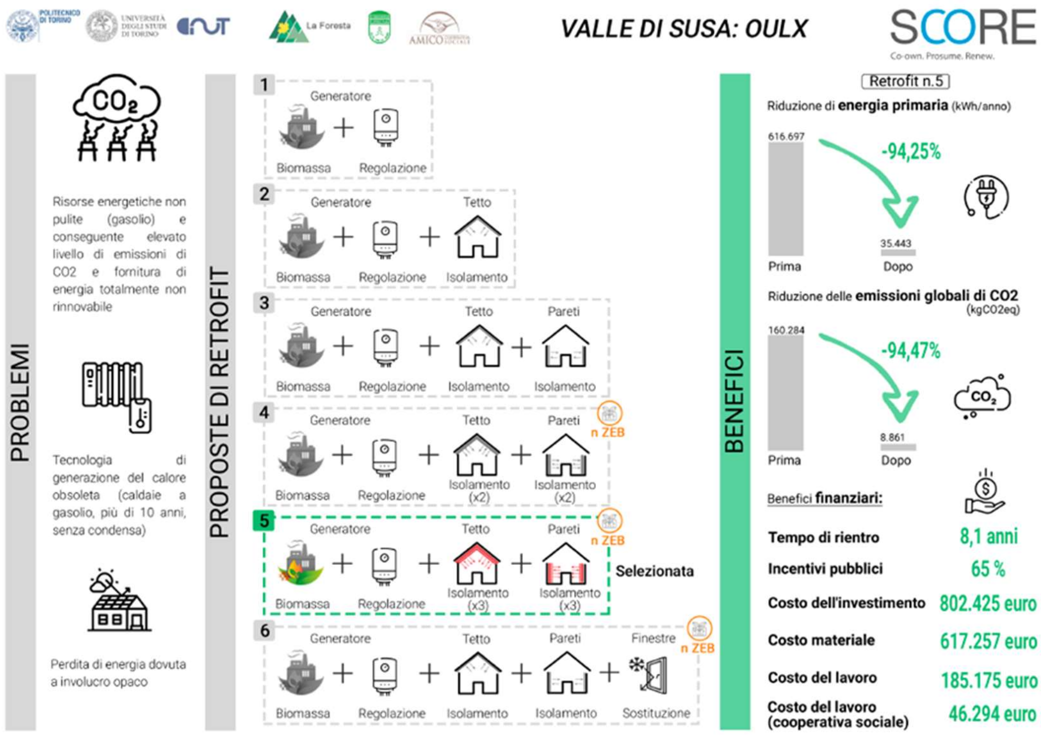

Figure 36. The PDF document containing the main research findings of the Oulx pilot project.

For the purpose of readability and understanding of the thesis, both for the workshop with public administration and with citizens, only the results concerning the second story (future scenario) and the strengths and weaknesses related to the creation of an energy community are described. To deepen the whole activities, these are extensively described in the previous SCORE project publication (Lombardi et al., 2021).

Public administration workshop.

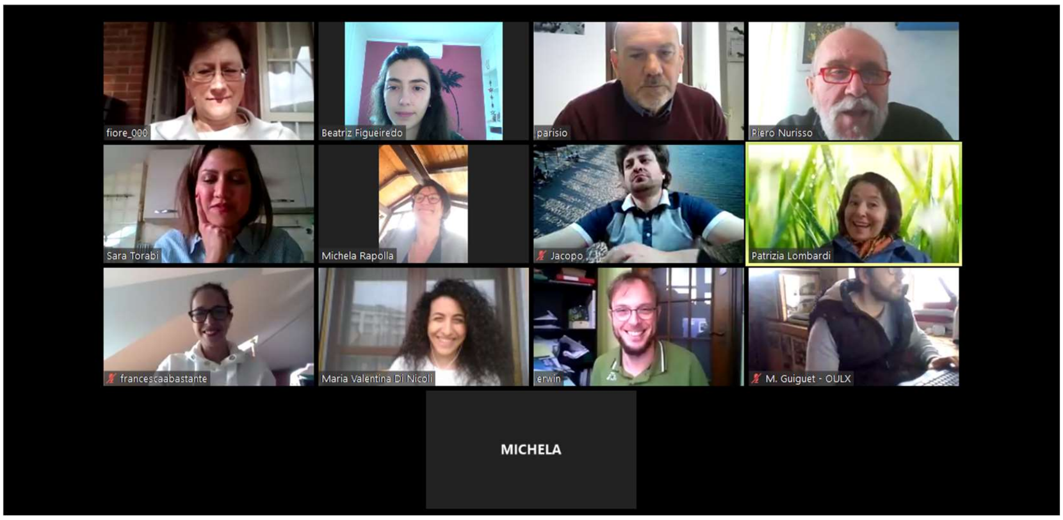

Figure 37. Public administration workshop.

The second story spine was designed with the aim at creating collectively a future scenario for the energy community in the Susa Valley. The moderators asked how the participants' typical day would be after becoming a co-owner of the REC system. As they were public administration members, they co-created one collective and participatory story from their point of view in relation to the energy community. Figure 38 illustrates the future scenarios discussed. Most of them were linked to the transfer of energy management from public administration to a co-ownership model, involving citizens' participation. This would give more time "to work in other things for the public administration" as the "energy community will be managed by someone else". Moreover, they said that REC will "free" them from "domestic commitments" and it will give energy security with "stabilized prices", giving support to the public administrators. In the end, they said that EC will "address and enforce the concept of community".

Workshop PUBLIC ADMINISTRATION (17.04.2020) |
The creation of the Energy Community in the Susa Valley
STORY SPINE 02 - Future Scenario

One day, in the Susa Valley, an energy community was created and ________________ (name of the character) became co-owner of the energy management. Consequently, his typical day will be like this.

Imagine a future scenario in which the energy community is a reality and describe the typical day of a character belonging to this energy community. What is expected from the energy community?

For us, it is expected to have the following future scenarios:
1- More time dedicated to the management of the plants entrusted to other subjects (more time to work in other things for the public administration).
2- The energy community will be managed by someone else, the citizens (users) will be only the supervisor/ co-owner.
3- Regarding the independent houses (that have their own autonomous energy source), they will be the users who have the greatest differences in their typical day. They will change from autonomous management to centralized management. Therefore, they will have less effort in energy management, and it will be entrusted to others.
4- It will free yourselves (public administration) from domestic commitments; we will have stabilized prices; and we will have security that the service will be done as it is entrusted to others but, at the same time, we can check if the work has been done.
5- It will address and enforce the concept of community in the Energy Communities (EC).
6- It will give support for the public administrators.

Figure 38. Future scenario written by participants from the public administration workshop.

In this way, the next story spine was to ask them which are the strengths and weaknesses they think this energy community could have in energy management. Different points of views and perspectives were listened and written. The information collected is an example of how the stakeholders comprehend the project, and which are the meaningful characteristics of the energy community for them. Table 18 illustrates all the weaknesses and strengths addressed by them.

Table 18. Strengths/Weaknesses points addressed by the participants of the Public Administration workshop.

Strengths	Weaknesses
Use of local resources	Conversion costs: what sources can be use and how much should be investing
Creation of a sense of community among the citizens	Operating costs
Rationalization of consumption	Logistics (e.g., distance from the plant)
Increase of security in energy management	Difficulty in establishing the Energy Communities (EC)
Reduction of energy expenditure	Bureaucratic-normative issues
Energy autonomy for the electric (car park)	Critical points in the beginning of the EC (e.g., social inclusion: it is not automatic; it has difficulties due to the land poverty)
Forest management	We need to have a good communication: the benefits must be understood among the citizens. We must motivate!
Rationalization of other renewable energy sources (photovoltaic, hydroelectric, etc.) than existing systems. Solving the problem of characteristic discontinuity of renewable energy	Internal management with different stakeholders. Those who manage must know how to mediate people’s interests with different objectives (citizens, private, public etc.)
Decrease in air pollution	We need to know how to manage a forest
Social aspect, attention to vulnerable groups (social inclusion)	

Citizen workshop.

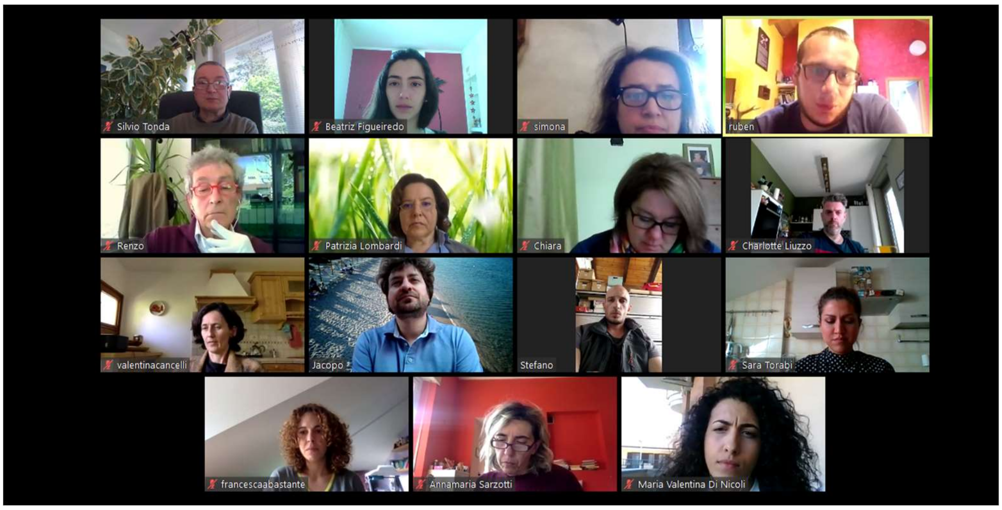

Figure 39. Citizens workshop.

Storytelling was applied to create a future scenario for the energy community in the Susa Valley. Figure 40 illustrates a scenario made by one participant of the citizens’ workshop. He says that now (after the installation of the energy community) he finally managed to install the hydroelectric plant he wanted for a long time. He has "fulfilled his dream" and he is "very happy with this innovation". He is now a "part of the energy community" and as the technology is super productive, he can also produce energy for his neighbourhood.

Workshop CITIZENS (23.04.2020) | The creation of the Energy Community in the Susa Valley
STORY SPINE 02 - Future Scenario

Residence City of the participant: Chianocco

One day, in the Val di Susa, an energy community was created and ____________________ (name of the character) became co-owner of the energy management. Consequently, his typical day will be like this.
Imagine a future scenario in which the energy community is a reality and describe the typical day of a character belonging to this energy community. What is expected from the energy community?

Ernesto is part of the energy community of the Municipality of Chianocco. He finally fulfilled his dream of installing the hydroelectric power plant on his land, to produce electricity for his packaging processes, etc. He is very happy with this innovation also because the turbine he installed is more powerful than he had dreamed 10 years ago, so with this new turbine he can also produce energy for some of his neighbors.

Figure 40. Future scenario written by one participant from the citizens' workshop.

Although three participants of this workshop did not participate specifically in this story spine, it was possible to obtain great stories from the remaining eight participants. P2 said that although he does not have a lot of savings and did not make a large investment, he still joined the energy community. He has been able to "install thermostats to optimize the heating" and he could reduce his fuel consumption, P3 invested 5000€ in the energy community. He said that it was difficult to find an agreement and decision making between the multiple project stakeholders. And despite the investment did not "produces significant direct economic results", he already sees results both locally and supra-local". "People are employed in the production chain and in construction", the "confidence has also increased in the future" and there is "a long-term economic advantage". The house of P4 is warmer and more comfortable now, but the cost of heating has not gone down. P6 commented that the EC did not disrupt his life, because he is "enjoying the energy saving, energy production and the satisfaction of using a free source". He said that it is "something to teach and encourage men". He has extra security and respects the environment, by consuming less resources. P7 would like that the excess of energy produced (e.g., from her photovoltaic panels) to remain in the territory and "maybe it would be stored and redistributed even in the evening". She would also like that through the EC, she had more access to "precise and simple information" or even "more access to subsidized loans". With the EC, P9 could solve his problems and did not need to close his business, because he integrated his boiler with solar panels and insulated his house. P8 said that he is "now a member of the energy community". He wakes up in a "heated environment" and "pollutes less". As the bills are a little lighter, "he can go out for dinner in the restaurant of his city and therefore making more money run inside the community". He also thinks that EC is a "small step towards the realization of a wider idea of community", that could be also extended to creation of agricultural communities.

Following the scenarios creation for the community energy in Susa Valley, a discussion was carried out by the SCORE group with the participants in order to illustrate some of the written future scenarios and potential conflicts, doubts, or certainty. In this way, the next step was to ask them which are the strengths and weaknesses they think of this energy community. As in the first workshop, different points of views and perspectives were listened and written. This information was aggregated at the same time with a Google Survey and in the end, it gave to the group an idea how the stakeholders comprehend the project, and which are the meaningful characteristics of the energy community for them. Table 19 illustrates all the weaknesses and strengths points addressed in the workshop with the citizens.

Table 19. Strengths/Weaknesses points addressed by the participants of the citizens' workshop.

Strengths	Weaknesses
Cost reduction	Shared decisions (element of uncertainty)
Better use of energy	Investment in non-owned properties (for how long?)
Better comfort	Innovation of the Energy Communities (EC) model (e.g., regulatory point of view)
Possibility to use in the production chain	Proximity of buildings (essential for thermal energy, no problem for electrical energy)
Transparency of information	
Better management of consumption	
Use of local resources	
Better environmental conditions (external)	
Investment confidence (following precise information)	
Less dependence ("release") from large energy multinationals	
Not just biomass! Openness to various energy sources	

The weaknesses and strengths were classified in four types: environmental (e.g., decrease in air pollution), economic (e.g., reduction of energy expenditure), technical (e.g., logistics, less distance from the plant) and social (e.g., attention to vulnerable groups). Figure 41 illustrates the results of this classification for the two workshops in percentage, separating it between the two workshops and the weaknesses/strengths. For the citizens and the public administration, most of the weaknesses of the project are about technical issues, although the last one has higher percentage (33%) in social weaknesses than the first one (25%). However, for the strengths, the public administration has a more balanced percentage among the four types, while the citizens have most of the strengths about economic topics (45%) and less about social topics (9%).

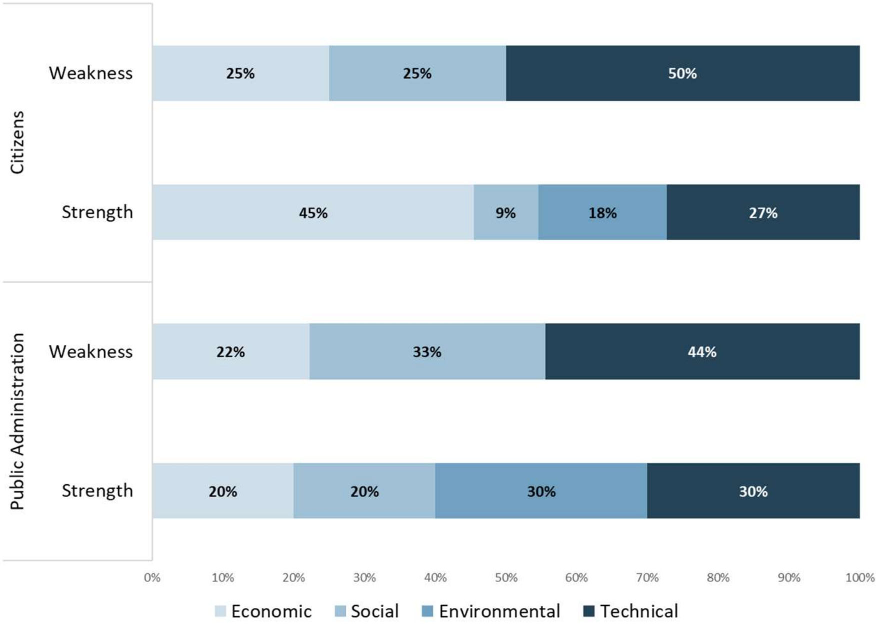

Figure 41. Weaknesses and Strengths points addressed on both workshops.

Besides that, these strengths and weaknesses were analysed, and it was found equivalent points addressed of both workshops, illustrated in Table 20. The use of local resources, better use and consumption of energy, and also a cost reduction were similar points addressed, that both types of stakeholders think that they are good points of the energy community project in the Susa Valley. However, both types of stakeholders think that involving different types of stakeholders must be in an efficient way manageable to have a feasible project. Also, normative and bureaucratic issues are a concern among them, which were always mentioned during the workshops. Moreover, their similar weaknesses regarding the technical issues could be solved after showing the project's details elaborated by the consortium.

Table 20. Equivalent Strengths/Weaknesses points addressed by the participants of both workshop .

Strengths	Weaknesses
Use of local resources	Technical issues regarding the distance between the buildings and the thermal plant
Rationalization of consumption	Bureaucratic-normative issues
Increase security in energy use	Uncertainty about the project management and decisions with different stakeholders
Cost reduction	
Use of different energy sources	
Improve environmental issues	

3. Workshop on "Creation of energy community in Susa Valley".

This third workshop was addressed to students of middle school, specifically the third (and last) year of middle school education. The purpose of this activity was (i) to raise awareness among younger generations about the nowadays energy and environmental issue; (ii) to make know the energy community concept, benefits and opportunities; (iii) to engage and involve younger people (students) in an energy community project through an interactive workshop; (iv) to describe the future energy community scenario through a process of discussion and co-creation. For this reason, a lecturing methodology was proposed and structured in four parts:

1) **preliminary survey**, a survey in order to investigate the students' knowledge about energy related keywords;
2) **frontal lesson**, a lesson in order to educate the students to energy and environmental issues and to renewable energies and energy community;
3) **practical activity**, an activity aimed to favour a graphic story in which students had to self-identify themselves as urban planners;
4) **final meeting**, a meeting in order to discuss the practical activity results.

The workshop was aimed at last year classes of middle school "Luigi Des Ambrois" of Oulx; specifically, three classes composed by around 50 students of average 13 years old are involved in this activity. The target group is usually underrepresented, since rarely teenagers are involved in urban project. The inclusion of this segment of the population represents a very specific strategic choice: to inform and educate young students at early stages during their academic path, when they first approach scientific and technical topics. In this way, teenagers can become themselves the bearers and spreaders of these concepts through family, friends and acquaintances in their neighbourhoods.

Initially, the workshop was designed to be done in presence at school but, due to COVID-19 restrictions to limit the contagion among the population and, therefore, the consequent closure of schools, the activities have been rethought to be carried out remotely, in virtual form through the Zoom platform. Specifically, for each class two days were dedicated:

- 3A class: December 14th, 2020 and January 14th, 2021;
- 3B class: December 15th, 2020 and January 14th, 2021;
- 3C class: December 18th, 2020 and January 19th, 2021.

Below, The application and the results achieved by the four parts that make up the workshop are described in detail.

First part: preliminary survey. Before the lesson, an energy and environmental related keywords has been sent to the students in order to investigate their knowledge. With this purpose, each student had to indicate with an X the terms they didn't know the meaning (listed below in Figure 42). This preliminary survey made possible to obtain a picture of the students' general knowledge in order to define the level of in-depth study addressed in the frontal lesson.

Do you know these terms?

Please, mark with an X the terms you know the meaning.

☐ Energy community	☐ Pollution
☐ Sustainability	☐ Energy efficiency
☐ Energy sources	☐ Energy requirements or energy needs
☐ Non-renewable or fossil sources	☐ Thermoelectric power plant
☐ Natural resource	☐ Photovoltaic panel
☐ Emissions	☐ User
☐ Greenhouse gas	☐ Self-production
☐ Carbon dioxide (CO_2)	☐ Self-consumption
☐ Climate change	☐ Consumer
☐ Irreversible consequences	☐ Prosumer
☐ Deforestation	☐ Economic investment
☐ Desertification	☐ Energy responsible behaviours
☐ Biodiversity	☐ Co-owner
☐ Deterioration	☐ Biomass
☐ Geopolitics	☐ Planimetry
☐ Inequalities	☐ Territory
☐ International agreements	☐ Planning

Figure 42. Keyword list.

Figure 43 shows the level of familiarity of the students of the three classes with the list of proposed keywords. By applying normalization to the keyword with the most preferences, it appears from the histogram that the familiarity with specific terms related to the energy community field is the lowest. Indeed, the terms energy community, emissions, deterioration, geopolitics, consumer, prosumer and co-owner received the highest number of preferences. On the other hand, this preliminary survey showed a general average familiarity with energy field terms such as sustainability, energy sources, carbon dioxide, climate change, deforestation, pollution, economic investment and territory. The photograph of the initial knowledge situation made it possible to recalibrate the frontal lesson in order to deepen the terms less known by the students in order to raise their awareness about energy community and co-ownership concepts.

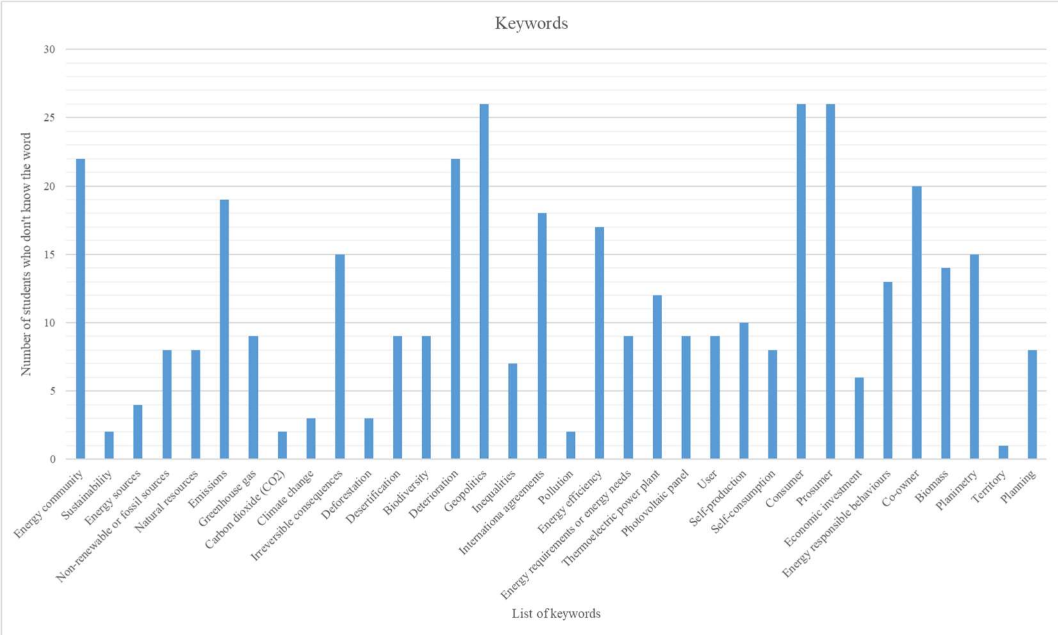

Figure 43. Keyword list survey result.

Second part: frontal lesson. The lesson represents a first element in the stakeholder inclusion process; indeed, the educational moments are functional to inform and to train the students to the energy and environmental issues. During the lesson (supported by a PowerPoint presentation) the concepts relating to the several (non-renewable and renewable) energy sources, the climate change and GHG effect, the energy communities and, finally, the SCORE project and its involvement in the Susa Valley are given. Figure 44 shows an extract of the slides, instead Figure 45 shows a screenshot of the online lesson, carried out with the support of Google Meet. During the lessons, the classes showed a proper level of interest in the topics dealt with since they actively participated by asking questions and speaking often.

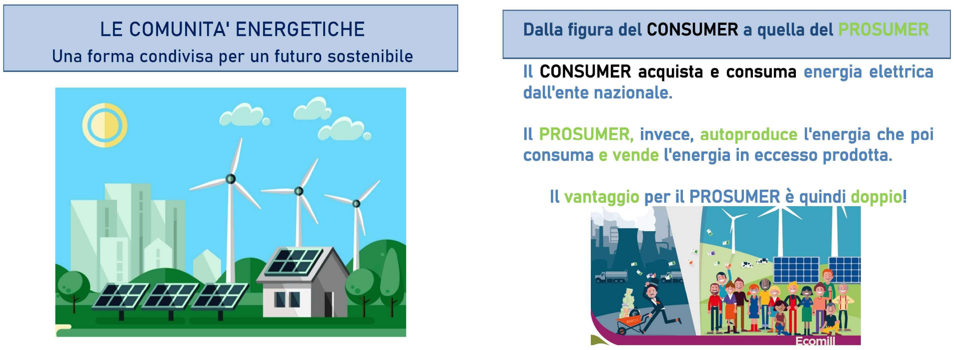

Figure 44. Example of lesson slides

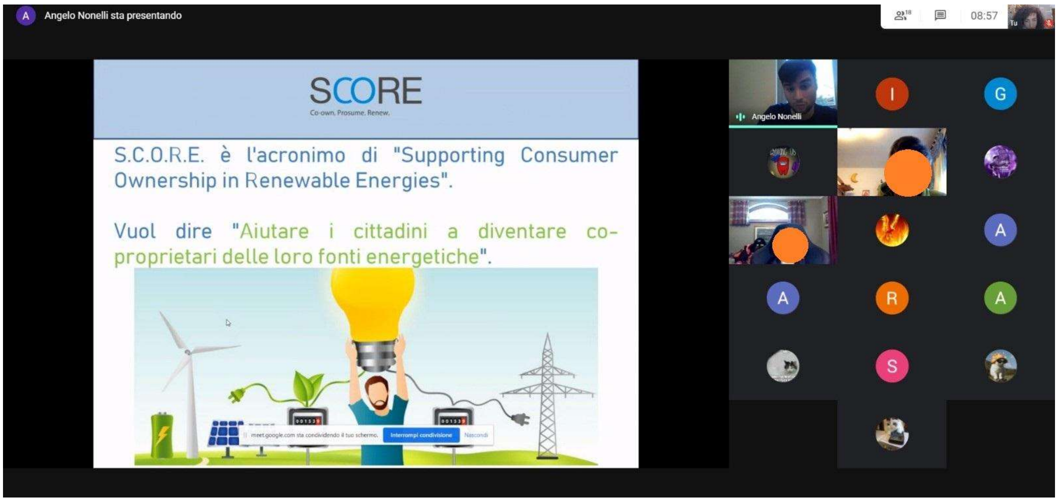

Figure 45. Screenshot during the frontal lesson.

Third part: practical activity. Once the concepts relating to energy-environmental issues have been clarified and given basic knowledge to the students, a tailored activity was structured in which the three classes of students had to self-identify themselves as urban planners. The activity was divided into four steps (questionnaire, context analysis, urban project and presentation); the first carried out individually, the other three in groups of 4 or 5 students.

Step 1: questionnaire. Students were requested to answer individually to an online survey. The questionnaire (written with Google Survey and reachable at the following link: https://forms.gle/SrKJJZ2PLmUKnKiD9) was defining according to several internal discussions and it is divided into three parts. The first part concerns the identification of the class and group (questions 1 and 2); the second part concerns the thinking of citizens about the renewable energy sources and the energy community and it is composed by 11 questions (questions 3 to 13); the third part concerns the personal thinking of the students and it is composed by 9 questions (14 to 22). The answers obtained are 46; below, the second and the third parts of the questionnaire are detailed.

Second part - What do citizens think about renewable energy and energy communities? Each student had to interrogate their parents, families, neighbours, with questions about renewable energies and energy community in order to gather information about the general reactions and to receive a general impression and opinion of the interviewed people. In addition, also, each student had to give their personal opinion regarding the interview conducted. The objective of this questionnaire part is to have a simple vision concerning the interest of citizens on the topic of energy communities through a graphic rendering on a cartographic basis. The details of the responses and results obtained are presented below.

- *How many people did you interview?*
  Figure 46 shows the people interviewed. Starting from 46 students, the total number of people reached is obtained by multiplying the number of people interviewed by each student for their attendance. In conclusion, the people interviewed are 245.

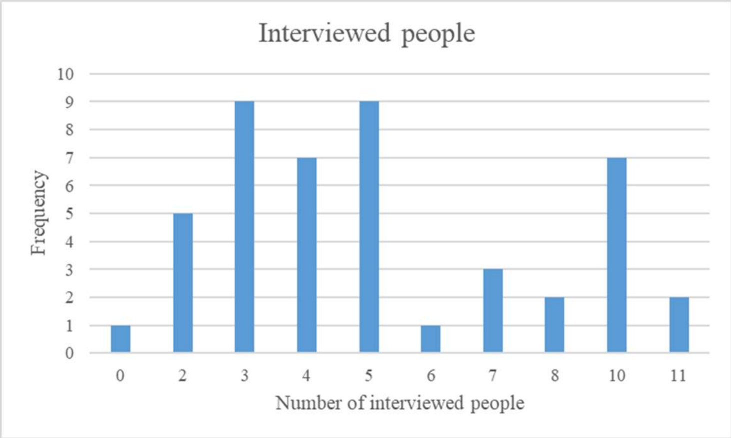

Figure 46. Interviewed people.

- *How many people are in favour of the topic of renewable energies and energy communities? How many are against? How many undecided?*
  Figure 47 shows the level of agreement of the people interviewed. The histogram shows that most people (196 people, 80%) are in favour of energy issues and community-based energy projects. Instead, 23 people (9.4%) said they were against it and 26 people (10.6%) said they were undecided.

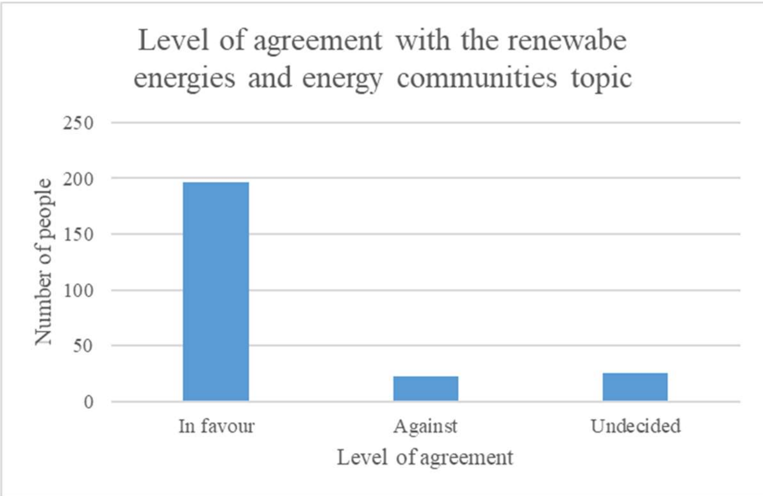

Figure 47. Level of agreement with renewable energies and energy communities' topic.

- *Briefly describe the motivation of the people in favour, against and undecided.*
  The reasons expressed by the people in favour concern mainly the environmental and/or economic aspects. Indeed, they believe that community projects based on renewable energy, on the one hand, can help to improve the environment by polluting less, fighting global warming, achieving the objectives of the 2030 Agenda and guaranteeing a better future for next generations. On the other hand, they believe that community projects based on renewable energies can lead to savings on the energy bills, also given by the sale of self-produced energy. The

reasons expressed by people against the topic of renewable energies and energy communities concern the unwillingness to support the initial investment, the lack of immediate benefits, especially in the short term, the unwillingness to change their habits and the reticence towards projects in which the collaboration of different individuals, since working alone often brings greater benefits. The reasons of undecided people are mainly due to a lack or scarce information on a recent issue.

Considering these first questions and according to the type of answers received, each student was requested to create a map, of the chosen area for interviewees, and they was requested to insert on it as many bullets as many the people they interviewed. The dots can be of three colours: if the respondent supports the creation of energy communities and is willing to take part an energy community, the dot is green; if the person is not sure, undecided, the dot is yellow, if the person is against new forms of energy management and the use of renewable energy sources, the dot is red.

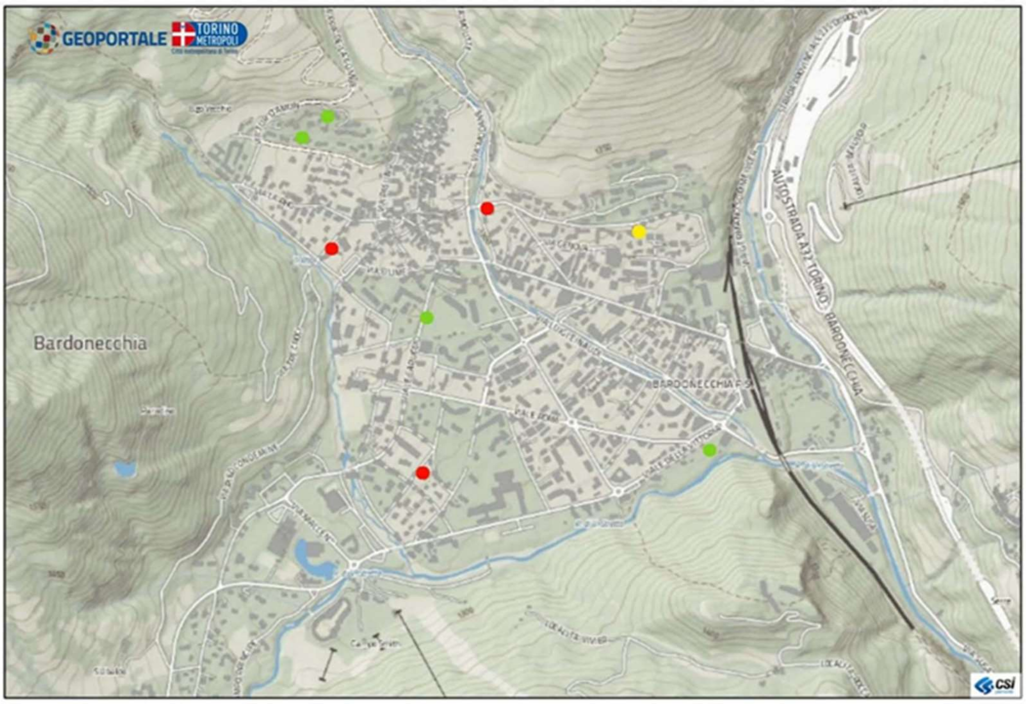

Figure 48. Example of interviewees map.

This map step has been designed with the intention of having a basic geo-referenced information about citizens' opinions/sentiments/views on the energy topics dealt with in this workshop. Figure 48 shows an example of a map drawn up by a student. Subsequently, each student was asked to express their opinion about the conducted interview through the following questions.

- *In your opinion, is it possible to convince undecided or opposed people to participate in energy communities? If yes, how? If not, why?*

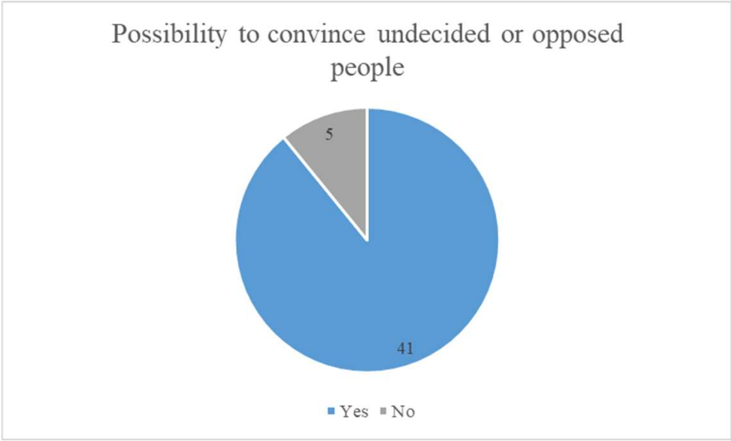

Figure 49. Possibility to convince people.

Figure 49 shows how 89.1% of students think it is possible to convince undecided people or people against to the topic of energy communities. The modalities concern the involvement in events and the organization of exhibitions or festivals, through the explanation of the advantages not only closely linked to them but also towards the environment, through incentives (especially economic) to facilitate entry into the energy community and through advertisements on social media for younger people and in newspapers for older people. Finally, however, 10.9% of students do not think can convince people to change their mind as everyone has their own beliefs that must be respected.

- *In your opinion, people interested in energy community projects, are especially interested in environmental or economic aspects?*

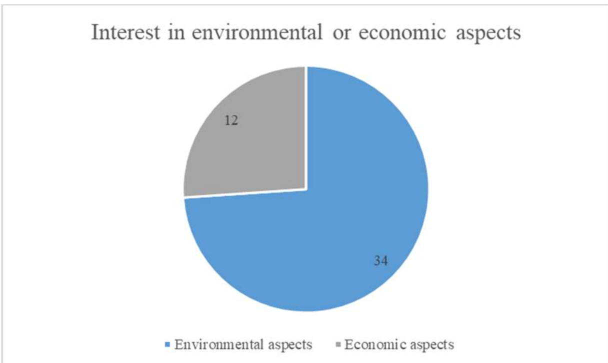

Figure 50. Interest in environmental or economic aspects.

Figure 50 shows how the students, based on the answers obtained during the interview, think that 73.9% of the interviewees are interested in energy community projects and projects based on renewable energy mainly for environmental aspects while 26.1% for economic aspects.

- *As a young student, how could you introduce other people or organizations (public or private) to the topic of renewable energy?*
  The main responses obtained concern the publication of information on social media, newspapers and flyers, through events or the organization of information meetings, through the explanation of the advantages and, finally, showing a real example of a project implemented in order to fully understand the functioning of an energy community.

Third part - What do you think? Each student had to express his/her opinion or condition concerning renewable energies, sustainable behaviours, energy communities and feelings and relations with territory/community in which he/she lives. Most of the questions require to choose only one answer option among those proposed. The questions in this section represent a simplified version of the first and second part of the questionnaire proposed to citizens (detailed in Chapter 4, Part IV: target group involvement) and at the same time include questions extracted from the questionnaire, detailed in (Di Nicoli, 2016), in which it was investigated pro-environmental behaviour and behavioural retrofit. The details of the responses and results obtained are presented below.

- *Where do you live?*

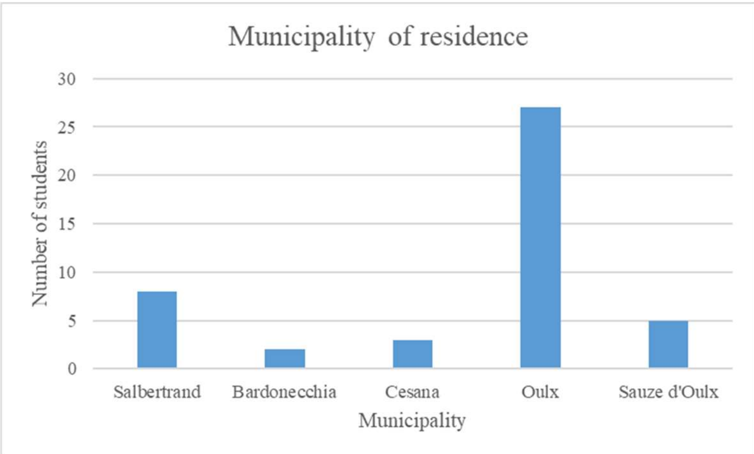

Figure 51. Municipality of residence.

Figure 51 shows the origin of the students attending the third grade of the middle school in Oulx.

- *Do you notice differences from an environmental and lifestyle point of view, between your municipality and a large centre (e.g. the city of Torino)? If yes, which ones? Please, describe them briefly.*
  All the students found differences between the municipality in which they live or go to school and large towns such as Torino. The small towns of the Susa Valley, indeed, are characterized by less pollution, presence of wooded areas or, in any case, areas in which to be in contact with nature, the possibility of moving on foot or by bike to reach any place because the municipality is small and finally, the absence of factories.

- *As far as you know, are there any aspects of your municipality/area that you appreciate (e.g. environmental aspects, safety of public spaces, etc.)?* The appreciated aspects of municipality are: presence of woods and green areas in which it is possible to practice sports, absence of air pollution, general cleanliness of the municipality and low population density.
- *How is important for you the environmental protection and safeguard?*

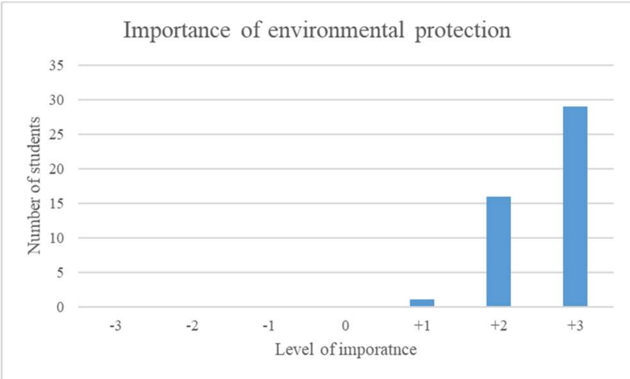

Figure 52. Importance of environmental protection.

The histogram in Figure 52 highlights how for 63% of the students attributed the maximum importance (+3), how 34.8% attributed importance +2 and 2.2% attributed importance +1. Consequently for all respondents, the environmental protection is very important.

- *Compared to what you have learned about energy communities and renewable energies, how much would you be interested in learning more about the subject?*

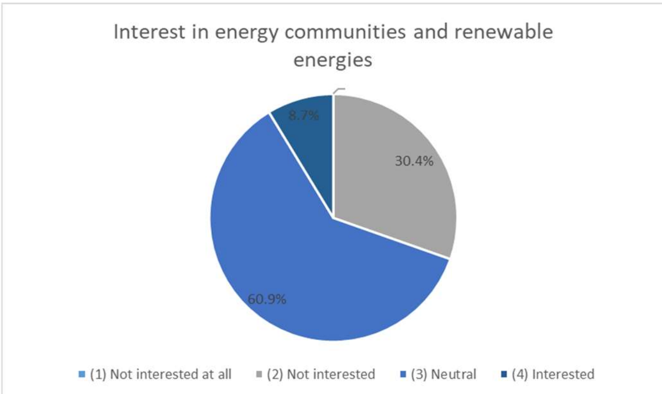

Figure 53. Level of students' interest.

Figure 53 shows that students are, in general, interested in learning more about the topic of energy communities and renewable energy; indeed, 8.7% said they were very interested and 60.9% were interested. Those who declared to be neutral are 30.4%.

- *Do you think that in your municipality, it would be useful to carry out an energy community project? If yes, briefly describe why and where.*
  There is not a shared vision by students. Part of the students say that it is not necessary to implement an energy community on their territory because many people already have individual plants for the production of renewable energy and because people struggle to organize themselves. On the other hand, they believes that there are favourable environmental conditions for the installation of the systems and they proposes to include buildings that need to be renovated and re-functionalized or schools and sports centres to raise awareness, above all, the young community towards behaviours attentive to environment and to energy saving.
- *What do you think of the following statements?*

Table 21. Community perception.

Statements	(1) I totally disagree	(2) I disagree	(3) Neutral	(4) I agree	(5) I totally agree
I feel strongly connected to the municipality where I live.	0	1	7	22	16
There are many people in my municipality that I consider to be good friends.	1	2	11	16	16
I often speak of my municipality as a great place to live.	0	5	15	16	10

The community/territory perception is investigated through three statement in which students were asked to indicate their level of agreement/disagreement, using the 5-point Likert scale, from 1 (I totally disagree) to 5 (I totally agree). In general, the answers obtained, presented in Table 21, show a substantial perception of belonging by the respondents to the territory/context in which they live. 82.6% of the respondents stated that they are agree or strongly agree to feel connected to the community in which they live. In fact, only 2.1% said they are strongly disagree or disagree with that statement. The remainder stated that they are neutral (15.2%). In line with what has been described above, 69.6% of respondents agree or strongly agree that they have good friends within their community and 56.5% of respondents often speak about the community in which they live as a great place to live. Also for these two statements the share of respondents not in agreement is very low.

- *Thinking about the municipality/territory in which you live, what feelings do you have?*

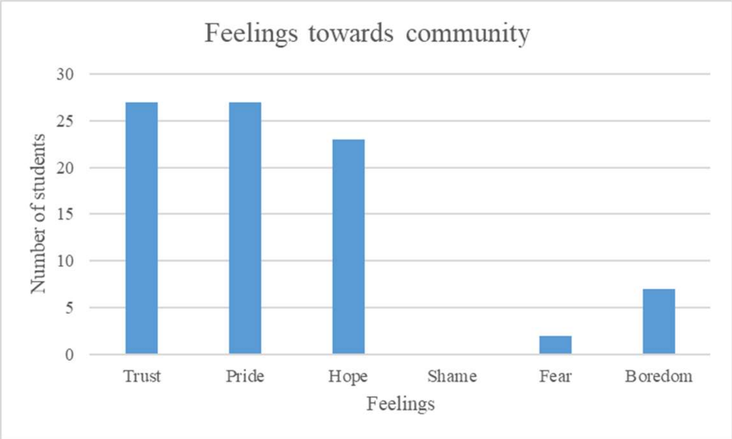

Figure 54. Students' feelings.

The question investigates the emotions felt by respondents towards the territory in which they live. Feelings under investigation are divided into feelings with a positive tinge (trust, pride and hope) and feelings with a negative tinge (shame, fear and boredom). Students were asked to choose one or more feelings. A first view of the results, showed in Figure 54, highlights how positive feelings obtained a higher preference (27 preferences for trust, 27 preferences for pride and 23 preferences for hope) than negative feelings (0 preferences for shame, 2 preferences for fear and 7 preferences for boredom).

- *How often do you adopt this behaviour?*

Table 22. Behaviours' adoption.

Statements	**(1) Never**	**(2) Rarely**	**(3) Occasionally**	**(4) Often**	**(5) Always**
Turn off the light even if you leave the room for a short time.	0	5	6	22	13
Turn off the devices completely without leaving them on standby.	9	8	4	18	7
In winter, wear heavier clothes instead of turning on the heat.	12	7	12	10	5
Turn off the water while brushing your teeth.	1	3	2	12	28
In winter, leave the window open to ventilate the rooms of the house.	5	1	7	15	18
Prefer a bath instead of shower.	23	6	10	2	5
Read articles or inquire about environmental issues.	5	15	19	5	2
Talking with friends/acquaintances/family about problems related	8	13	16	7	2

to the environment.					
Point out to other behaviours that waste energy.	3	2	15	14	12

The question investigates behaviours adopted by respondents. Students were asked to indicate a level of frequency in implementing the listed behaviours, using the 5-point Likert scale, from 1 (Never) to 5 (Always). In general, the answers obtained, presented in Table 22, show in general the adoption of behaviours in a pro-environmental perspective by a good part of the respondents. In fact, 76.1% of respondents said they often or always turn off the lights in the rooms, 54.3% said they often or always turn off the devices without leaving them on stand-by, 87.0% said they often or always turn off the tap water while brushing their teeth, 56.5% said they often or always point out other energy-wasting behaviours. On the other hand, behaviours that are not fully applied are reading articles and getting information on environmental issues and, consequently, talking about environmental problems with acquaintances, family and friends.

Step 2: context analysis. Starting from this step, the classes were divided into groups of 4/5 students and each of them was assigned a small fraction of the municipality of Oulx (Beaulard, Savoulx, Signols, Gad, Oulx). The objective of this step is the study of the assigned area in order to understand its characteristics, peculiarities, strengths and weaknesses for the subsequent energy community project. In addition, the students were asked to think about the several types of technologies related to the renewable energies production (e.g. solar panels, photovoltaic panels, wind turbines, biomass plant, etc.) and to think how, with which users, what type of buildings and where to create the energy community. As an example, Figure 55 shows the choice of the project area by a group. The chosen area is close to Lake Borello (Oulx) and incorporates two buildings: the "Des Ambrois" high school and the tourist village.

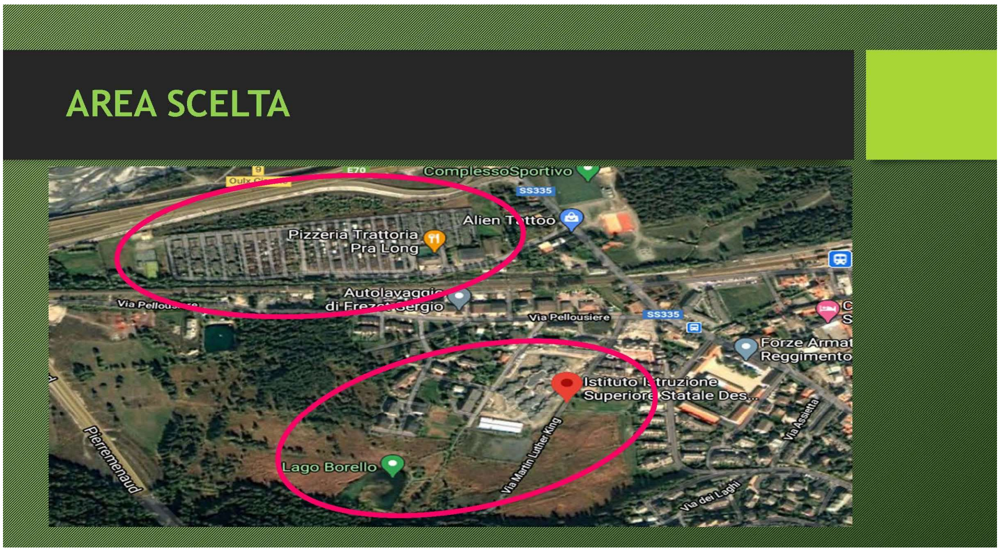

Figure 55. Context analysis and selected area.

Step 3: urban project. The objective of this step is the energy community project. In this way, the groups were asked to develop a plan representing the energy community through symbols and connections. In other words, it is asked to define the size of the energy community, to choose the type of the best technology/technologies to be adopted, to define how many and which actors and buildings to include in the project and, finally, to list the benefits, pros and cons related to the energy community creation in that specific fraction of the municipality of Oulx. The design project requires a team work in which the members of the group are called to think and discuss, thus, simulating the dynamics of a design studio.

The following example (Figure 56) shows the energy community project designed for the municipality of Oulx. As mentioned previously, the group has chosen the area of Lake Borello in order to take advantage of the area used as a lawn thatextends all around. The "Des Ambrois" high school represents the main building in the implementation of the energy community; indeed, it is close to the lake area but, being a school, it brings students, or future generations, closer to energy-environmental issues. In this project, teenagers are seen as the vector that allows the rest of the community (family and friends) to be sensitized and those who in the near future may be called to make important decisions and, for this reason, should be trained. In this way, the project also focuses on the inclusion of the Pra-Long tourist village where many young people (especially teenagers) spend their holidays both summer and winter. As for the technical part, the project involves the installation of solar panels and wind turbines in the flat area and photovoltaic panels on the roof of the high school. The main positive point of this project is its replicability, in fact it could be an example for other educational, touristic or sports complexes.

Figure 56. Project map.

Step 4: presentation. The objective of this step is the project presentation to the class and to the Politecnico SCORE team. Each group is required to present the project using their preferred support tool (e.g. PowerPoint) and justifying the choices made in the design phase. The presentation includes the results of the three previous steps. Thanks to the relaxation of the restrictive measures for Covid-19, the project exposition was able to take place in the presence as documented by Figure 57 which shows the moment of presentation by a group.

Figure 57. Presentation of project.

Fourth part: final meeting. Once the presentations of the projects by each group were finished, the works were assessed and evaluated by the Politecnico SCORE research group together with the school technology professor, who also followed each previous step of the workshop activity. The assessment was based on the presentations given by the groups, on the explanations and motivations that drove them in making the different choices for their projects. In addition, It was assessed how much the proposed energy community project could contribute to the community life improvement.

Many groups produced good quality material, with richness of details in every part and, most important, they respected one of the central requirements of the activity: to justify and give reasons for every choice they made in their projects. They integrated proficiently what they learned from the online lesson on renewable energies and energy communities, their knowledge of the territory, the new information coming from the questionnaire and interviews they carried out at the beginning of the activity, and the planning task and group interaction they were required to perform. All presentation an interesting design ideas for new energy communities in their area, connecting and involving local businesses, private citizens and municipal institutions. Many of them involved the main school building and the participation of the students themselves, some local businesses, connected with sustainable local tourism and the preservation of the environment. During the presentations, they showed great interest in the topic and commitment to their projects and ideas. The workshop was also an opportunity to improve team-work skills; the groups were formed allowing the students to organise themselves but with the supervision of the professor. Moreover, through the interviews with the citizens, the workshop managed to extend the topics of renewable energies and energy communities also outside the classes.

Part IV: target group involvement

In this part, the actions related to obtain data about users' characteristics, in order to identify the main drivers that favour/hinder their participation in energy community projects, and, consequently, clustering the population on the basis of one's possibilities, in order to promote specific inclusion strategies to commit towards an energy community project, are addressed.

a) Questionnaire

Design phase. The questionnaire was created in paper-based (Appendix B) and in online versions (http://survey.polito.it/34418/lang-it). Regarding the online version, following a study on the different existing platforms, the questionnaire was written using the *Limesurvey* platform since this tool allowed to implement the question/answer logic and the possibility, for respondents, to save the answers and resume them later.

Distribution phase. The distribution of the questionnaire began on March 17, 2020 and it was influenced by the health emergency determined by the risk of infection from Covid-19. Specifically, the Italian Government, in the figure of Prime Minister Giuseppe Conte, on March 9, 2020, imposed the national lockdown in order to limit the movement of the population except for necessity, work and health motivations. These restrictive measures continued until May 18, 2020. Therefore, the distribution of the questionnaire can be divided into two stages.

First stage. Given the lockdown situation, the first distribution took place only online through an email invitation and, in order to disseminate the questionnaire among the citizens of the Susa Valley, in this particular situation of emergency, four key intermediaries have been identified. These are individuals with whom an information-sharing relationship was previously established; indeed, some are part of the consortium of the European project SCORE, others are citizens who have shown particular interest in previous informative and workshop meetings. Furthermore, their contribution was fundamental; indeed, living and working in Susa Valley they have a strong knowledge of the context/territory in which, in turn, they are known. The email invitation was prepared and was structured containing the following information: a brief description of the questionnaire purposes, its structure, the required time for the compilation and the link to access the questionnaire. In addition, they were asked to forward the email to their contacts (co-workers, friends, family, etc.), remembering the only limitations for the questionnaire compilation is to reside in a municipality of the Susa Valley and be of legal age (the latter is not a binding condition but preferable due to the complexity of the questions proposed). Besides, they were asked if they were willing to disseminate to update on the number of contacts reached (see Table 23). Finally, the flyer was attached to the email, in this way, the potential respondents could know in detail the research context in which the questionnaire is inserted. In this phase, three reminders were sent about 10 days apart. Below, in Table 23, the list of individuals involved and the potential number of people reached is indicated.

Table 23: List of key intermediaries and contacts reached in the first phase of distribution.

Entity	Contacts typology	Number of contacts
CoopAmico (Social cooperative)	Workers, acquaintances, friends, family	23
La Foresta (Energy cooperative)	Workers, acquaintances, friends, family	100
Consorzio Forestale Alta Valle Susa (CFAVS)	Mayors of municipality in Alta Valle	39 (3 mayors decide to publish the questionnaire link on social media page of municipality)
Unione montana	Mayors of municipality in Bassa Valle	
Active citizen	Acquaintances, friends, family	NA

In this first phase of distribution, three mayors (of the municipalities of Vaie (see Figure 58), Oulx and Gravere) decided to share the survey on the municipality social page; specifically, two images of the flyer, a very brief description of the purpose of the questionnaire and its link have been shared. Moreover, at the end of the two workshops "The creation of energy community in Susa Valley" (April 17 and 23, 2020) the questionnaire was explained, the its link and QR code was left and kindly asked to participants to fill it in, allowing 10 days; a week later a reminder was sent by email.

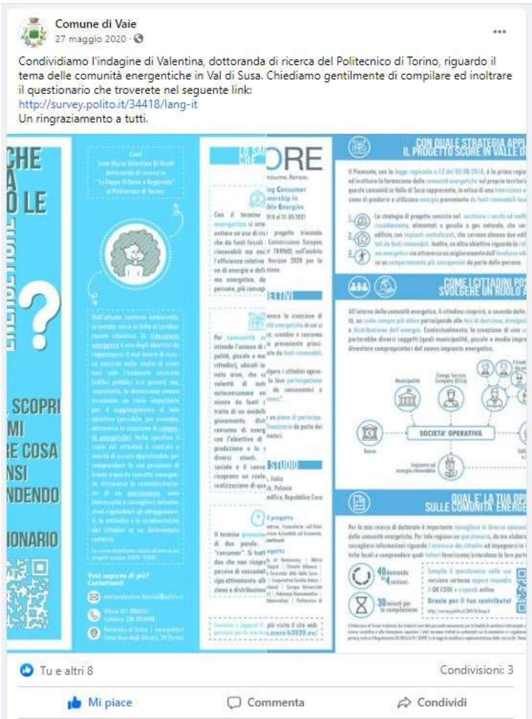

Figure 58. Sharing of the questionnaire on the Facebook page of the municipality of Vaie.

The first results showed a strong limitation in the adopted distribution method, remembering that this choice was dictated by the national emergency of heath situation. Indeed, the total number of answers collected is 143, of these 99 are partial answers and only 44 are completed answers. In addition, 4 responses were discarded because the respondents declared that they reside in a municipality outside the Val di Susa. It is important to point out that there are no better methods than another, but contexts in which some methods work better than others. This is what has been found during the distribution of the questionnaire in the Susa Valley. Indeed, although some key people were asked for help for the online dissemination, although the most exhaustive material possible was attached to make up for the explanation in person, although several reminders, these actions were not enough. In this context, the diffusion through email invitation has been found as detached approach, in a context where everyone knows each other; moreover it turned out to be another e-mail that was added to the many received in that period in which all communications took place remotely (due to the pandemic situation). In conclusion, these considerations led to the evaluation of a second distribution stage.

Second stage. Considering this first result and taking advantage of the relaxation of the restrictive measures imposed by the Italian state, in July 2020, the second phase of distribution of the questionnaire started. At this stage, the paper distribution in person was preferred, not forgetting the online one; besides, also in this phase, the contribution of key intermediaries was fundamental for the questionnaire spread in the territory. The events organized and attended are listed below in chronological order; furthermore, a summary of them is shown in Table 24.

The first event attended was the internal meeting of the members of CoopAmico, in Almese on July 10, 2020. Talking and explaining the research and the survey and interacting personally with the participants were the characteristics that distinguished this meeting. Indeed, during the first quarter of an hour of the meeting it was allowed to present the doctoral research and how it was related to the SCORE project. Then, the purpose of the questionnaire was presented and was briefly described. Finally, the flyer, the GDPR document and, obviously, the questionnaire were distributed to each present. In this event, 30 paper-based questionnaires were left; a week later, on 17 July 2020, the 19 completed questionnaires were withdrawn.

Secondly, the attention was focussed to the municipality of Oulx for two reasons. The first reason is the existing contact with the president of the Consorzio Forestale Alta Valle Susa (CFAVS) and the establishment of new contact with the deputy mayor of the Oulx municipality; the second reason is the need to intervene suddenly on the case study. Indeed, if on the one hand Oulx represented the most advanced case study for the detail of the data in possession and for the analyses carried out, on the other hand, the sudden breakdown of the school's heating system determined its priority of intervention. These reasons have therefore determined the need to proceed with the replacement of the plant and the desire to investigate, in particular, the opinion of the citizens of Oulx in a perspective of energy community creation. On September 2, 2020, a restricted meeting was organized, in Oulx, with the deputy mayor of the Oulx and the president of the CFAVS. In this occasion, 30 survey package (flyer, GDPR and questionnaire) were delivered to the deputy mayor in order to disseminate it among the employees in the municipal offices; in addition, 40 survey package and 30 flyers containing the QR code were delivered to the CFAVS president in order to distribute them among their workers. Furthermore, the opportunity was taken to distribute the questionnaire to the tourist office, located near the municipality building and overlooking the main square of Oulx, and to the weekly market, which always takes place in same square. At the tourist office 10 survey package and 20 flyers containing the QR code were left. Regarding the weekly market, it was preferred to distribute only the flyer containing the QR code for filling in the questionnaire online; indeed, asking people to fill out the paper-based questionnaire implies to entertain them between 15 and 20 minutes outdoors. Therefore, for this reason, it was preferred to allow people to inquire and fill in the questionnaire at home in absolute comfort. This approach has brought out a limitation in this specific context: this presupposes having a device that allows scanning and surfing the internet and this condition is hardly satisfied for market-goers, characterized by an average age quite high and from having devices not suitable for my objective. In any case, anyway, 10 flyers containing the QR code have been distributed. Finally, again on September 2, 2020, in Susa, 20 survey package and 20 flyers containing the QR code were left to the president of La Foresta in order to spread them among his employees. A little more than a week was left to fill in the questionnaire and on September 11, 2020, 40 paper-based questionnaire were withdrawn, divided as follows: 15 from the municipality offices, 11 from the CFAVS, 10 from the tourist office and 4 from La Foresta. The Table 24 below details the distribution of the questionnaire during the second phase in presence.

Table 24: Questionnaire distribution in the second phase.

Date	Municipality	Event typology	Questionnaire	Flyer	Withdrawn questionnaire	Rate
10.07.2020	Almese	Internal meeting of COOPAMICO members	30	-	19	63.3%
02.09.2020	Oulx	Weekly market	-	10	-	
02.09.2020	Oulx	Oulx deputy mayor	30	-	15	50.0%
02.09.2020	Oulx	Touristic office	10	20	10	100%
02.09.2020	Oulx	CFAVS	40	30	11	27.5%
02.09.2020	Susa	La Foresta	20	20	4	20.0%
Total			**130**	**80**	**59**	**45.4%**

The in-person distribution was flanked by the online spread of the questionnaire. In this case, social networks were used. Specifically, the questionnaire was disseminated through posts and stories on Instagram, Facebook, LinkedIn and Twitter (Figure 59). In addition, several hashtags and location tag have been used to capture the users' attention.

Figure 59. Sharing of the questionnaire through Instagram posts and stories.

Data pre-processing and analysis. The questionnaire answers were accepted in the period between March 17, 2020 and November 13, 2020. Due to the double type of questionnaire (paper-based and online) and distribution methods, the overall online response rate cannot be assessed in a uniquely way. Regarding the paper-based questionnaires, as shown in Table 24, 130 questionnaires were distributed and 59 questionnaires were returned; hence, the response rate is 45.4%. In addition, it is important to point out that all the questionnaires obtained proved to be complete in every part. Regarding the online questionnaires, the total responses are 207, the complete responses are 64 and, consequently, the partial ones are 143. The overall response rate is 30.9%. In addition, it is important to point out that in the total number of online responses, only the answers of those who opened the link and started the questionnaire compilation are considered (whether they completed it or did not complete it). Moreover, due to several approaches used for the online dissemination (email invitation (Table 23), flyer (Table 24), publication on social channels, etc.), it is difficult to accurately determine the number of citizens actually reached. In general, the minimum number of people reached was 337, the complete responses 123 and, consequently, the overall response rate (based on paper-based and online questionnaire) is 36.5%.

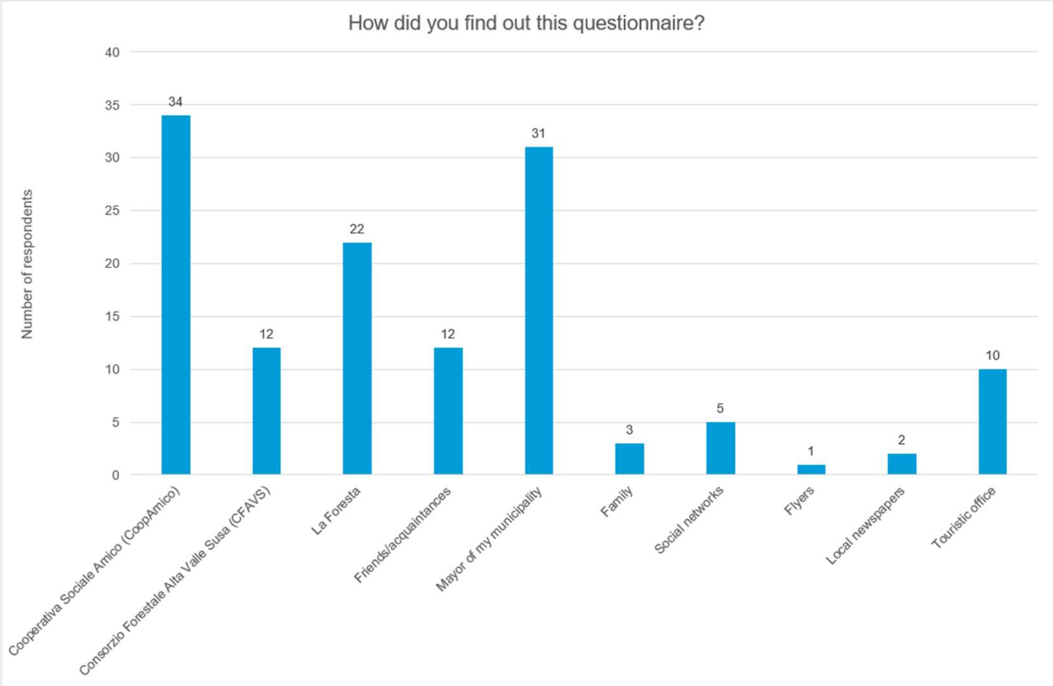

Figure 60. Dissemination (Part 4, Question 13).

Figure 60 refers to the question *"How did you find out this questionnaire?"* (Part 4 - Question 13) and shows how the questionnaire spreads throughout the territory. The question provided the possibility of a multiple answer, in the event that the sources were more than one; for this reason the totality of the answers is 132. The histogram highlights how the contribution of the local intermediaries, known in the area/territory, was fundamental; indeed, they have received a greater preference (CoopAmico 34, Municipality 31, La Foresta 22 and CFAVS 12).

First of all, before proceeding with the preliminary analyses, the responses, collected through the paper-based questionnaires, were manually entered into the online LimeSurvey platform, since it allows to export data in different formats (Microsoft Word (latin charset), Microsoft Excel (all charsets), CSV File (all charsets) and PDF) facilitating, therefore, the analysis with software such as Microsoft Excel and R. Subsequently, it is necessary to prepare the dataset through the data cleaning processes. The operation performed is the dataset cleaning from unwanted observation, i.e. answer outside the sample of interest. The only limitations in the distribution of the questionnaire are the municipality of residence and the age of the respondents. Specifically, for the purpose of the survey, only the answers from respondents who live in Susa Valley are considered valid; furthermore, due to the complexity of the questions, it is preferable that the minimum age of the sample is 18 years.

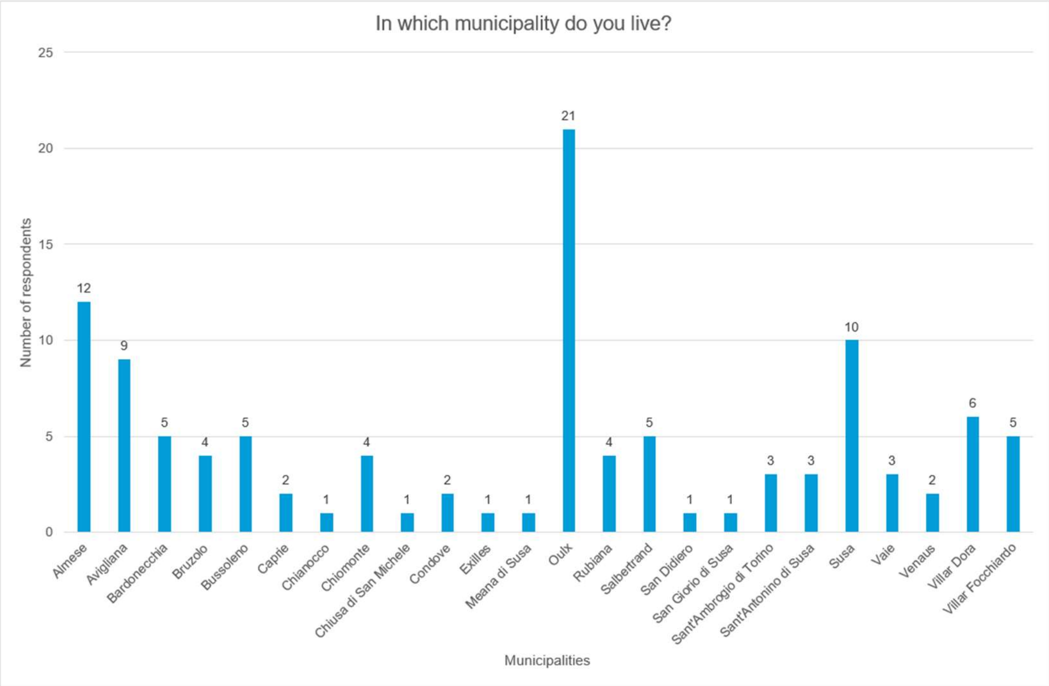

Figure 61. Municipality of residence in Susa Valley (Part 4, Question 12).

Figure 61 shows the distribution of respondents in the municipalities of the Susa Valley (only the municipalities with at least one respondent were included in the histogram). Considering the residence condition, 12 responses were not taken into consideration as the questionnaire was filled in by people who declared that they live outside the Susa Valley (Pinerolo (1), Trana (3), Rivalta di Torino (1), Siena (1), Giaveno (1), Rivoli (2)) or who preferred not to answer (3). Subsequently, the age reported in the 111 responses was analysed. The minimum value is 20 years old, the maximum value is 77 years old and the average age of the respondents is equal to 49 years old; therefore the age condition of the investigation is met. Following these first dataset cleaning operations, the sample consists of 111 answers. Moreover, usually, in the cleaning phase of the dataset, attention is paid to the blank answers. In this specific case, all the questions have been set as mandatory and no blank answers are present. However, both in the online version and in the paper-based version for all questions has been inserted, among the answer options, the options "I prefer not to answer" and, in some cases, also "I don't know". The choice, by the respondents of one of these two options, should not be interpreted as a lack of response but, rather, as a will and a very specific position towards the question.

In the following paragraphs, the results obtained are shown maintaining the same structure of the questionnaire. For this reason, the results concerning the information on attitude and willingness are first displayed, then the results concerning the information on feelings and community identity, subsequently the results on the technical information and, finally, the results concerning the socio-demographic information.

Please, note: questions are identified by the code *Px-Qy*, where *x* indicates the questionnaire part number and *y* is the question number.

The average time for completing the online questionnaire was 57 minutes. The minimum time recorded was about 10 minutes, while the maximum time was 14 hours and 47 minutes. The interquartile range (IQR) is between 17 minutes (25^{th} percentile) and 36 minutes (75^{th} percentile); the second quartile (50^{th} percentile) is 23 minutes. Time values greater than 1 hour and 6 minutes (upper whisker) are highlighted as statistically anomalous; on the other hand, for the definition of time as an always positive quantity, any anomalous data, lower than the lower whisker (that is equal to 0) cannot be evaluated. In this specific case, seven value greater the upper whisker were recorded. A detailed check was carried out and it showed that they are not to be considered anomalous data since the questionnaire allows to save the given answers and continue it later. Consequently, due to this reason, also the average compilation time is influenced by this possibility of save and recovery.

First part: information on attitude and willingness.

This paragraph shows the results relating to the first part of the questionnaire which deepens (i) the interest and the willingness towards renewable energy community project, (ii) the willingness to energy consumption and (iii) the social influence and the personal environmental judgment.

(i) In the interest and the willingness towards RECPs (Renewable Energy Community Projects), questions aimed at exploring first, a general interest, then, the interest in actively participating and, finally, the willingness and interest in investing economically are analysed and the in Table 25 the main results are summarized. Hence, the main questions go from investigating simple interest (P1-Q01), to active participation (P1-Q03), to economic investment (P1-Q05) up to active participation in buildings not directly used by users (P1-Q06). Participants were asked to indicate their level of interest, using the 5-point Likert scale, from 1 (Not interested at all) to 5 (Very interested). In addition, the possibility to choose the "I don't know" or "I prefer not to answer" option is given.

Table 25. Main questions relating the willingness towards RECP.

Question	(1) Not interested at all	(2) Not interested	(3) Neutral	(4) Interested	(5) Very interested	I do not know	I prefer not to answer
Q01: Are you interested in “community” projects based on renewable energy (e.g. creating energy communities)?	(2) 1.8%	(5) 4.5%	(13) 11.7%	(50) 45.0%	(40) 36.0%	(1) 0.9%	(0) 0.0%
Q03: Are you interested to actively participate in “community” projects based on renewable energy?	(2) 1.8%	(10) 9.0%	(21) 18.9%	(50) 45.0%	(25) 22.5%	(2) 1.8%	(1) 0.9%

Q05: Are you willing to invest in “community” projects based on renewable energy in your area?	(6) 5.4%	(22) 19.8%	(26) 23.4%	(37) 33.3%	(11) 9.9%	(8) 7.2%	(1) 0.9%
Q06: Are you willing to actively participate in “community” projects based on renewable energy even if the intervention did not immediately concern the building in which you lives (but in future yes)?	(3) 2.7%	(6) 5.4%	(22) 19.8%	(59) 53.2%	(11) 9.9%	(9) 8.1%	(1) 0.9%

The comparison of the response percentages of each option shows how, as the effort required of the citizen increases, the preference shifts towards a lower interest level. Indeed, most of the respondents (81.1%) stated that they were "Interested" or "Very Interested" in simply participating in community projects based on renewable energy. With regard to active participation, the preference of respondents also includes a non-negligible neutral and non-interest preference. Investing economically in a community project based on renewable energy requires overcoming major obstacles, not surprisingly 25.2% of respondents said they were "Not interested" or "not interested at all". Finally, the interest in active participation in community projects that concern, only in a first moment, buildings not directly used by the respondents presents a level of interest that is absolutely comparable with the levels expressed for active participation.

To better understand the respondents' point of view, some secondary questions, linked to these main questions, have been posed. Specifically, in these questions, the respondent was asked to choose one or more options among those proposed. Figure 62 shows the result on involvement conditions in a community project based on the use of renewable energy (P1-Q02). Contributing to the environment and the Planet protection (with 64 preferences) is the most preferable condition that would bring citizens closer to this project typology; following, almost equally in preference, providing a service for the community (36 preferences) and having an economic advantage (35 preferences) and, finally having an advantage in terms of more efficient services (23 preferences). Furthermore, two respondents stated that they would not get involved under any conditions. It is important to emphasize how the environment and the Planet protection has received greater preference over economic benefits, demonstrating how, despite the crisis that characterizes this period, this value is perceived as important; furthermore, this output is in line with the results previously obtained in the workshop with vulnerable citizens.

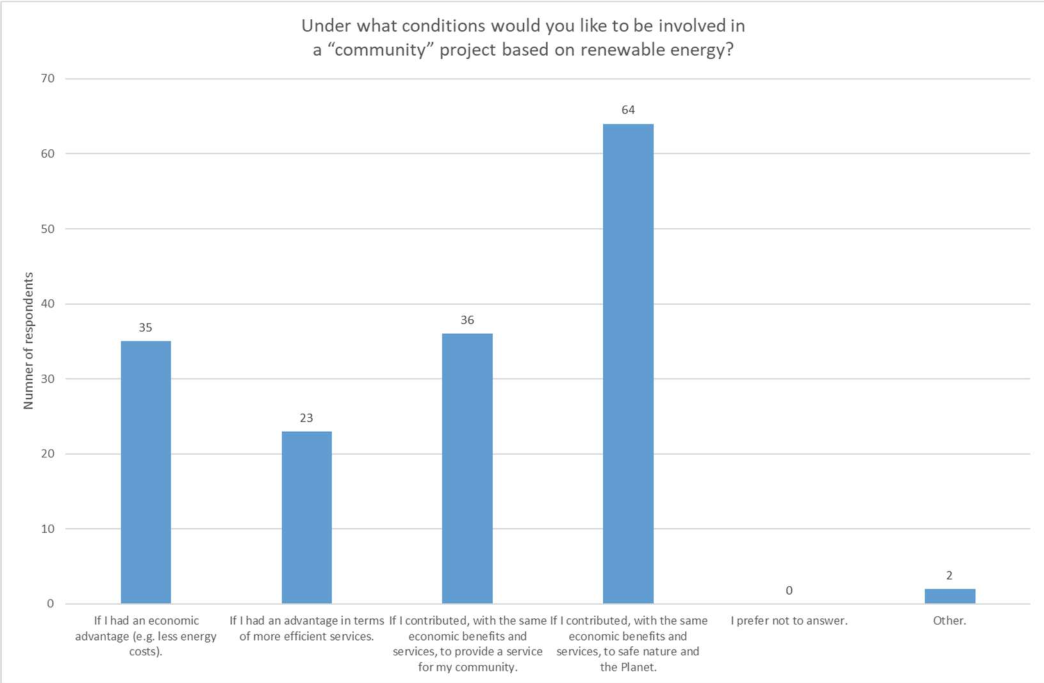

Figure 62. Involvement condition in RECP (P1-Q02).

Afterwards, the results related to the in-depth analysis of the active participation in community projects based on renewable energy sources (P1-Q03) are shown in Table 26. Based on the answer given to Question 03, two possibilities arise:

- if the respondent has declared to be “Very interested” or “Interested”, was asked how the respondent would like to actively participate (P1-Q03.1). The most frequent actions are “participation in meetings” (with 34 preferences), “investment according to my possibilities” and “dissemination of information” (both with 33 preferences). Finally, “providing functional surfaces for the installation of energy production systems” received 22 preferences; while “playing an active role in the management of the energy community” received 18 preferences.
- if the respondent has declared to be “Not interested” or “Not interested at all”, was asked the reason(s) (P1-Q03.2) and the needs of not active participation (P1-Q03.3). The main obstacle to active participation is determined by not having enough time (8 preferences). In addition, not having enough money and not having knowledge and skills on the energy community issue also does not favour the participation. Finally, two respondents stated that an obstacle is dictated by not getting along/trusting in one's neighbourhood and, therefore, they would only be in favour of independent interventions, aimed at their individual housing units. Instead, with regard to needs, respondents need to feel contributors toward sustainable ways of living (2 preferences), need financial support (2 preferences) and need a compensation/incentive (1 preference). In addition, two respondents

stated that they need to have more information on this type of community projects in order to assess their impact on daily life and they want policies that are antithetical to the city as the city system is perceived as a source of pollution and territories impoverishment. Finally, one respondent stated that he was not interested in any way.

Table 26. Modalities, reasons and needs relating to (not) active participation (P1-Q03.1,2,3).

Very interested or interested	
How would you like to actively participate?	
Participating in meetings.	34
Investing according to my possibilities (e.g. money, natural resources owned by me (e.g. woods), etc.).	33
Providing functional surfaces for the installation of energy production systems.	22
Playing an active role in the management of the energy community.	18
Spreading information (e.g. talking about energy community to friends and/or family members, etc.)	33
Other.	0
I prefer not to answer.	3
Not interested or not interested at all	
For what reason(s) can you not actively participate?	
I don't have enough time.	8
I don't have enough money.	2
I don't have enough knowledge or skills.	2
I don't know and where.	0
I have distrust toward innovative projects.	0
I think there is too much bureaucracy to deal with.	0
Other.	2
I prefer not to answer.	1
What do you need to actively participate?	
I need to be pro-actively engaged by existing renewable energy communities.	0
I need financial support to participate (e.g. zero interest loan to finance my participation or tax benefits).	2
I need a compensation/incentive for my participation.	1
I need the feeling that I contribute toward my community.	0
I need the feeling that I contribute toward sustainable ways of living.	2
I need something else.	3
I prefer not to answer.	5

Subsequently, the obstacles that prevent respondents (that declared to be "Not interested" or "Not interested at all") from investing economically in a community project (P1-Q05) are shown in Figure 63. Specifically, in Question 05.1, the respondent was asked to choose one or more options among those proposed. The main difficulty in economic investment is, of course, the lack of financial resources (with 18 preference). Other reasons follow which have a minor preference but which are noteworthy as (a) distrust toward the project, (b) fear of being represented solely in relation to the investment amount, (c) too risky investment, (d) preference in other investments economically more interesting, (e) too much legal bureaucracy and (f) personal reasons.

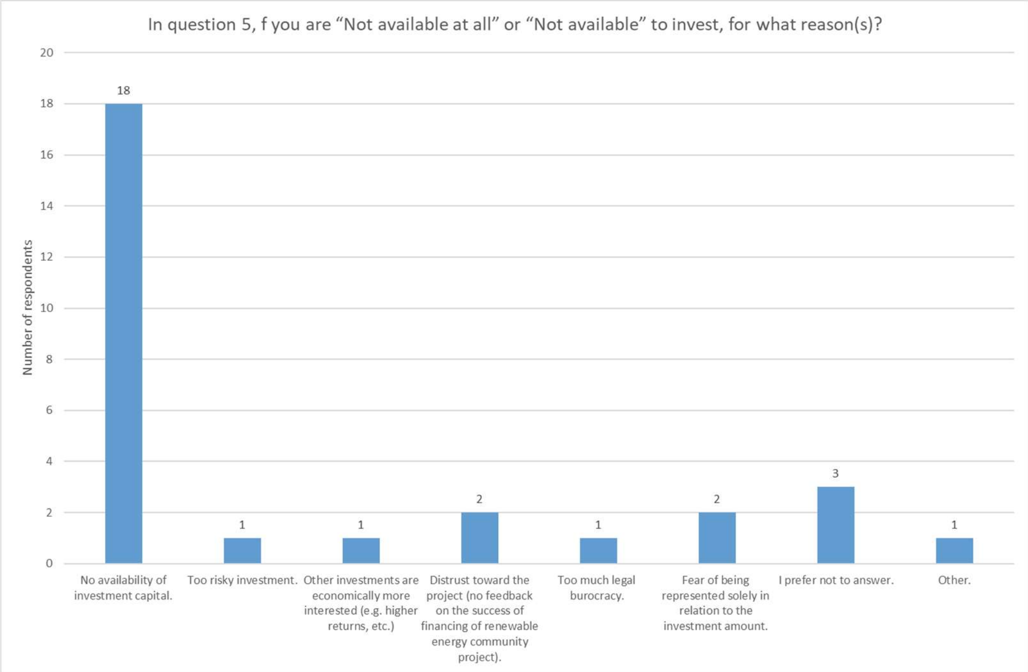

Figure 63. Obstacles to economic investment availability (P1-Q05.1).

In addition, the willingness to invest economically, specifically the inclination to the one-off investment contribution (P1-Q05.2), was investigated among all respondents. The result shows an equilibrium situation: 36.9% of respondents stated to be willing to invest, 36.0% of respondents claimed to be not willing to invest and, the remaining part, 27.1% of respondents preferred not to answer. The 78% of those in favour of the investment (32 respondents) expressed the amount of their contribution. No constraints were placed in the question and no reference was deliberately inserted in order not to influence the respondents' choice. The minimum contribution expressed is 10 €, the maximum contribution 50000 €; the average is around 5000 € (with a standard deviation of about 11000 €). Furthermore, 7 respondents declared that they wanted to contribute but only after knowing the technical details of the intervention and the participation structure.

In addition, in Question 04, the participation in the production of energy from renewable sources is investigated; as shown in Figure 64, 35.1% of the respondents declared their participation in the production of energy from renewable sources; instead, the remaining part (64.9%) gave a negative answer. Among those who have declared a current participation, 18 respondents are the owner or co-owner of a photovoltaic system, 16 respondents of a solar thermal system, 5 respondents of a biofuel system and two respondents preferred not to answer.

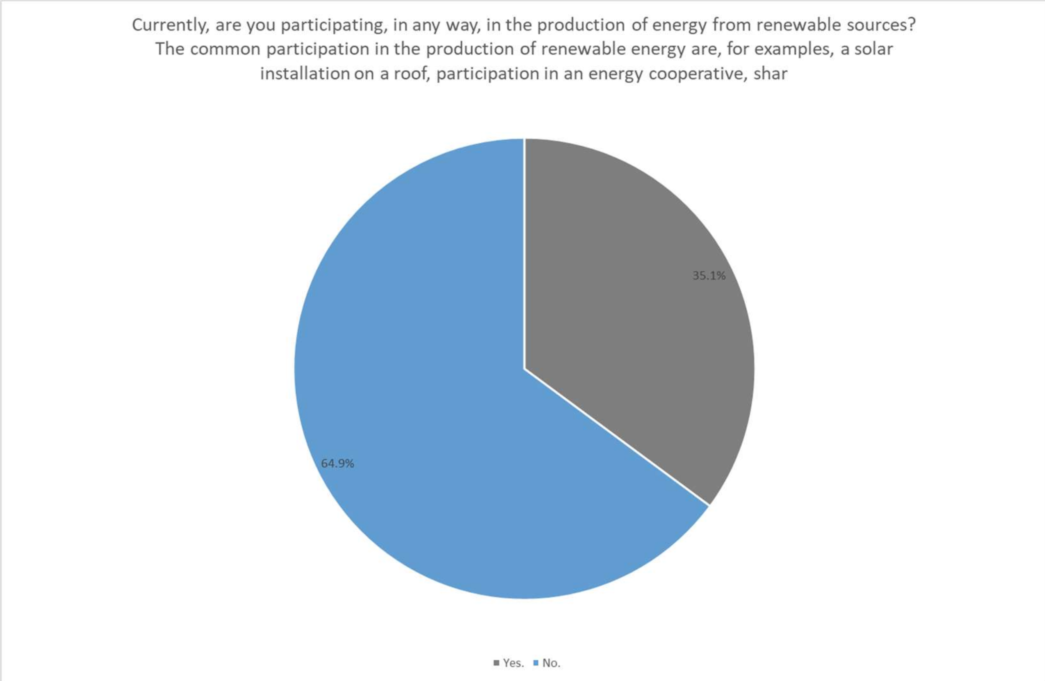

Figure 64. Renewable energy production participation (P1-Q04).

(ii) Inside the first part of the questionnaire the willingness to reduce the energy consumption in buildings, investigating users' actions to increase the efficiency of the building envelope components and of the energy plant system, investigating users' behavioural change and, finally, investigating the energy use adaptation to the renewable energy production model characterized by volatility, is explored. The willingness to improve the building energy efficiency is investigated in Question 07; specifically, in Table 27 the availability by replacing old appliances (big and/or small appliances) with newer models that use less energy is investigate (P1-Q07.1); instead in Table 28 the availability by intervening on envelope and/or energy system is explored (P1-Q07.3). Participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In addition, the possibility to choose the "I don't know" or "I prefer not to answer" option is given.

Table 27. Improvement of energy efficiency: replacement of appliances (P1-Q07.1).

Question 07.1: I would be willing to...	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I Agree**	**(5) I strongly agree**	**I do not know**	**I prefer not to answer**
a: ...exchange older lighting with LED lamps.	(4) 3.6%	(1) 0.9%	(4) 3.6%	(43) 38.7%	(58) 52.3%	(0) 0.0%	(1) 0.9%
b: ...exchange old big appliances such as refrigerator, washing machine, oven, etc.	(3) 2.7%	(6) 5.4%	(15) 13.5%	(46) 41.4%	(38) 34.2%	(1) 0.9%	(2) 1.8%
c: ...exchange old	(4)	(10)	(9)	(56)	(29)	(0)	(3)

small appliances (e.g. TV or hi-fi equipment).	3.6%	9.0%	8.1%	50.5%	26.1%	0.0%	2.7%
d: ...exchange an older heat pump.	(3) 2.7%	(3) 2.7%	(12) 10.8%	(44) 39.6%	(27) 24.3%	(12) 10.8%	(10) 9.0%

In general, the majority of respondents are "agree" or "strongly agree" with all proposed actions. Furthermore, the 82.9% of respondents declared that they had already replaced all or some of the listed equipment; the frequency of the interventions carried out is shown in Figure 65. Instead, 11.7% of respondents said they did not replace any equipment; while 5.4% preferred not to answer. Among those who left a comment, the main reasons linked to a lack of intervention are listed below:

- give priority to other issues;
- high replacement costs and therefore prefer to replace them only when they are deteriorated or broken;
- no need is seen or little interest in energy saving and increased energy efficiency;
- lack of money to invest for equipment replacements;
- preference towards other investments, such as improving the building envelope systems or installing renewable energy systems.

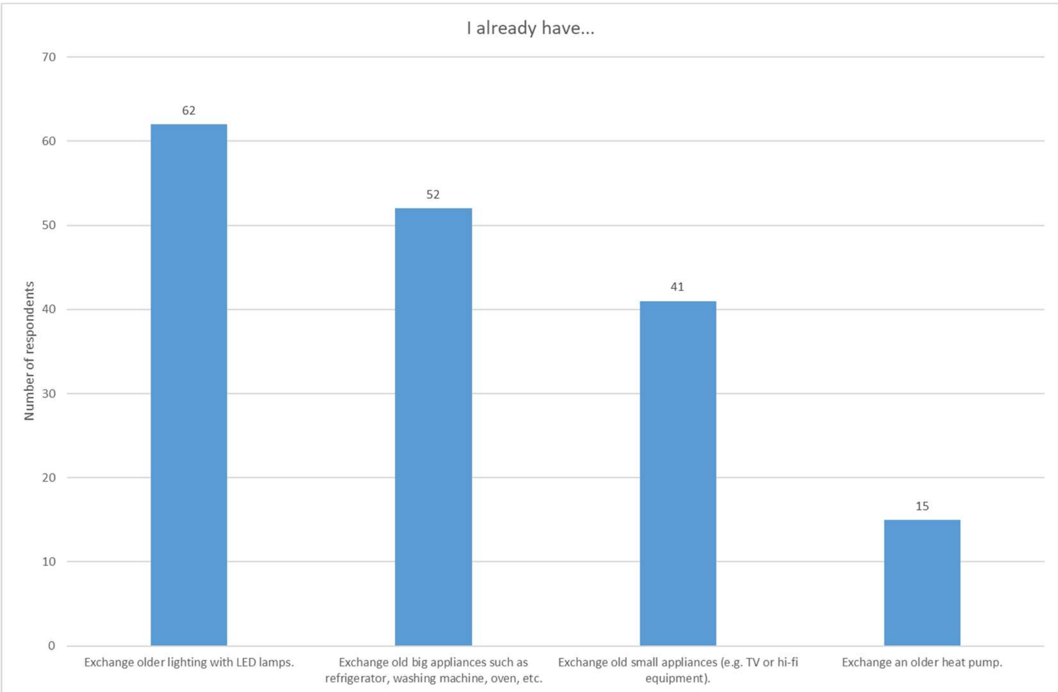

Figure 65. Frequency of appliances replacement (P1-Q07.2).

Table 28. Improvement of energy efficiency: intervention on envelope and/or energy system (P1-Q07.3).

Question 07.3: I would be willing to...	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I Agree**	**(5) I strongly agree**	**I do not know**	**I prefer not to answer**
e: ...change the windows with other with double or triple glazing.	(3) 2.7%	(3) 2.7%	(8) 7.2%	(39) 35.1%	(53) 47.7%	(1) 0.9%	(4) 3.6%
f: ...insulate the building “with a thermal coat”.	(3) 2.7%	(7) 6.3%	(11) 9.9%	(42) 37.8%	(42) 37.8%	(4) 3.6%	(2) 1.8%
g: ...replace an old boiler.	(2) 1.8%	(1) 0.9%	(6) 5.4%	(47) 42.3%	(48) 43.2%	(2) 1.8%	(5) 4.5%
h: ...install energy production systems from renewable sources (PV panels, solar thermal panels, etc.).	(2) 1.8%	(3) 2.7%	(8) 7.2%	(37) 33.3%	(51) 45.9%	(5) 4.5%	(5) 4.5%

In general, the majority of respondents are “agree” or “strongly agree” with all proposed actions. Furthermore, the 68.5% of respondents declared that they had already intervened on the envelope and/or on the energy system of their home; the frequency of the interventions carried out is shown in Figure 66. Instead, 27.0% of respondents said they did not intervene on the envelope and/or on the energy system; while 4.5% preferred not to answer. Among those who left a comment, the main reasons linked to a lack of intervention are listed below:

- not owning a house but being rented and often the landlord is not interested in implementing such interventions;
- the building, being of recent construction or having been recently renovated, already has good levels of energy efficiency;
- lack of economic capital to invest;
- too expensive interventions;
- need to have tax incentives to be able to carry out the interventions.

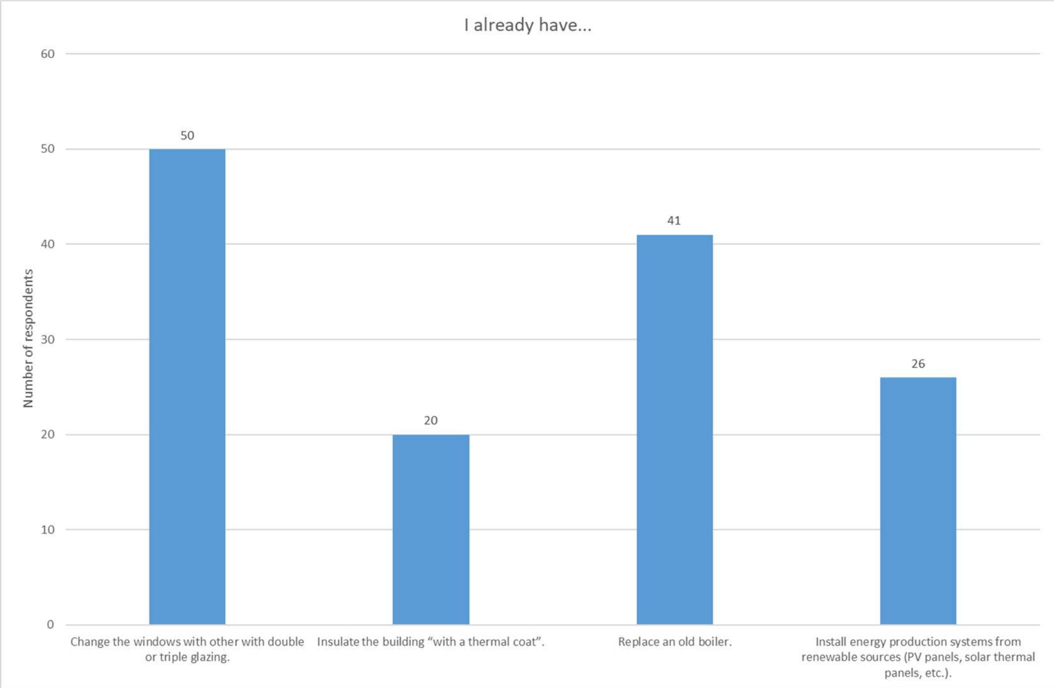

Figure 66. Frequency of retrofit interventions (P1-Q07.4).

Furthermore, the willingness to change the building users' behaviour is investigated in Question 08; specifically, in Table 29 the availability by modifying the use of energy related to the use of household appliances and/or interaction with the systems present in the home and/or applying specific behavioural practices is investigate (P1-Q08.1). Participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In addition, the possibility to choose the "I don't know" or "I prefer not to answer" option is given.

Table 29. Improvement of energy savings: user's behaviour (P1-Q08.1).

Question 08.1: I would be willing to...	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I Agree**	**(5) I strongly agree**	**I do not know**	**I prefer not to answer**
i: ...turn off the light even if you leave the room for a short time.	(1) 0.9%	(1) 0.9%	(5) 4.5%	(49) 44.1%	(54) 48.6%	(1) 0.9%	(0) 0.0%
l: ...use sockets with an off switch to prevent the appliances from operating in stand-by mode.	(1) 0.9%	(1) 0.9%	(17) 15.3%	(47) 42.3%	(41) 36.9%	(2) 1.8%	(2) 1.8%
m: ...use appliances (e.g. washing machine, dishwasher, etc.) in eco mode.	(3) 2.7%	(2) 1.8%	(4) 3.6%	(54) 48.6%	(44) 39.6%	(2) 1.8%	(2) 1.8%
n: ...use appliances (e.g. washing	(2) 1.8%	(1) 0.9%	(7) 6.3%	(50) 45.0%	(48) 43.2%	(2) 1.8%	(1) 0.9%

machine, dishwasher, etc.) only when fully charged.							
o: ...defrost the refrigerator or freezer regularly to prevent the ice from forming.	(2) 1.8%	(2) 1.8%	(8) 7.2%	(53) 47.7%	(44) 39.6%	(1) 0.9%	(1) 0.9%
p: ...in winter, to wear heavier clothes instead of turning on the heat.	(1) 0.9%	(15) 13.5%	(12) 10.8%	(46) 41.4%	(35) 31.5%	(1) 0.9%	(1) 0.9%
q: ...turn off the heating, knowing that you will be leaving your home for more than 4 hours.	(2) 1.8%	(17) 15.3%	(16) 14.4%	(36) 32.4%	(37) 33.3%	(1) 0.9%	(2) 1.8%
r: ...in winter, to have a room temperature not exceeding 21 °C.	(2) 1.8%	(3) 2.7%	(3) 2.7%	(46) 41.4%	(56) 50.5%	(0) 0.0%	(1) 0.9%
s: ...in summer, to have a room temperature not lower than 26 °C.	(1) 0.9%	(9) 8.1%	(10) 9.0%	(43) 38.7%	(45) 40.5%	(2) 1.8%	(1) 0.9%

In general, the majority of respondents are "agree" or "strongly agree" with all proposed actions. Furthermore, the 89.2% of respondents declared that they had already apply daily the behaviours aimed to energy saving; the frequency of the interventions carried out is shown in Figure 67. Instead, only the 3.6% of respondents said they did not apply the habitual behaviour; while 7.2% preferred not to answer.

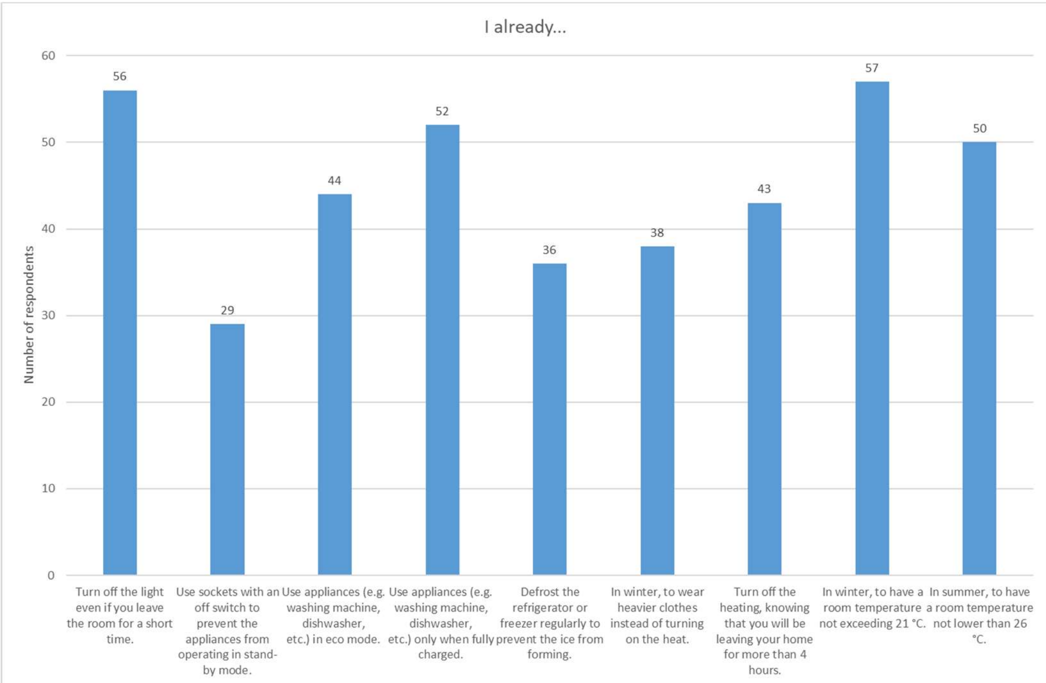

Figure 67. Frequency of behavioural change actions (P1-Q08.2).

In addition, as shown in Figure 68, the general willingness of respondents to modify their behaviour is investigated in Question 09. Participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (Not available at all) to 5 (Very available). In addition, the possibility to choose the "I don't know" or "I prefer not to answer" option is given.

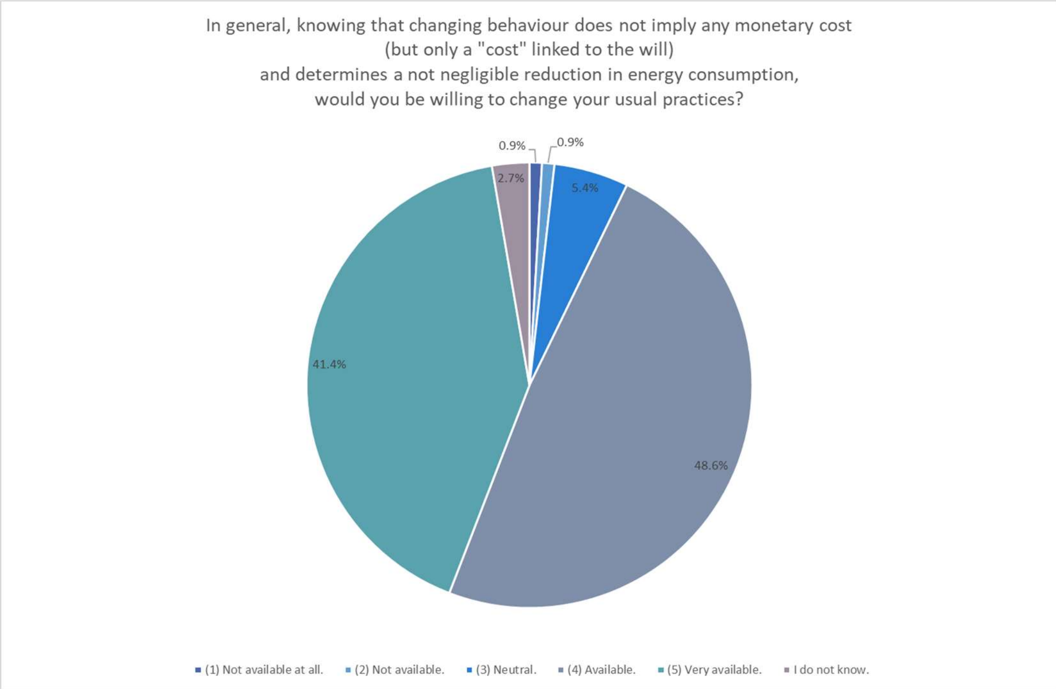

Figure 68. General disposition to behavioural change (P1-Q09).

This result is in line with what the respondents expressed in the specific questions relating to the willingness to change their behaviour (P1-Q08.1). Indeed, the majority of respondents are “Very available” (41.4%) or “Available” (48.6%) with the behavioural change issue. This highlights the interviewees’ inclination towards a reduction in consumption which does not imply a monetary cost, due to the purchase of elements with greater efficiency, but which implies overcoming the difficulties linked to will. Only 1.8% of respondents said they were “Not available at all” or “Not available”. Finally, 5.4% stated that they have a neutral position on the issue; instead, 2.7% said they did not know.

Moreover, the issue related to the problem linked to the expansion of the success of renewable energy, i.e. its volatility, is investigated (P1-Q10). Also in this case, participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In addition, the possibility to choose the "I don't know" or "I prefer not to answer" option is given. Below, in Table 30, the results related to the use of household appliance, the recharge of electrical devices and the recharge of electric vehicles are shown. In addition, the general agreement of respondents to adaptation to new energy production models is highlighted; indeed, for each question, more than half of the sample expressed their agreement.

Table 30. Adaptation to new model of energy production (P1-Q10).

I would be willing to...	(1) I strongly disagree	(2) I disagree	(3) Neutral	(4) I Agree	(5) I strongly agree	I do not know	I prefer not to answer
...using household appliance mainly when the share of electricity from renewable sources in the grid is very high.	(4) 3.6%	(4) 3.6%	(17) 15.3%	(60) 54.1%	(20) 18.0%	(5) 4.5%	(1) 0.9%
...recharging electrical devices (e.g. laptop, etc.) mainly when the share of electricity from renewable sources in the grid is very high.	(4) 3.6%	(3) 2.7%	(15) 13.5%	(65) 58.6%	(17) 15.3%	(5) 4.5%	(2) 1.8%
...recharging electric vehicles mainly when the share of electricity from renewable sources in the grid is very high	(4) 3.6%	(3) 2.7%	(14) 12.6%	(61) 55.0%	(20) 18.0%	(6) 5.4%	(3) 2.7%

Furthermore, Question 11 investigated the respondents' willingness to install some devices (e.g. smart meters) for monitoring energy consumption. The result, shown in Figure 69, highlights how the majority of respondents are "Available" (44.1%) or "Very available" (27.0%) with the device installation. Only 3.6% of respondents said they were "Not available at all" or "Not available". Finally, 13.5% stated that they have a neutral position on the issue; instead, 9.9% said they did not know and 1.8% declared they preferred not to answer.

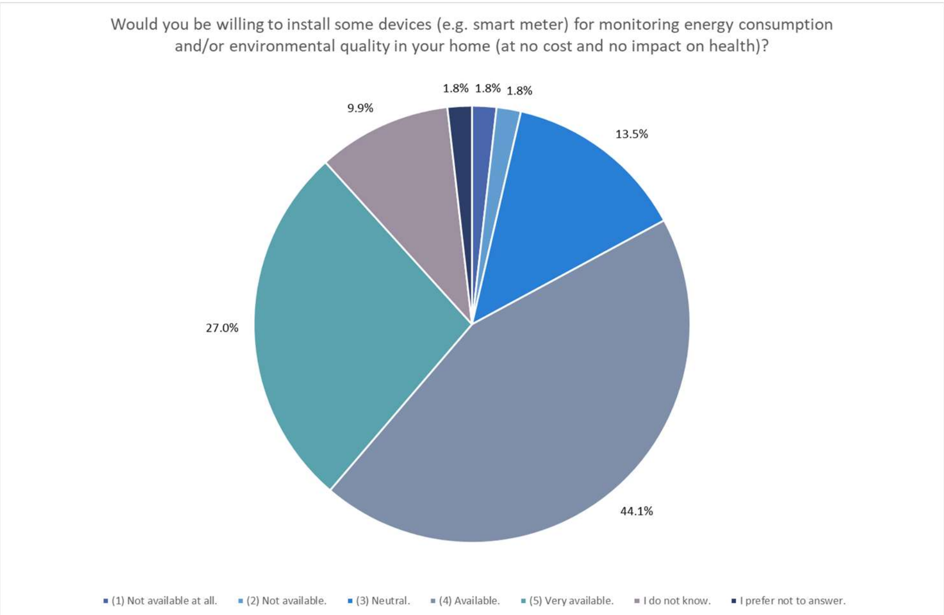

Figure 69. Energy consumption monitoring (P1-Q11).

(iii) Inside the first part of the questionnaire the social influence and personal environmental judgment is explored, through the investigation of what acquaintances, friends or family may think about what is right or expect that a person to do. Specifically, the social influence was investigated through three statement in which participants were asked to indicate their level of agreement/disagreement, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In Table 31, the results percentage are shown. In general, with regard to these statements, the respondents have shown mainly to support a neutral position, declaring, however, a propensity to be agree.

Table 31. Statements on social influence (P1-Q12).

Statements	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I Agree**	**(5) I strongly agree**	**I do not know**	**I prefer not to answer**
Many people I know produce energy from renewable sources.	(1) 0.9%	(14) 12.6%	(37) 33.3%	(33) 29.7%	(9) 8.1%	(16) 14.4%	(1) 0.9%
My acquaintances expect me to save energy and/or produce energy from renewable sources.	(3) 2.7%	(12) 10.8%	(45) 40.5%	(22) 19.8%	(8) 7.2%	(18) 16.2%	(3) 2.7%
The people I care about would support my participation in “community” projects.	(1) 0.9%	(0) 0.0%	(31) 27.9%	(43) 38.7%	(23) 20.7%	(11) 9.9%	(2) 1.8%

Furthermore, the importance of environmental protection and safeguard has been investigated (P1-Q13). The histogram in Figure 70 shows the responses obtained, highlighting how for almost all respondents the environmental protection covers a very important issue; indeed, the 73.9% attribute on importance of +3, the 20.7% attribute an importance of +2 and, finally, the 1.8% attribute an importance of +1.

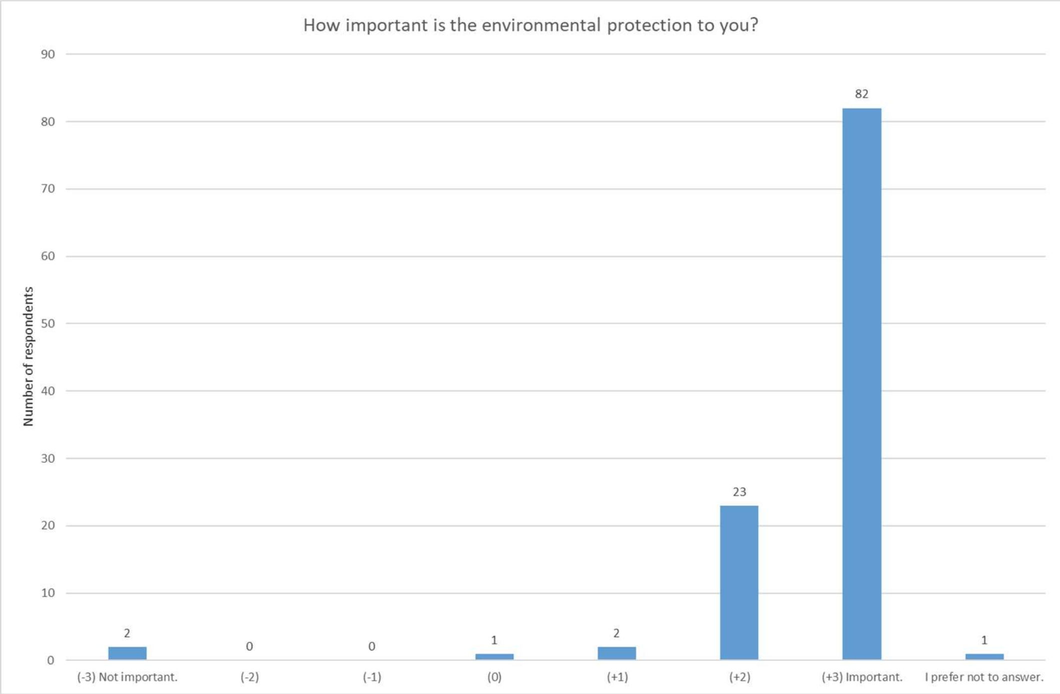

Figure 70. Importance of environmental protection (P1-Q13).

Second part: information on feelings and community identity.

This paragraph shows the results relating to the second part of the questionnaire which deepens (i) the level of feeling and emotions, (ii) the community/territory perception and (iii) the trust and relationship with other people.

(i) The Question 01 of this section investigates the emotions felt by respondents towards the territory in which they live. Feelings under investigation are divided into feelings with a positive tinge (trust, pride and hope) and feelings with a negative tinge (shame, fear and boredom). Participants were asked to indicate their level of feelings, using the 5-point Likert scale, from 1 (I don't feel this feeling at all) to 5 (I feel this feeling strongly); in addition, the possibility to choose the "I don't know" or "I prefer not to answer" option is given. A first view of the results, showed in Table 32, highlights how the higher percentages for positive feelings are oriented towards a neutral position or to feel that particular feeling (Trust: "Neutral" 28.8%, "I feel this feeling" 42.3%; Pride: "Neutral" 31.5%, "I feel this feeling" 26.1%; Hope: "Neutral" 22.5%, "I feel this feeling" 44.1%;). As for negative feelings, most respondents do not have these feelings; indeed, the higher percentages are found in correspondence with the options "I don't feel this feeling at all" and "I don't feel this feeling" (Shame: "I don't feel this feeling at all" 41.6%, "I don't feel this feeling" 22.5%, Fear: "I don't feel this feeling at all" 35.1%, "I don't feel this feeling" 27.0% and Boredom: "I don't feel this feeling at all" 36.9%, "I don't feel this feeling" 21.6%.

Table 32. Level of feelings (P2-Q01).

Feelings	(1) I don't feel this feeling at all	(2) I don't feel this feeling	(3) Neutral	(4) I feel this feeling	(5) I feel this feeling strongl y	I do not know	I prefer not to answer
Trust	(5) 4.5%	(9) 8.1%	(32) 28.8%	(47) 42.3%	(9) 8.1%	(1) 0.9%	(8) 7.2%
Pride	(4) 3.6%	(11) 9.9%	(35) 31.5%	(29) 26.1%	(20) 18.0%	(0) 0.0%	(12) 10.8%
Hope	(2) 1.8%	(9) 8.1%	(25) 22.5%	(49) 44.1%	(20) 18.0%	(0) 0.0%	(6) 5.4%
Shame	(46) 41.4%	(25) 22.5%	(21) 18.9%	(7) 6.3%	(0) 0.0%	(0) 0.0%	(12) 10.8%
Fear	(39) 35.1%	(30) 27.0%	(21) 18.9%	(9) 8.1%	(0) 0.0%	(0) 0.0%	(12) 10.8%
Boredom	(41) 36.9%	(24) 21.6%	(24) 21.6%	(6) 5.4%	(4) 3.6%	(0) 0.0%	(12) 10.8%

(ii) Subsequently, the community/territory perception is investigated, in Question 02, through three statement in which participants were asked to indicate their level of agreement/disagreement, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In general, the answers obtained, presented in Table 33, show a substantial perception of belonging by the respondents to the territory/context in which they live. 58.5% of the respondents stated that they are agree or strongly agree to feel connected to the community in which they live. In fact, only 8.1% said they are strongly disagree or disagree with that statement. The others stated that they are neutral (29.7%), do not know (0.9%) or prefer not to answer (2.7%). In line with what has been described above, 69.3% of respondents agree or strongly agree that they have good friends within their community and 65.5% of respondents often speak about the community in which they live as a great place to live. Also for these two statements the share of respondents not in agreement is low, the greatest weight is determined by those who hold a neutral position, respectively 17.1% and 22.5%.

Table 33. Statements on community perception (P2-Q02).

Statements	(1) I strongl y disagre e	(2) I disagre e	(3) Neutral	(4) I Agree	(5) I strongl y agree	I do not know	I prefer not to answer
I feel strongly connected to the community in which I live.	(3) 2.7%	(6) 5.4%	(33) 29.7%	(36) 32.4%	(29) 26.1%	(1) 0.9%	(3) 2.7%
There are many people in my community that I consider to be good friends.	(3) 2.7%	(8) 7.2%	(19) 17.1%	(52) 46.8%	(25) 22.5%	(2) 1.8%	(2) 1.8%

I often speak of my community as a great place to live.	(5) 4.5%	(4) 3.6%	(25) 22.5%	(46) 41.4%	(29) 26.1%	(1) 0.9%	(1) 0.9%

(iii) For the implementation of an energy community based on co-ownership, the analysis of trust and relationship with other people plays an important role and was investigated through two questions (Question 03 and Question 04). Question 03 investigates trust in other people and, in general, as shown in Figure 71, this feeling is generally felt among respondents. Specifically, 40.5% said they can trust enough, 39.6% can trust and only 1.8% that they can trust completely. Instead 7.2% of respondents absolutely must not trust and 9.0% must not trust. Finally, only 1.8% said they did not know.

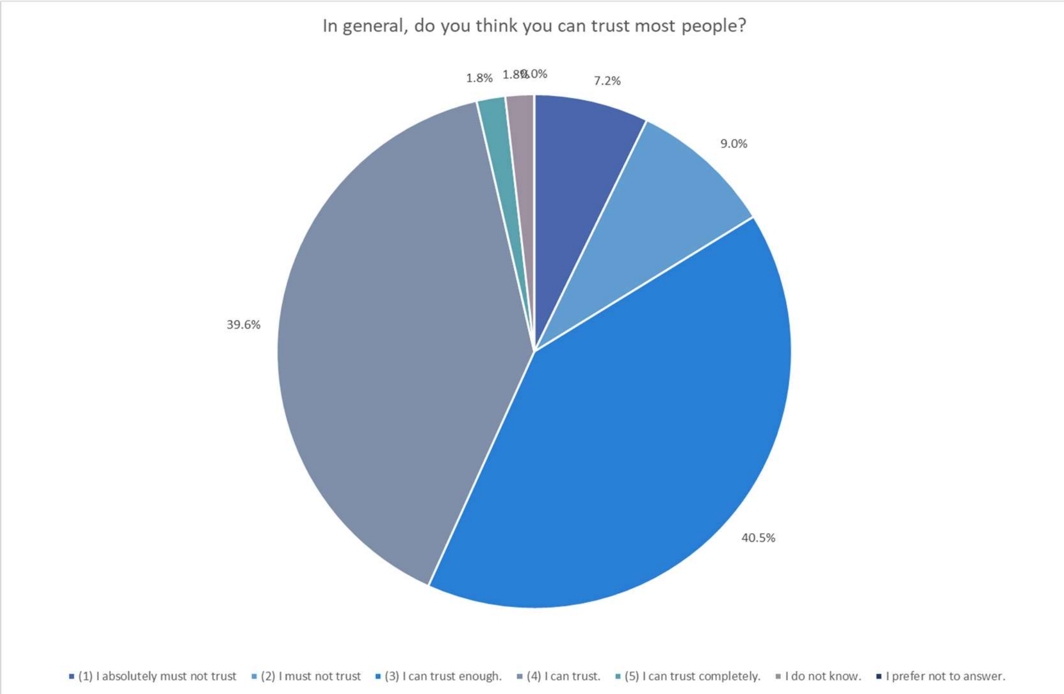

Figure 71. Trust in other people (P2-Q03).

Furthermore, Question 04 investigates relationships with other people and, specifically, the attention that must be paid for these relationships to be positive. In general, as shown in Figure 72, most of the respondents stated that they had to pay attention to relationships with people (36.0%). However having positive relationships implies an effort: 11.7% of respondents said they had to pay close attention and 19.8% had to pay enough attention. In addition, 17.1% of respondents think they don't need to pay attention while 5.4% said they don't need to pay any attention to relation whit others. Finally, 8.1% of respondents declared do not know, while 1.8% preferred not to answer.

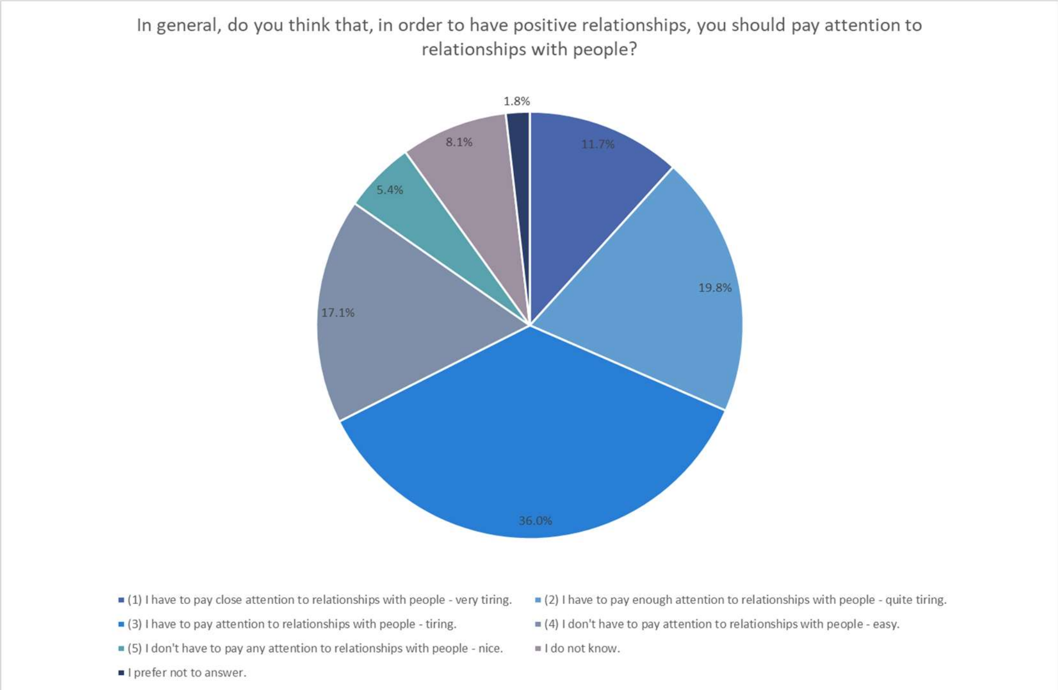

Figure 72. Level of attention in relationship with other people (P2-Q04).

Third part: technical information.

This paragraph shows the results relating to the third part of the questionnaire which deepens (i) general building's characteristics, (ii) the energy system characteristics and the energy expenditure information and (iii) the relationship between user, building and context.

(i) The general building's characteristics is explored through two questions. Questions 01 concerns the building typology and Question 02 concerns the building's construction year.

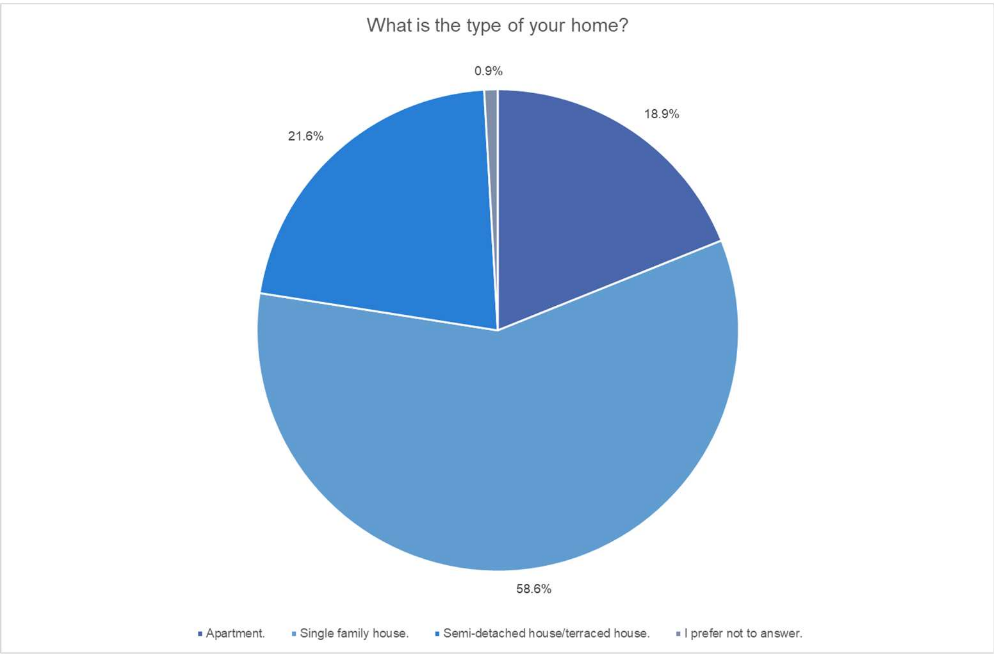

Figure 73. Building typology (P3-Q01).

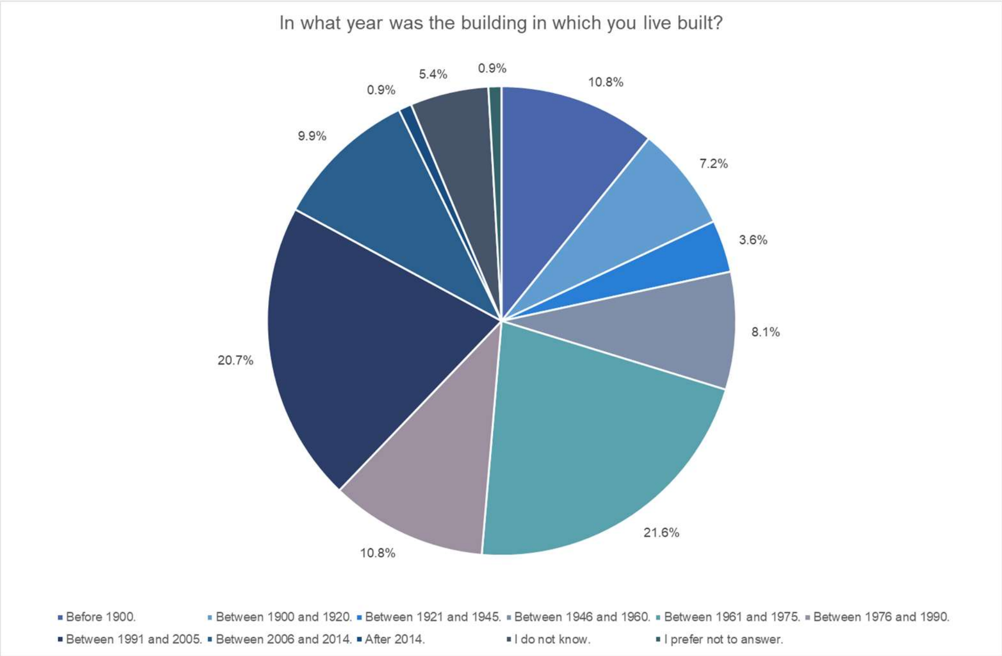

Figure 74. Building construction year (P3-Q02).

As shown in Figure 73, most of the respondents (58.6%) reported living in a single-family house, 21.6% in a semi-detached house/terraced house and 18.9% in an apartment. Only one respondent preferred not to answer the question. On the other hand, the age of the buildings is shown in Figure 74. Buildings built between 1991 and 2005 and buildings built between 1961 and 1975 have received greater preference, respectively by 20.7% and 21.6%. In addition, 10.8% of the respondents declared that they live in buildings built before 1900 and in buildings built between 1976 and 1990. The other construction periods were chosen with a lower percentage by the remaining respondents.

(ii) The energy system characteristics and the energy expenditure information is explored through six main questions.

Figure 75 (Question 03) shows how, currently, most of the respondents (66.7%) do not have a plant for the production of energy from renewable sources. Instead, 33.3% of the respondents (37 users) stated that they have, at least, a systems for the production of energy from renewable sources. Of these, 67.6% use the energy produced solely for self-consumption while 32.4% both for self-consumption and for sale. Currently no one produces energy from renewable sources solely for sale.

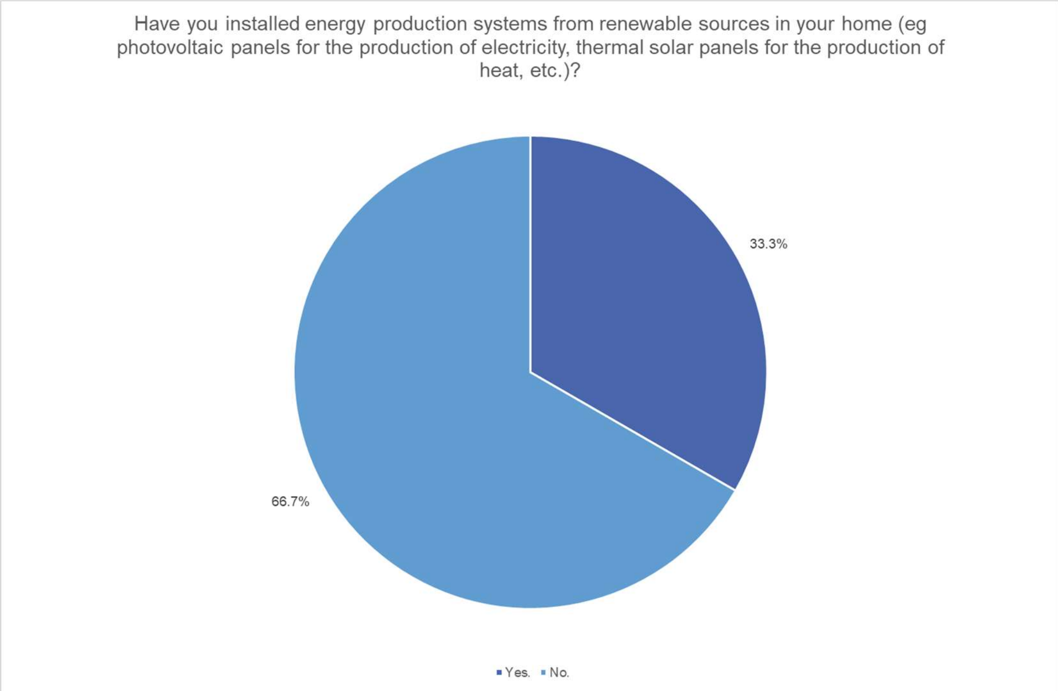

Figure 75. RE production systems installation (P3-Q03).

Through two open questions, the type of system (Question 04) and the year of the heating system (Question 05) was investigated. 72.1% of respondents explicitly stated that they have an autonomous system; on the other hand, the others have declared that they have a centralized plant system or have not expressed their opinion on the issue. Concerning for the age of the main heating system, the average age is about 11 years, with a standard deviation of 9 years. Exploring the management of the energy system (Question 06), 47.7% of the respondents expressed that they were able to manage the plant alone; the same percentage said they rely on other people for management. 5 respondents (4.5%) said they preferred not to answer. Question 07 and Question 08 examine respectively the quantity of energy (heat and electricity) used annually and the energy expenditure (again for heat and electricity) incurred for the respondents' home. The 50.5% of interviewees said they were aware of how much energy is used in their home (in addition, 41.4% are not aware of it and 8.1% preferred not to answer). With further secondary questions (optional) it emerged that consumption electricity averages around 2250 kWh while heat consumption is around 4250 kWh. The 74.8% of interviewees said they were aware how much is the energy expenditure (in addition, 18.9% are not aware of it and 6.3% preferred not to answer). As expected, looking at the percentages of the two previous questions, respondents are more aware of the expenditure they incur (per month or year) to obtain energy than the amount of energy used. This happens because they periodically have to pay their bills to continue receiving the service offered and, therefore, these are expenses that are usually always clear in everyone's mind. With further secondary questions (optional) it emerged that spending for electricity consumption average is around 110 €/month while spending for heat consumption average is around 1300 €/year.

(iii) The relationship between user, building and context is explored through three questions. Figure 76 shows that 83 respondents (47.8%) are homeowners, 21 (18.9%) are rented out and 7 (6.3%) preferred not to respond. Furthermore, according to what has been stated, the average stay time, in the current home, is around 18 years, with a minimum of a few months to a maximum of 65 years; in addition 4 respondents preferred not to answer.

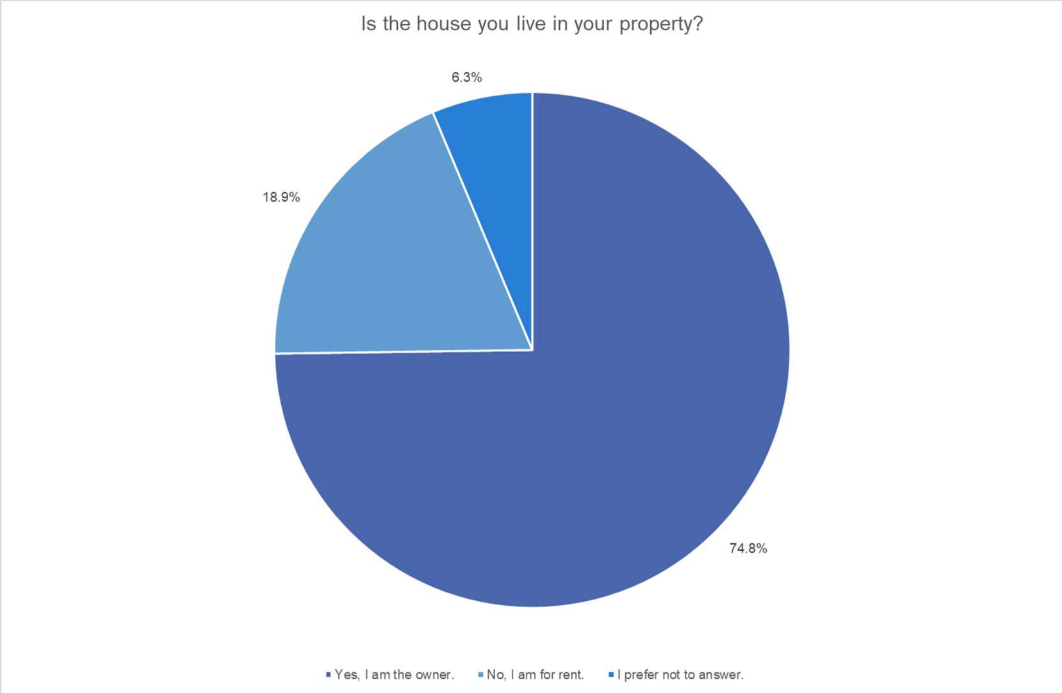

Figure 76. Building property (P3-Q09).

Finally, respondents were asked to imagine their future over a 3-5 year period (results in Figure 77). Most of the respondents (67.6%) declared that they live in the same house, 10.8% that they lived in another house but in the same municipality, 5.4% that they lived in another house but always in a municipality of the Valle di Susa. 2 respondents (1.8%), on the other hand, declared that they wanted to live outside the Susa Valley and 16 respondents (14.4%) did not have clear what their future could be.

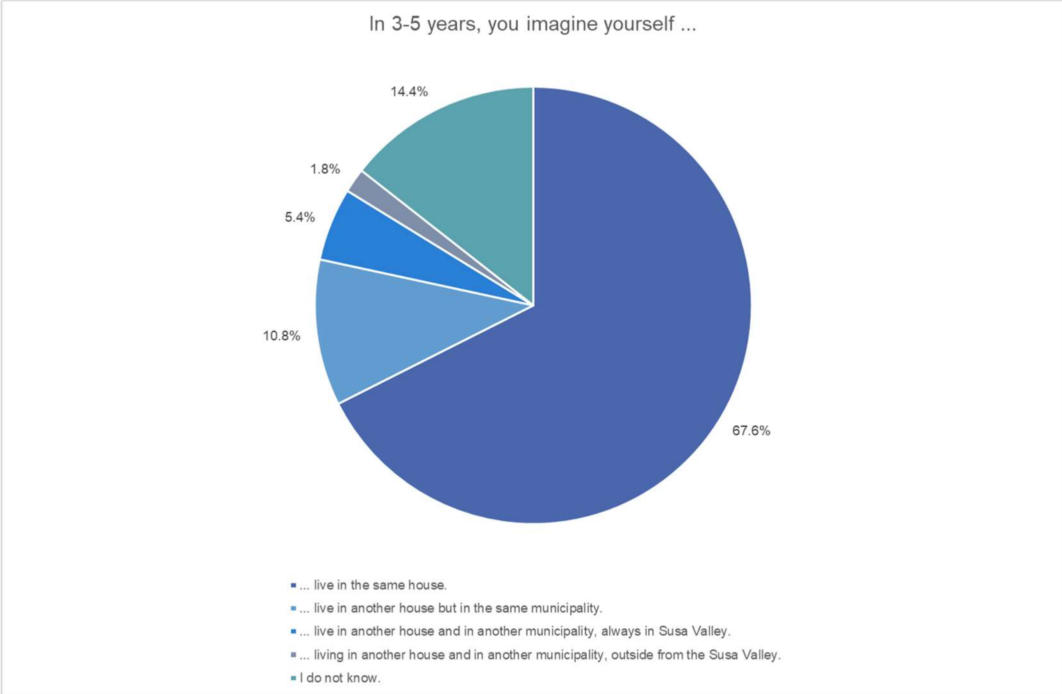

Figure 77. Future (P3-Q11).

Fourth part: socio-demographic information.

This paragraph shows the results relating to the fourth part of the questionnaire which deepens (i) the economic situation/condition of building occupants, (ii) the socio-demographic respondents' characteristics.

(i) The economic situation/condition of building occupants is explored through five questions. Question 01 concerns the respondents' occupation. As shown in Figure 78, the majority of respondents (85.6%) said they were employed while only 1.8% were not employed. 9.0% of respondents are retired while students are 1.8%; finally, 1.8% said something else or preferred not to answer.

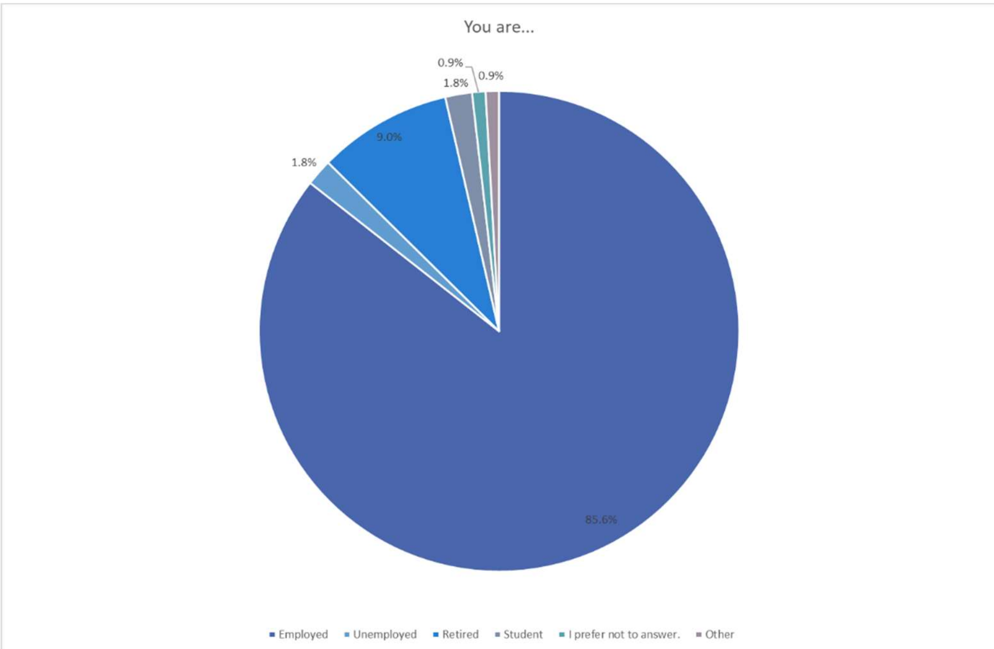

Figure 78. Occupation (P4-Q01).

Furthermore, the economic situation was investigated through three questions. Specifically, with Question 04 the interviewees were asked to indicate, on the basis of the total monthly net income of all the people living in their own home, one of the indicated income range. Figure 79 shows how the monthly income with the highest percentage of preferences (20.7%) is between 2001€ and 2500€, followed by 17.1% an income between 1001€ and 1500€. Again, 16.2% of respondents said they had a monthly net income between 3001€ and 4000€ and 12.6% between 1501€ and 2000€. The other ranges got less consensus.

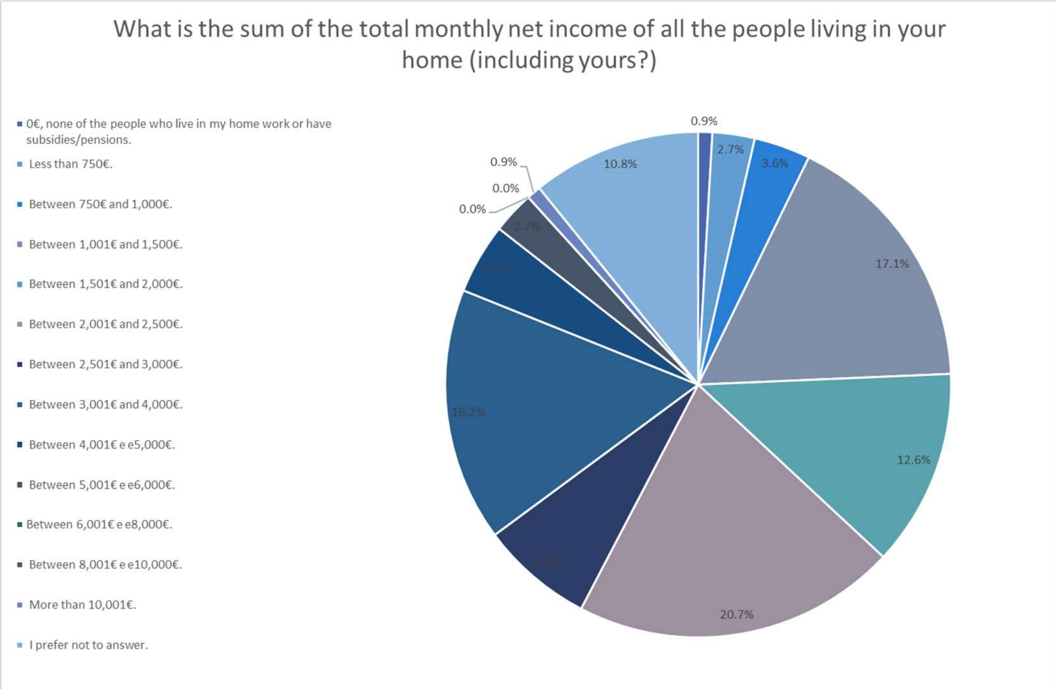

Figure 79. Family net income (P4-04).

Subsequently, the "monthly availability" of the family was investigated with Question 05, to which the interviewee had to answer by choosing only one range from those proposed. The result, shown in Figure 80, highlights how, excluding fixed costs, 16.2% said they had an availability between 200€ and 400€, 10.8% an availability between 400€ and 600€ and, finally, 11.7% an availability between 600€ and 800€. Finally, since the questions on income represent a rather delicate type of survey, it was chosen to ask a further question (Question 06) in which the respondent was asked to rate their economic condition on a 5-point scale from “live very comfortably” to “have great difficulties”. The answers obtained (Figure 81) show an almost positive situation, despite the difficulties that characterize these years to which the pandemic situation has been added. Indeed, 46.8% of respondents said to live comfortably, 37.8% said to neither have difficulties nor live comfortably (in other words, they just manage to cope with current expenses) and 9.0% said to have small difficulties. The options "live very comfortably" and "have great difficulties" were both selected by 1.8% of respondents. Instead, 2.7% of respondents preferred not to answer the question.

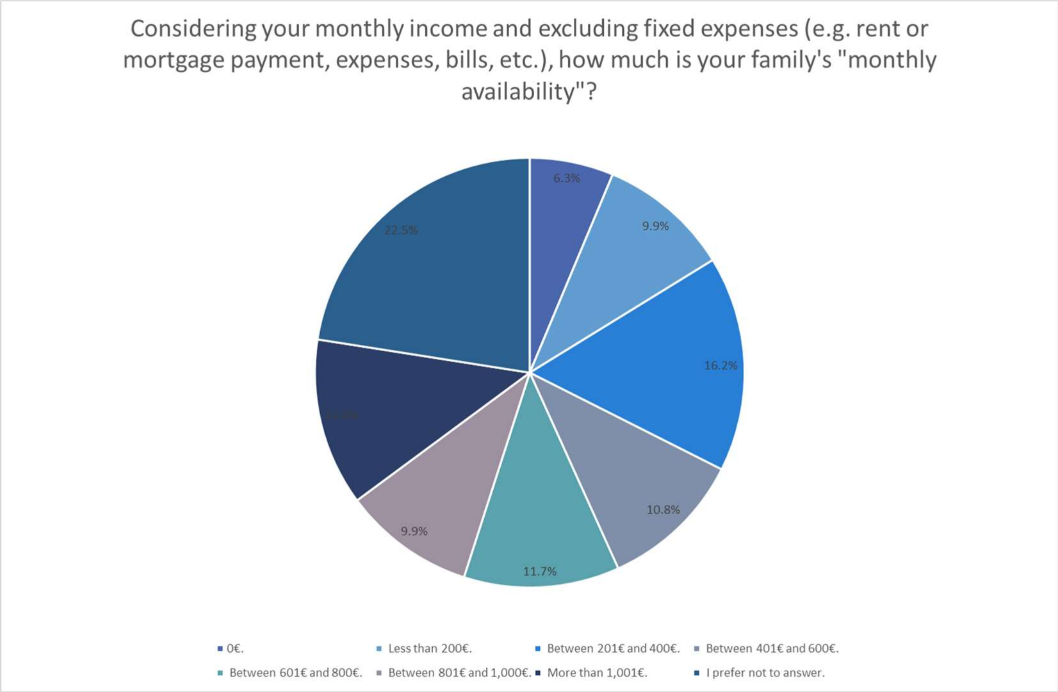

Figure 80. Family monthly availability (P4-Q05).

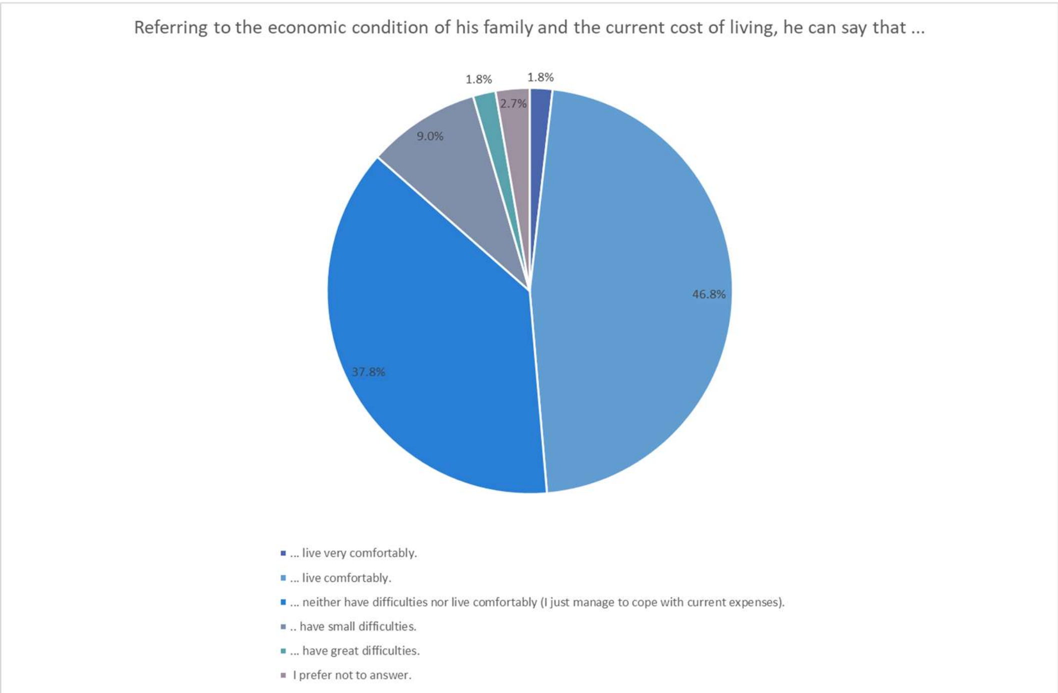

Figure 81. Personal opinion on family economic condition (P4-Q06).

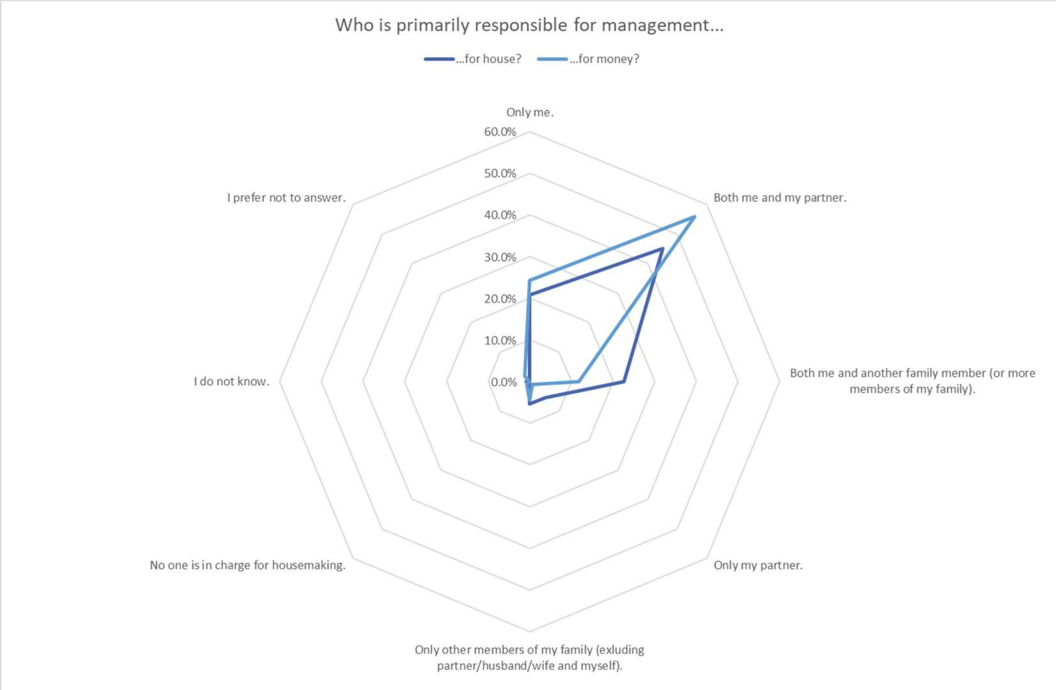

Figure 82. House and money management (P4-Q02/Q03).

Figure 82 shows the results relating to home and money management in the family. The radar chart shows how, usually, this is managed jointly between partners (45.0% and 55.9%), only by the person interviewed (20.7% and 24.3%) or jointly with other members of their family (22.5% and 11.7%). Finally, analysing the family composition (Question 07), on average the family unit is made up of almost three people (exactly like the Italian average situation); this does not exclude different cases in which a minimum of 1 component and a maximum of 7 has been detected.

(ii) Concerning the socio-demographic respondents' characteristics, the sample is composed by 39.6% of women and the remaining part (60.4%) of men. 49 years is the average age of the respondents (with a standard deviation of about 13 years); the youngest respondent is 20 years old, while the oldest is 77 years old. The following figure (Figure 83) shows the educational status of the respondents. The 50.5% of the respondents obtained a high school diploma, 29.7% a degree (bachelor and/or master's degree), 15.3% a secondary school diploma and 3.6% a research doctorate. Only one respondent preferred not to answer. Finally, analysing the marital status (Question 11), most of the respondents are married (53.15%), 27.0% are unmarried, 14.4% are separated or divorced and 1.8% are widowed. The 2.7% of respondents preferred not to answer the question.

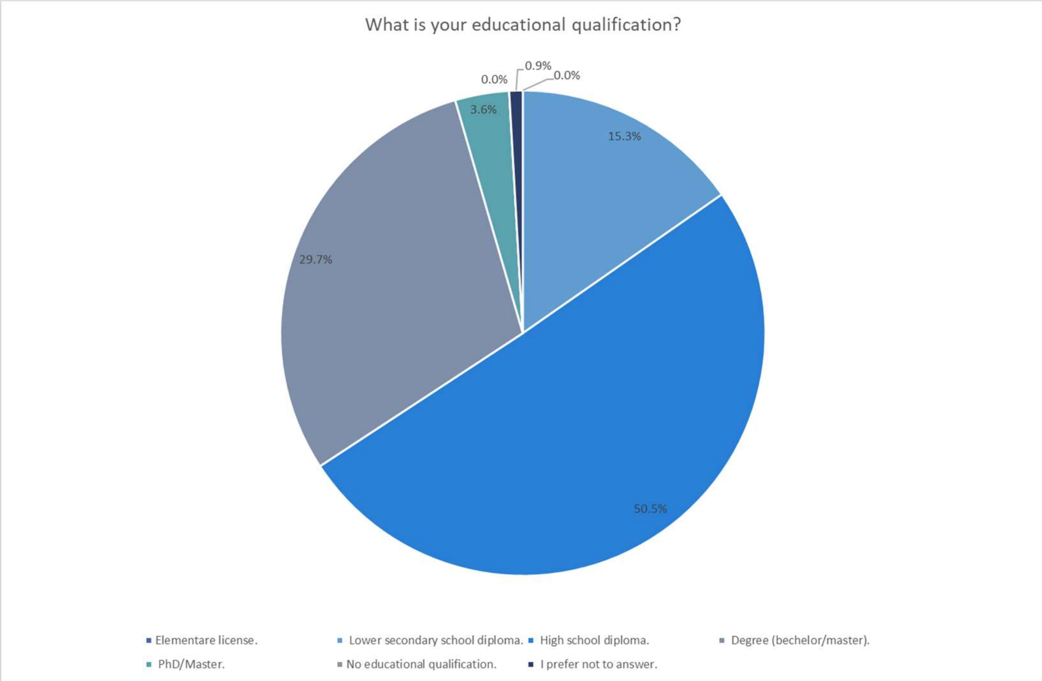

Figure 83. Educational qualification (P4-Q10).

b) Citizens clusters

In this part, through the cluster analysis, homogeneous groups of citizens are identified in order to promote specific inclusion strategies to commit towards an energy community project. The clustering is based on the variables of the first two part of the questionnaire: the variables relating the attitude and availability towards community projects based on renewable energy and the variables relating to feelings and community identity. The variables of these first two parts of the questionnaire are 43 and they are listed, respectively, in Table 34 and Table 35.

Table 34. The variables of first part of questionnaire.

Question number	Variable name	Range of values
Variables regarding the renewable energy community project.		
Q01	RECP interest	Judgment on statement, expressed by a score from 1 (Not interested at all) to 5 (Very interested), I do not know.
Q03	RECP active participation	Judgment on statement, expressed by a score from 1 (Not interested at all) to 5 (Very interested), I do not know.
Q04	RE production	Judgment on statement, expressed by Yes or No.
Q05	RECP economic investment	Judgment on statement, expressed by a score from 1 (Not available at all/) to 5 (Very available), I do not know.
Q05.2	RECP una tantum investment	Judgment on statement, expressed by Yes or No.
Q06	RECP active participation, other buildings	Judgment on statement, expressed by a score from 1 (Not available at all/) to 5 (Very available), I do not know.

Variables regarding the improvement of energy efficiency in buildings.		
Q07.1-A	Lighting	Judgment on statement, expressed by a score from 1 (I strongly disagree) to 5 (I strongly agree), I do not know.
Q07.1-B	Big appliances	
Q07.1-C	Little appliances	
Q07.1-D	Heat pump	
Q07.3-E	Windows	
Q07.3-F	Insulation	
Q07.3-G	Boiler	
Q07.3-H	RE	
Variables regarding the behavioural change.		
Q08.1-I	Lighting	Judgment on statement, expressed by a score from 1 (I strongly disagree) to 5 (I strongly agree), I do not know.
Q08.1-L	Stand-by	
Q08.1-M	Eco-mode	
Q08.1-N	Full load	
Q08.1-O	Defrost	
Q08.1-P	More cloths	
Q08.1-Q	Turn off energy system	
Q08.1-R	In winter, 21°C	
Q08.1-S	In summer, 26°C	
Q09	Habitual practice	Judgment on statement, expressed by a score from 1 (Not available at all) to 5 (Very available), I do not know.
Variables regarding the adaptation to new energy production model.		
Q10-A	Appliances	Judgment on statement, expressed by a score from 1 (I strongly disagree) to 5 (I strongly agree), I do not know.
Q10-B	Electric device charging	
Q10-C	Electric vehicle charging	
Variables regarding the device installation.		
Q11	Monitoring device	Judgment on statement, expressed by a score from 1 (Not available at all/) to 5 (Very available), I do not know.
Variables regarding the social influence		
Q12-A	RE use	Judgment on statement, expressed by a score from 1 (I strongly disagree) to 5 (I strongly agree), I do not know.
Q12-B	Energy saving	
Q12-C	RE participation	
Variables regarding the environmental protection		
Q13	Environmental protection	Judgment on statement, expressed by a score from -3 (Not important) to +3 (Important).

Table 35. The variables of second part of questionnaire.

Question number	**Variable name**	**Range of values**
Variables regarding feelings.		
Q01	Trust	Judgment on statement, expressed by a score from 1 (I don't feel this feeling at all) to 5 (I feel this feeling strongly), I do not know.
	Pride	
	Hope	
	Shame	

	Fear	
	Boredom	
Variables regarding the community identity.		
Q02-A	Bond	Judgment on statement, expressed by a score from 1 (I strongly disagree) to 5 (I strongly agree), I do not know.
Q02-B	Good friends	
Q02-C	Good place	
Q03	Trust in people	Judgment on statement, expressed by a score from 1 (I absolutely must not trust) to 5 (I can trust completely), I do not know.
Q04	Relationship	Judgment on statement, expressed by a score from 1 (Very tiring) to 5 (Not at all tiring), I do not know.

Since some variables investigate the same aspect, these have been grouped in order to reduce their number equal to 23. The analysed variables are listed in Table 36; each new variable has taken on a value obtained by adding the values of the variables it consists of.

Table 36. Variables used for cluster analysis.

Variable number	Variable name	Range of values
V101	RECP interest	Judgment on statement, expressed by a score from 1 (Not interested at all) to 5 (Very interested), I do not know.
V103	RECP active participation	Judgment on statement, expressed by a score from 1 (Not interested at all) to 5 (Very interested), I do not know.
V104	RE production	Judgment on statement, expressed by Yes or No.
V105	RECP economic investment	Judgment on statement, expressed by a score from 1 (Not available at all/) to 5 (Very available), I do not know.
V105.2	RECP *una tantum* investment	Judgment on statement, expressed by Yes or No.
V106	RECP active participation, other buildings	Judgment on statement, expressed by a score from 1 (Not available at all/) to 5 (Very available), I do not know.
V107.1	Improvement of energy efficiency in buildings (appliances)	Judgment on statement, expressed by a score from 4 (I strongly disagree) to 20 (I strongly agree), I do not know.
V107.3	Improvement of energy efficiency in buildings (envelope)	Judgment on statement, expressed by a score from 4 (I strongly disagree) to 20 (I strongly agree), I do not know.
V108.1	Behavioural change	Judgment on statement, expressed by a score from 9 (I strongly disagree) to 45 (I strongly agree), I do not know.
V109	Habitual practice	Judgment on statement, expressed by a score from 1 (Not available at all) to 5 (Very available), I do not know.
V110	Adaptation to new energy production model	Judgment on statement, expressed by a score from 3 (I strongly disagree) to 15 (I strongly agree), I do not know.
V111	Monitoring device	Judgment on statement, expressed by a score from 1 (Not available at all) to 5 (Very available), I do not know.
V112	Social influence	Judgment on statement, expressed by a score from 3 (I strongly disagree) to 15 (I strongly agree), I do not know.
V113	Environmental protection	Judgment on statement, expressed by a score from -3 (Not important) to +3 (Important).
V201-A	Trust	Judgment on statement, expressed by a score from 1 (I don't feel this feeling at all) to 5 (I feel this feeling strongly), I do not know.
V201-B	Pride	Judgment on statement, expressed by a score from 1 (I

		don't feel this feeling at all) to 5 (I feel this feeling strongly), I do not know.
V201-C	Hope	Judgment on statement, expressed by a score from 1 (I don't feel this feeling at all) to 5 (I feel this feeling strongly), I do not know.
V201-D	Shame	Judgment on statement, expressed by a score from 1 (I don't feel this feeling at all) to 5 (I feel this feeling strongly), I do not know.
V201-E	Fear	Judgment on statement, expressed by a score from 1 (I don't feel this feeling at all) to 5 (I feel this feeling strongly), I do not know.
V201-F	Boredom	Judgment on statement, expressed by a score from 1 (I don't feel this feeling at all) to 5 (I feel this feeling strongly), I do not know.
V202	Community identity	Judgment on statement, expressed by a score from 3 (I strongly disagree) to 15 (I strongly agree), I do not know.
V203	Trust in people	Judgment on statement, expressed by a score from 1 (I absolutely must not trust) to 5 (I can trust completely), I do not know.
V204	Relationship	Judgment on statement, expressed by a score from 1 (Very tiring) to 5 (Not at all tiring), I do not know.

Cluster analysis was performed using R software and, accordingly, the dataset was prepared. To proceed with the cluster analysis it is necessary that the data matrix consists solely of numerical values. The variables investigated are ordinal or dichotomous variables. The sortable variables have been transformed into a score from 1 to 5, where 1 indicates “disagree/not interested/not available” and 5 indicates “agree/interested/available”. Instead, the question options "I prefer not to answer" and "I don't know" have been transformed, after discussion, by assigning a score of 0. Finally, the dichotomous variables have been transformed into 0/1, where 0 indicates the absence of the investigated characteristic and 1 its presence.
Subsequently, after having prepared the matrix of the observations, the k-means method was applied. The first step was the identification of the number of clusters though the so-called "Elbow" method. The code implemented in R is written below and the graphical output of the method is shown in Figure 84.

```
>   dataset<-read.csv2("CA-dataset-def.csv")
>   View(dataset)
>   install.packages(c("cluster", "factoextra"))
>   scaled_dataset<- scale(dataset)
>   set.seed(123)
>   k.max <- 20
>   data <- scaled_dataset
>   wss <- sapply(1:k.max, function(k){kmeans(data, k, iter.max = 25,
    nstart=50) $tot.withinss})
>   wss
>   plot(1:k.max, wws, type="b", pch = 19, frame = FALSE, xlab="Number
    of clusters K", ylab="Total within-clusters sum of squares")
```

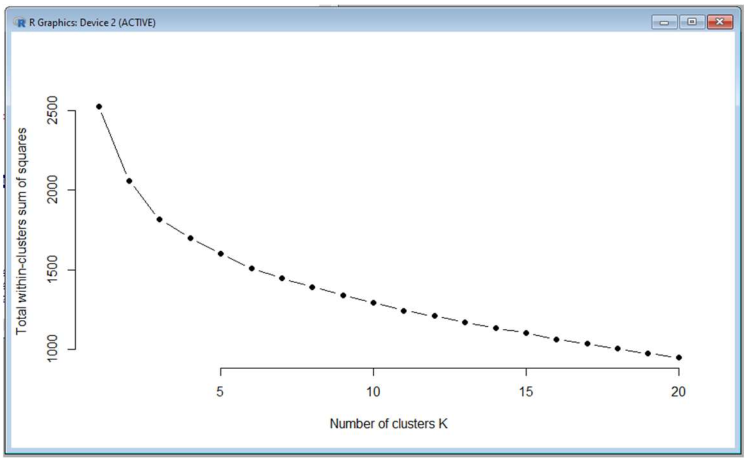

Figure 84. Identification of the number of clusters.

The final step is the cluster definition, using as input data the result obtained through the Elbow method (4 clusters in this case), through the following code.

```
> km.res <- kmeans(scaled_dataset, 4, iter.max = 25, nstart = 50)
> print(km.res)
```

Table 37 shows the output of cluster analysis. The 4 clusters are made up of 42, 40, 7, 22 users and for each variable, the mean value for each cluster is expressed.

Table 37. Cluster analysis result.

K-means clustering with 4 clusters of sizes 42, 40, 7, 22

Variable	Cluser 1	Cluster 2	Cluster 3	Cluster 4
Q101	3.904762	4.550000	2.857143	3.863636
Q103	3.714286	4.175000	2.571429	3.136364
Q104	0.4285714	0.3500000	0.2857143	0.2272727
Q105	2.595238	3.650000	2.571429	2.636364
Q105.2	0.2380952	0.6000000	0.2857143	0.2272727
Q106	3.190476	3.800000	2.571429	3.090909
Q107.1	15.880952	17.800000	8.428571	11 .454545
Q107.3	17.26190	18.32500	4.00000	12.77273
Q108.1	33.69048	42.32500	21.00000	37.45455
Q109	4.095238	4.725000	2.571429	4.000000
Q110	11 .642857	12.300000	4.285714	8.545455
Q111	3.619048	3.900000	3.142857	3.045455
Q112	9.333333	10.450000	3.571429	6.954545
Q113	2.595238	2.850000	1.428571	2.500000
Q201-A	3.000000	3.975000	1.428571	2.590909
Q201-B	3.0476190	4.1750000	0.2857143	2.2727273
Q201-C	3.500000	4.275000	1.285714	2.909091
Q201-D	1.8809524	1.5750000	0.2857143	1.9545455
Q201-E	2.0000000	1.8250000	0.2857143	1 .7727273
Q201-F	2.1666667	1.8750000	0.2857143	1.6818182
Q202	10.857143	13.050000	6.714286	9.272727
Q203	3.047619	3.650000	2.000000	2.772727
Q204	2.404762	2.750000	1 .714286	1.909091

Within cluster sum of squares by cluster :
[1] 2482.619 1905.950 1143.714 2206.591
(between_SS / total_SS =49.5 %)

Cluster 1. This cluster consists of 42 users (37.8% of respondents). In general, they are respondents who have a general interest and a willingness to participate in community projects based on renewable energy. The will to participate economically is high. The feelings towards the community are, in general, positive even if there is some fear and boredom. It is possible to say that for this cluster it is essential to pay attention and define inclusion policies. They are proactive but in order for them to be fully committed they must be encouraged, they must be more involved, thinking of targeted actions and tailor-made incentives.

From the observation of the socio-economic data, shown in Table 38, it is evident that within this cluster 61.9% live in an independent house and 23.8% in a semi-detached house. Furthermore, 71.4% own the house they live in and 76.2% said they want to continue living in that same house in the near future. These are elements that favour the implementation of projects first of energy efficiency and then of co-ownership of renewable energies. The percentage between those who have installed a renewable source plant (47.6%) and those who have not (52.4%) is similar. Consequently, this cluster alone is able to approach environmental issues. As regards the economic situation of the family, the income stands with higher percentages between € 2000 and € 5000; 28.3% of respondents said they had more than € 800 available at the end of the month and, consequently, 45.2% say they live comfortably (although 45.2% also said they had no difficulty but did not live comfortably). In addition, the average age of this cluster is 47 years old, 67.7% male and predominantly with a high school diploma (54.8%) or a university degree (26.2%).

Cluster 2. This cluster consists of 40 users (36.0% of respondents). Users are interested in participating in RECP, they are interested in actively participating, they are interested in investing economically, they agree in undertaking actions aimed at improving energy efficiency and in undertaking new behaviours aimed at energy saving. They also have positive feelings, such as pride and hope, and they trust other people. In short, he is the user ready to participate fully in a community project based on renewable energy. No training is needed for them, only initiatives are needed that keep their interest alive; on the contrary, they can be the ones to spur other clusters.

From the observation of the socio-economic data, shown in Table 38, it is evident that within this cluster 62.5% live in an independent house and 20% in a semi-detached house. Furthermore, 85% own the house they live in and 65% said they want to continue living in that same house in the near future. These are elements that favour the implementation of projects first of energy efficiency and, then, of co-ownership of renewable energies. 65.0% declared that they had not installed any production plant from renewable sources, while 35.0% declared they own it. As regards the economic situation of the family, the income stands with higher percentages between € 2000 and € 4000; 30% of respondents said they had more than € 800 available at the end of the month and consequently 57.5% say they live comfortably. In addition, the average age of this cluster is 49 years old, 65% male and predominantly with a high school diploma (50.0%) or a university degree (37.5%).

Cluster 3. This cluster consists of 7 users (6.3% of respondents). Users are not interested in participating in RECP, they are not interested in actively participating, they are not interested in investing economically, they disagree in undertaking actions aimed at improving energy efficiency and in undertaking new behaviours aimed at energy saving. Rather than not being interested, they often expressed a desire not to want to answer the questions asked. As for the feelings they have, they have neither positive nor negative feelings. In some ways they can be defined apathetic towards the issue. This is the cluster to which to devote more effort and attention; certainly towards them it is first necessary to capture their attention and then increase awareness of their behaviour and increase the sense of belonging to their community.

From the observation of the socio-economic data, shown in Table 38, it is evident that within this cluster 57.1% live in condominium apartment. Furthermore, 71.4% live for rent. Even if, the 57.1% said they want to continue living in that same house in the near future, the house typology and the building ownership are elements that hinder the implementation of projects first of energy efficiency and, then, of co-ownership of renewable energies. 85.7% declared that they had not installed any production plant from renewable sources, while 14.3% declared they own it. As regards the economic situation of the family, 28.6% declared to receive less than € 750; 28.6% of respondents said of not being able to save anything at the end of the month and, consequently, 42.9% say they have small difficulties and 42.9% declared to be able to cope with current expenses. In addition, the average age of this cluster is 57 years old, 57.1% male and predominantly with a high school diploma (42.9%) or a middle school diploma (42.9%).

Cluster 4. This cluster consists of 22 users (19.8% of respondents). In general, they have a very similar profile to the first cluster but with a decidedly lower interest in community projects. The greatest feeling experienced is shame and lack of trust in others. Also for this cluster it is essential to pay attention and define inclusion policies. In this case, first of all, it is necessary to increase the sense of belonging towards the living context by aiming to transform the feeling from shame to pride.

From the observation of the socio-economic data, shown in Table 38, it is evident that within this cluster 54.5% live in an independent house and 18.2% in a semi-detached house. Furthermore, 77.3% own the house they live in and 59.1% said they want to continue living in that same house in the near future. These are elements that favour the implementation of projects first of energy efficiency and then of co-ownership of renewable energies. The percentage between those who have installed a renewable source plant (9.1%) and those who have not (90.9%) is completely different. As regards the economic situation of the family, the income stands with higher percentages between medium range values; 40.9% say they have small difficulties and 40.9% declared to be able to cope with current expenses. In addition, the average age of this cluster is 50 years old, 59.1% female and predominantly with a high school diploma (45.5%) or a university degree (22.7%).

Table 38. Statistical analysis of the classes of the variables (Susa Valley).

Variable	Cluster 1 (42)	Cluster 2 (40)	Cluster 3 (7)	Cluster 4 (22)
What is the typology of your home?				
Apartment.	5	6	4	6
Single family house.	26	25	2	12
Semi-detached house/terraced house.	10	8	0	4
I prefer not to answer.	0	0	1	0
Other.	1	1	0	0
When was your building constructed?				
Before 1900.	5	2	1	4
Between 1900 and 1920.	6	2	0	0
Between 1921 and 1945.	3	1	0	0
Between 1946 and 1960.	2	4	0	3
Between 1961 and 1975.	11	11	0	2
Between 1976 and 1990.	4	2	2	4
Between 1991 and 2005.	5	11	1	6
Between 2006 and 2014.	3	6	1	1
After 2014.	0	0	0	1
I do not know.	3	1	2	0
I prefer not to answer.	0	0	0	1
In your house, did you install any energy production systems from renewable sources?				
Yes.	20	14	1	2
No.	22	26	6	20
Do you manage the energy system by yourself or is there any person to manage and maintenance it?				
I manage the energy system by myself.	25	15	5	8
There is a person for the management and maintenance of the energy system.	14	25	2	12
I prefer not to answer.	3	0	0	2
Do you know how much energy (heat and electricity) your household uses approximately per year?				
Yes.	7	7	0	3
No.	34	33	7	18
I prefer not to answer.	1	0	0	1
Do you know how much your household pays for energy (heat and electricity) approximately per month?				
Yes.	21	21	2	12
No.	17	17	5	7
I prefer not to answer.	4	2	0	3
Do you live in a rented accommodation or in your own home?				
Yes, I am the owner.	30	34	2	17
No, I am for rent.	9	3	5	4
I prefer not to answer.	3	3	0	1
In 3-5 years, you imagine yourself ...				
...live in the same house.	32	26	4	13
...live in another house but in the same municipality.	5	4	1	2
...live in another house and in another municipality, always in Susa Valley.	1	3	0	2
...live in another house and in another municipality, outside from the Susa Valley.	0	2	0	0
I do not know.	4	5	2	5
You are…				
occupied.	39	30	6	20
unoccupied.	0	1	1	0

retired.	1	7	0	2
student.	1	1	0	0
other.	1	0	0	0
I prefer not to answer.	0	1	0	0
Who is mainly responsible for homemaking in your household (cooking, cleaning etc.)?				
Only me.	7	4	2	10
Both me and my partner.	22	20	2	6
Both me and another family member (or more members of my family).	7	11	1	5
Only my partner.	2	3	1	0
Only other members of my family (excluding partner/husband/wife and myself).	3	1	1	1
I do not know.	1	0	0	0
Other.	0	1	0	0
Who is responsible for the daily management of money in your family?				
Only me.	7	5	4	11
Both me and my partner.	26	24	3	9
Both me and another family member (or more members of my family).	4	7	0	1
Only my partner.	1	0	0	0
Only other members of my family (excluding partner/husband/wife and myself).	2	2	0	1
No one is in charge for money.	1	0	0	0
I do not know.				
Other.	0	1	0	0
I prefer not to answer.	1	1	0	0
In which range can you place the sum of the total monthly net income of all the people living in your home (including yours)?				
0€, none of the people who live in my home work or have subsidies/pensions.	0	0	0	1
Less than 750€.	1	0	2	0
Between 750€ and 1,000€.	2	1	0	1
Between 1,001€ and 1,500€.	10	4	1	4
Between 1,501€ and 2,000€.	6	4	1	3
Between 2,001€ and 2,500€.	5	9	1	8
Between 2,501€ and 3,000€.	4	3	0	1
Between 3,001€ and 4,000€.	8	9	0	1
Between 4,001€ and 5,000€.	2	3	0	0
Between 5,001€ and 6,000€.	1	2	0	0
Between 6,001€ and 8,000€.	0	0	0	0
Between 8,001€ and 10,000€.	0	0	0	0
More than 10,001€.	1	0	0	0
I prefer not to answer.	2	5	2	3
If you exclude the average amount of fixed expenses (e.g. rent or mortgage payment, expenses for food/bills/etc.), how much money remain monthly for the family?				
0€.	1	2	2	2
Less than 200€.	3	5	1	2
Between 201€ and 400€.	10	4	1	3
Between 401€ and 600€.	4	4	0	4
Between 601€ and 800€.	3	6	1	3
Between 801€ and 1,000€.	6	4	0	1
More than 1,001€.	6	8	0	0
I prefer not to answer.	9	7	2	7
Considering the economic condition of your family and the actual cost of living, you can to…				
...live very comfortably.	0	2	0	0
...live comfortably.	19	23	1	9
...neither have difficulties nor live comfortably (I just manage to cope with current expenses).	19	11	3	9
..have small difficulties.	2	3	3	2

...have great difficulties.	1	1	0	0
I prefer not to answer.	1	0	0	2
How old are you?				
Age (years)	47	49	57	50
What is your gender?				
Female	14	14	3	13
Male	28	26	4	9
What is the highest degree you obtained?				
Elementare license.	1	0	0	0
Lower secondary school diploma.	6	3	3	5
High school diploma.	23	20	3	10
Degree (bechelor/master).	11	15	0	7
PhD/Master.	1	2	1	0

5.3 Litoměřice (Czech Republic)

Litoměřice is a city in the north of the Czech Republic, capital of the district with the same name, in the Ústí nad Labem region.

5.3.1 The energy community project

The Litoměřice case study concerns three RE investment projects (Figure 85) for PV power plant installation: the Centrum Srdíčko, providing social and health service; the Apartment Block Plešivecká, consisting of 32 housing units which are using electricity for normal operation, excluding heating and electricity consumption for the provision of hot water; and the PAVE, consisting of former military barracks (former dormitory and boiler room from 1980) which are converted into the first so-called "energy active public building" with small flats for young families from Litoměřice.

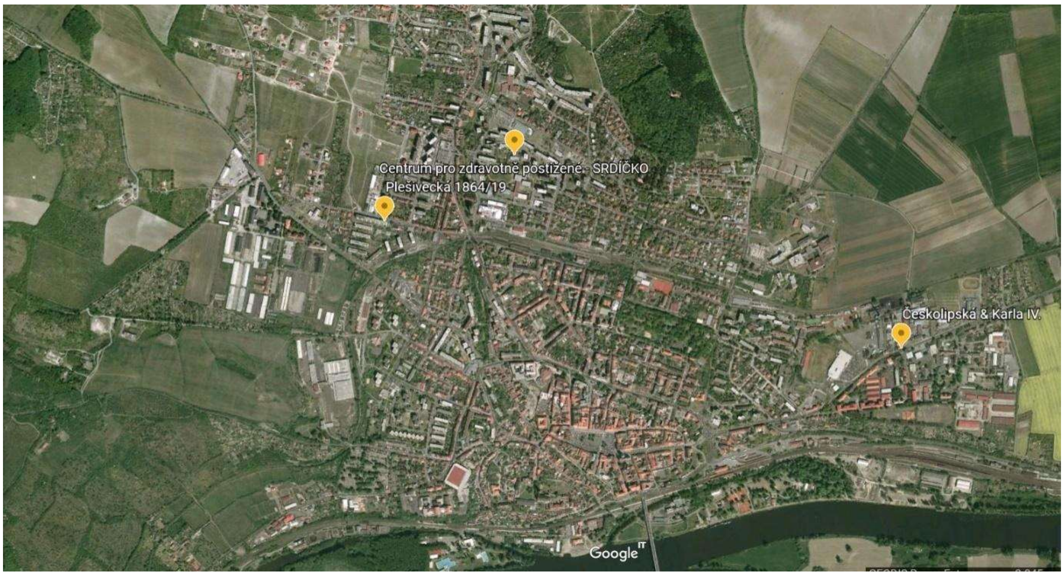

Figure 85. Location of pilot projects in Litoměřice (source www.earth.google.com).

The first project, providing social services will help decrease the energy consumption and the CO_2 emissions, while the savings will increase the amount of funds available to the day-care centre. The second project in Plešivecká apartments will increase self-sufficiency and reduce the operative costs in the building, while the PAVE project will seek the revitalisation of a former dormitory and boiler room into the first energy active public building providing flats for local inhabitants in Litoměřice. This project does not only include the installation of renewable energy but also encompass energy storage capacity (because of a lack of grid compatibility) and electro-mobility development. The PV installation was maximised to ensure the overall coverage of the building's energy consumption.

In the next paragraphs, following the structure described in Chapter 4, the actions aimed at creating an energy community in Litoměřice are described. Specifically, the part of the technical structure is fully described in the project Deliverable (Union, 2020); in this thesis, only the social structure is deepened, since it represents the core of the energy community creation.

5.3.2 Social structure

In this paragraph, the application regarding the social structure is described. Specifically, for this case study, only the target group involvement, that concerns all the processes aimed at encouraging the users' inclusion/participation in community projects or promoting a behaviour change, is exposed and in-depth.

Part IV: target group involvement

In this part, the actions related to obtain data about users' characteristics, in order to identify the main drivers that favour/hinder their participation in energy community projects, and, consequently, clustering the population on the basis of one's possibilities, in order to promote specific inclusion strategies to commit towards an energy community project, are addressed. The application context is the whole city of Litoměřice.

a) Questionnaire

Design phase. For the case study of Litoměřice, a reduced version of the questionnaire was defined, with the possibility, for respondents, to choose one of the following languages: Czech or English. The reference questionnaire is the extended version in Italian language but some questions have been deleted or reformulated, after a discussion with a panel of experts, in order to make the questionnaire more streamlined. In addition, the questionnaire was pre-tested with citizens (citizens not necessarily with training in the energy field and knowledge on the topic of energy communities). The final composition consists of 30 questions, always divided into 4 parts: information on attitude and willingness, information on feelings and community identity, technical information and socio-demographic information. It is reported in Appendix C.

Distribution phase. The questionnaire is administered between citizens of the specific context in Litoměřice. The distribution of the questionnaire began on November 2, 2020 and ended on November 25, 2020; it was influenced by the health emergency determined by the risk of infection from Covid-19; for this reason, the dissemination of the questionnaire took place only online. For this reason, an online version was defined using the SoSci Survey platform (https://www.soscisurvey.de/scorepilots/), since this tool allows to implement the question/answer logic. The definition of an Action Plan allows to choose and plan through which channels and how to distribute the questionnaire. The distribution methods are listed below.

- Email invitation. Sending questionnaire links to a default contact list; in addition, the sending of reminders has been scheduled.
- Event participation. For online events, the questionnaire link has been shared using the platform used for the meeting and sent through email.

Data pre-processing and analysis. In this paragraph, a first general analysis on the data is treated. As described for the Susa Valley case study, the action are the dataset cleaning (the removal of unwanted observations, the adjustment of structural errors and the filtering of unwanted outliers) and the first analysis relating to the statistical description of the responses (highlighting maximums, minimums, mode and median values; in addition, the distribution of the answers is shown, mainly through histograms and pie charts).

The questionnaire answers were accepted in the period between November 2, 2020, 2020 and November 25, 2020. Due to the several approaches used for the online dissemination, it is difficult to accurately determine the number of citizens actually reached. Pointing out that the total number of online responses concerns the answers of those who opened the link and started the questionnaire compilation, whether they completed it or did not complete it, the total number of online responses are 82. The completed responses are 75; therefore, the overall response rate is 91.5%. The average time for completing the online questionnaire was 12 minutes. The minimum time recorded was about 2 minutes, while the maximum time was 2 hours and 5 minutes. The interquartile range (IQR) is between 5 minutes (25th percentile) and 12 minutes (75th percentile); the second quartile (50th percentile) is about 7 minutes. Time values greater than 22 minutes (upper whisker) are highlighted as statistically anomalous; on the other hand, for the definition of time as an always positive quantity, any anomalous data, lower than the lower whisker (that is equal to 0) cannot be evaluated. In this specific case, six values greater the upper whisker was recorded. A detailed check was carried out and it showed that they are not to be considered anomalous data since the questionnaire allows to save the given answers and continue it later. Consequently, due to this reason, also the average compilation time is influenced by this possibility of save and recovery.

In the following paragraphs, the results obtained are shown maintaining the same structure of the questionnaire: first the information on attitude and willingness, then the information on feelings and community identity, afterwards the technical information, and, finally, the socio-demographic information.

First part: information on attitude and willingness.

This paragraph shows the results relating to the first part of the questionnaire which deepens (i) the interest and the willingness towards renewable energy community projects, (ii) the willingness to energy consumption and (iii) the social influence and the personal environmental judgment.

(i) In the interest and the willingness towards RECPs (renewable energy community projects), questions aimed at exploring first, a general interest (Q01), then, the interest in investing economically (Q12) are analysed and the in Table 39 the main results are summarized. Participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In addition, the possibility to choose the "I don't know" option or to leave the answer blank is given.

Table 39. Main questions relating the willingness towards RECP.

Question	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I agree**	**(5) I strongest agree**	**I do not know**	**No answer**
Q01: In principle, I am interested in participating in a renewable energy community.	(2) 2.7%	(3) 4.0%	(17) 22.7%	(24) 32.0%	(22) 29.3%	(7) 9.3%	(0) 0.0%
Q12: I would be willing to invest in a renewable energy project.	(3) 4.9%	(2) 2.9%	(18) 24.0%	(34) 45.3%	(11) 14.7%	(7) 9.3%	(0) 0.0%

The comparison of the response percentages of each option shows how, despite the effort required to move from a simple interest to participation in renewable energy community projects to an economic investment, the preferences are in balance. Indeed, most of the respondents (29.3%) stated that they "strongly agree" and 32.0% stated that they "agree" in participating in community projects based on renewable energy. With regard to investing in a community project, the total percentage of the citizens in agreement are similar to the previous ones: 14.7% stated that they "strongly agree" and 45.3% stated that they "agree".

To better understand the respondents' point of view, some secondary questions, linked to these main questions, have been posed. Specifically, in these questions, the respondent was asked to choose one or more options among those proposed. The results related to the in-depth analysis of the participation in community projects based on renewable energy sources are shown in Table 40. Based on the answer given to Question 01, two possibilities arise:

- If the respondent has declared to be “Strongly agree” or “Agree”, was asked the reasons of interest in participating in a renewable energy community (Q02) and how the respondent would like to participate (Q03).
- If the respondent has declared to be “Strongly disagree” or “disagree” was asked the reason(s) (Q04) and the needs of not participation (Q05).

Table 40. Modalities, reasons and needs relating to (not) active participation.

Strongly agree or Agree	
Why are you interested in participating in a renewable energy community?	
I have an economic advantage (e.g. less energy costs)	33
I have an advantage in terms of more efficient services.	7
I have an economic advantage from making a profit.	11
I serve my community.	13
I contribute to the preservation of nature and the planet.	23
Other.	0
How would you like to participate in a renewable energy community?	
I would contribute or invest money.	23
I would contribute my knowledge e.g. in management or energy technology.	10
I would contribute my free time e.g. to take over tasks within the community.	13
I would provide surfaces to install energy production systems (e.g. on a roof or a field).	13
I would take an active role in the management of the renewable energy community.	4
I would spread information about planned projects/ activities in the neighbourhood and recruit new members.	14
Other.	0
Strongly disagree, Disagree or Neutral	
What factors make you not interested in participating in a renewable energy community?	
I don't have enough time.	1
I don't have enough money.	2
I don't have enough knowledge or skills.	0
I don't know and where.	1
I would have other disadvantages from participation (e.g. reduction of social benefits).	0
I prefer conventional energy supply.	1
I think the bureaucratic burden is too high.	0
I do not think that such a project is profitable.	0
I think that such a project is doomed to failure.	0
I mistrust such projects.	0
I generally do not want to invest.	1
I don't know why I don't want to participate.	0
Other.	0
What would convince you to participate in a renewable energy community?	
I want to be actively approached and involved by existing renewable energy communities.	0
I need financial support to participate, e.g. a zero interest loan to finance my participation or tax benefits.	1
I need and easier way to participate in the energy transition	0
I need an incentive for my participation	0
I would like to have the feeling of making a contribution to my social environment through my participation.	1
I want to feel that through my participation I am contributing to a sustainable lifestyle.	0
I need something else.	0
Nothing could convince me to participate.	3
I do not know.	0

In addition, the willingness to invest economically was investigated among all respondents in Question 18. The result shows that 30.7% of respondents expressed a zero-investment quota or did not answer, instead 69.3% of the respondents expressed a sum. No constraints were placed in the question and no reference was deliberately inserted in order not to influence the respondents' choice. Considering only the latter percentage of respondents, the minimum contribution expressed is 100€, the maximum contribution 30000€; the average is around 13000€. Furthermore, the average of annual return is 6 years and 6 are the average years since the investment is paid for itself. Furthermore, the reasons for not willingness in renewable energy project investment is analysed in Question 13. The figure below (Figure 86) shows the main barriers and obstacles expressed by respondents.

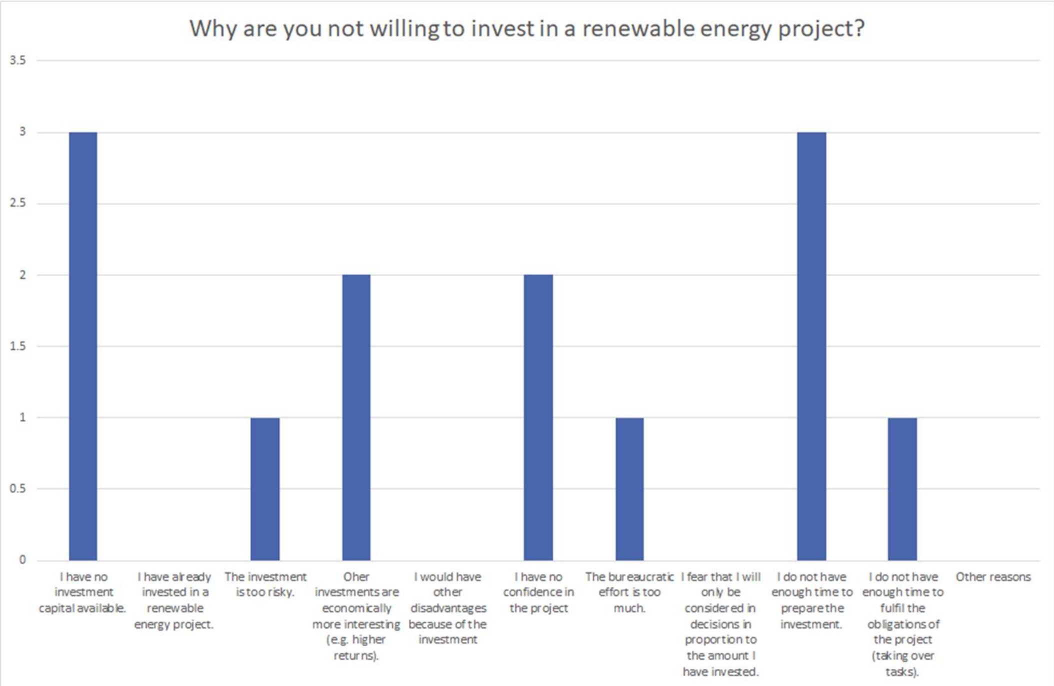

Figure 86. Reasons relating to not invest.

In Question 06, the participation in the production of energy from renewable sources is investigated; as shown in Figure 87, 21.3% of the respondents declared their participation in the production of energy from renewable sources; instead, the remaining part (78.7%) gave a negative answer. Among those who have declared a current participation (Question 07), 6 respondents are the owner or co-owner of a photovoltaic installation, 8 respondents of a solar thermal installation, 2 respondents of a wind turbine, 2 respondent of a biogas plant and 2 respondents are a co-owner of other installation. In addition, regarding the use of the produced energy through renewable energy installation (Question 08), 8 respondents use energy only for self-consumption, 5 respondents use energy only for sale, 2 respondents use energy both for self-consumption and for sale and 1 respondent use energy in other ways.

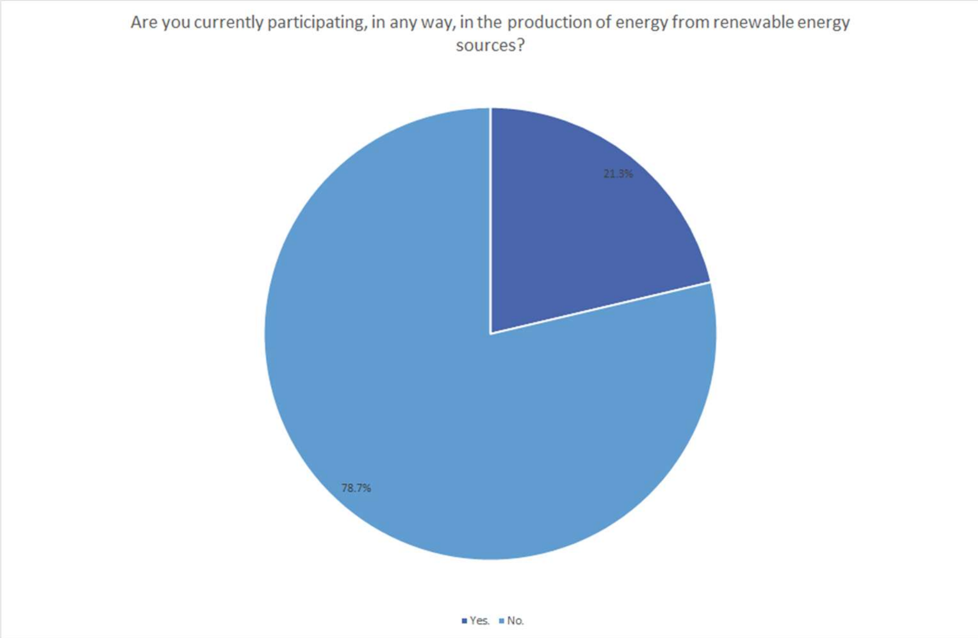

Figure 87. Renewable energy production participation (Q06).

(ii) Inside the first part of the questionnaire the willingness to reduce the energy consumption in buildings, investigating users' actions to increase the efficiency of the building envelope components and of the energy plant system, investigating users' behavioural change and, finally, investigating the energy use adaptation to the renewable energy production model characterized by volatility, is explored. The willingness to improve the building energy efficiency is investigated in Question 14; specifically, in Table 41 the availability by replacing old appliances (big and/or small appliances) with newer models that use less energy is investigated. Participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In addition, the possibility to choose the "I don't know" option or to leave the answer blank is given.

Table 41. Improvement of energy efficiency: replacement of appliances (P1-14).

Question 14: In order to reduce energy consumption, I am willing to...	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I Agree**	**(5) I strongly agree**	**I do not know**	**I prefer not to answer**
a: ...exchange older lighting with LED lamps.	(1) 1.3%	(2) 2.7%	(20) 26.7%	(21) 28.0%	(20) 26.7%	(11) 14.7%	(0) 0.0%
b: ...exchange an older refrigerator or freezer.	(1) 1.3%	(3) 4.0%	(17) 22.7%	(27) 36.0%	(14) 18.7%	(13) 17.3%	(0) 0.0%
c: ...exchange other older household appliances (e.g. dishwasher, washing machine, oven or dryer).	(2) 2.7%	(5) 6.7%	(27) 36.0%	(22) 29.3%	(14) 18.7%	(5) 6.7%	(0) 0.0%

d: ...exchange older consumer electronics (e.g. TV or hi-fi equipment).	(1) 1.3%	(8) 10.7%	(25) 33.3%	(23) 30.7%	(12) 16.0%	(6) 8.0%	(0) 0.0%
e: ...replace an older heating pump.	(2) 2.7%	(16) 21.3%	(23) 30.7%	(13) 17.3%	(6) 8.0%	(15) 20.%	(0) 0.0%

Furthermore, the 64% of the respondents declared that they had already replaced all or some of the listed equipment; the frequency of the interventions carried out is shown in Figure 88.

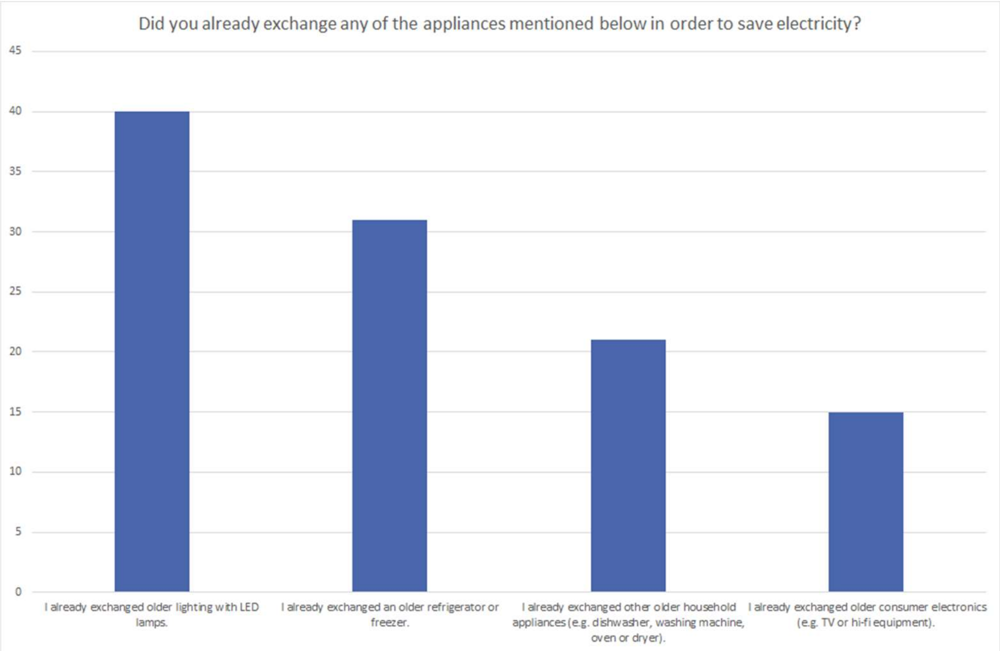

Figure 88. Frequency of appliances replacement (Q15).

Furthermore, the willingness to change the building users' behaviour is investigated in Question 16; specifically, in Table 42 the availability by modifying the use of energy related to the use of household appliances and/or interaction with the systems present in the home and/or applying specific behavioural practices is investigated. Participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In addition, the possibility to choose the "I don't know" option or to leave the answer blank is given.

Table 42. Improvement of energy savings: user's behaviour (Q16).

Question 16: To save electricity, I would be willing...	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I Agree**	**(5) I strongly agree**	**I do not know**	**I prefer not to answer**
f: ...turn off the light, even if I only leave the room for a short time.	(1) 1.3%	(12) 16.0%	(15) 20.0%	(25) 33.3%	(14) 18.7%	(8) 10.7%	(0) 0.0%
g: ...use power strips	(1)	(15)	(24)	(23)	(7)	(5)	(0)

with an off switch to avoid electrical appliances running in stand-by mode.	1.3%	20.0%	32.0%	30.7%	9.3%	6.7%	0.0%
h: ...use household appliances (e.g. washing machine or dishwasher) in energy-saving mode.	(1) 1.3%	(7) 9.3%	(22) 29.3%	(30) 40.0%	(9) 12.0%	(6) 8.0%	(0) 0.0%
i: ...use household appliances (e.g. washing machine or dishwasher) only when they are fully loaded.	(1) 1.3%	(10) 13.3%	(14) 18.7%	(30) 40.0%	(14) 18.7%	(6) 8.0%	(0) 0.0%
l: ...regularly defrost the refrigerator or freezer to avoid a layer of ice.	(2) 2.7%	(3) 4.0%	(25) 33.3%	(26) 34.7%	(13) 17.3%	(6) 8.0%	(0) 0.0%

Furthermore, 65.3% of respondents declared that they had already applied daily behaviours aimed to energy saving; the frequency of the interventions carried out is shown in Figure 89.

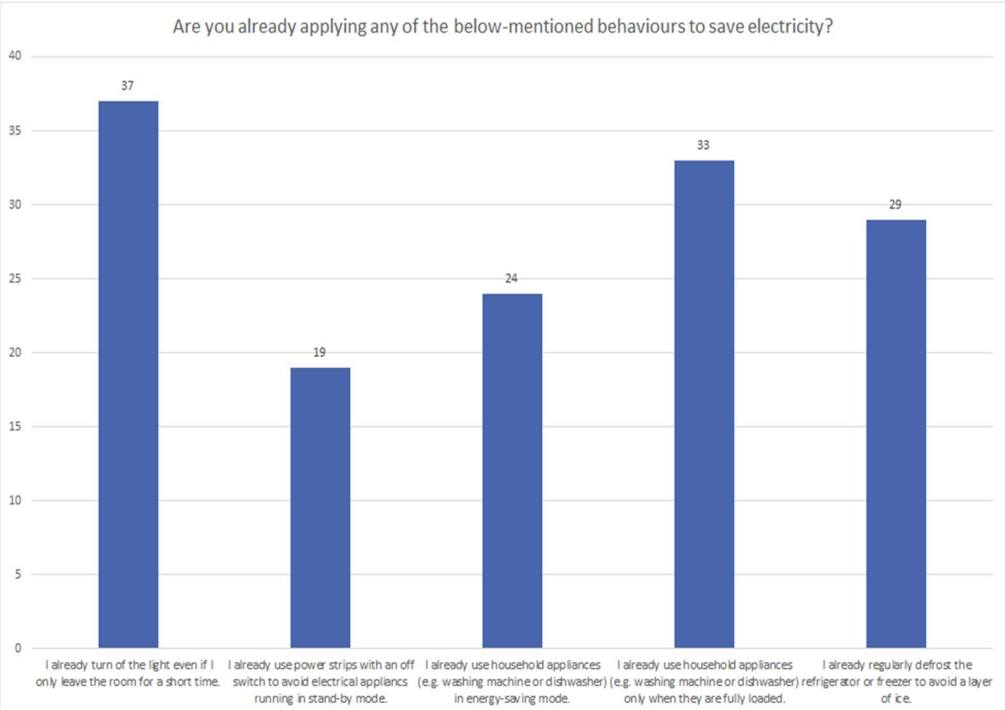

Figure 89. Frequency of behavioural change actions (Q17).

Finally, the energy use adaptation to the renewable energy production model characterized by volatility (Question 19) is investigated and the results are shown in the table below (Table 43). Participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In addition, the possibility to choose the "I don't know" option or to leave the answer blank is given.

Table 43. Energy use adaptation (Q19).

Question 19: To stabilise the electricity grid, I am willing to...	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I Agree**	**(5) I strongly agree**	**I do not know**	**I prefer not to answer**
m: ...use household appliances (e.g. washing machine, dishwasher) mainly when the share of electricity from renewable sources in the grid is very high.	(2) 2.7%	(4) 5.3%	(25) 33.3%	(28) 37.3%	(10) 13.3%	(6) 8.0%	(0) 0.0%
n: ...recharge electrical devices (e.g. notebook) mainly when the share of electricity from renewable sources in the grid is very high.	(3) 4.0%	(9) 12.0%	(36) 48.0%	(12) 16.0%	(11) 14.7%	(4) 5.3%	(0) 0.0%
o: ...recharge electrical means of transportation (e.g. electric car/ scooter/ bike) mainly when the share of electricity from renewable sources in the grid is very high.	(4) 5.3%	(7) 9.3%	(24) 32.0%	(20) 26.7%	(8) 10.7%	(12) 16.0%	(0) 0.0%

Furthermore, Question 20 investigated the respondents' willingness to install some devices (e.g. smart meters) for regulating the energy consumption in household. The histogram in Figure 90 shows the responses obtained, highlighting how for almost all respondents the device installation covers a neutral issue; indeed, the 30.7% attribute on importance of +1, the 26.7% attribute an importance of 0 and, finally, the 16.0% attribute an importance of -1.

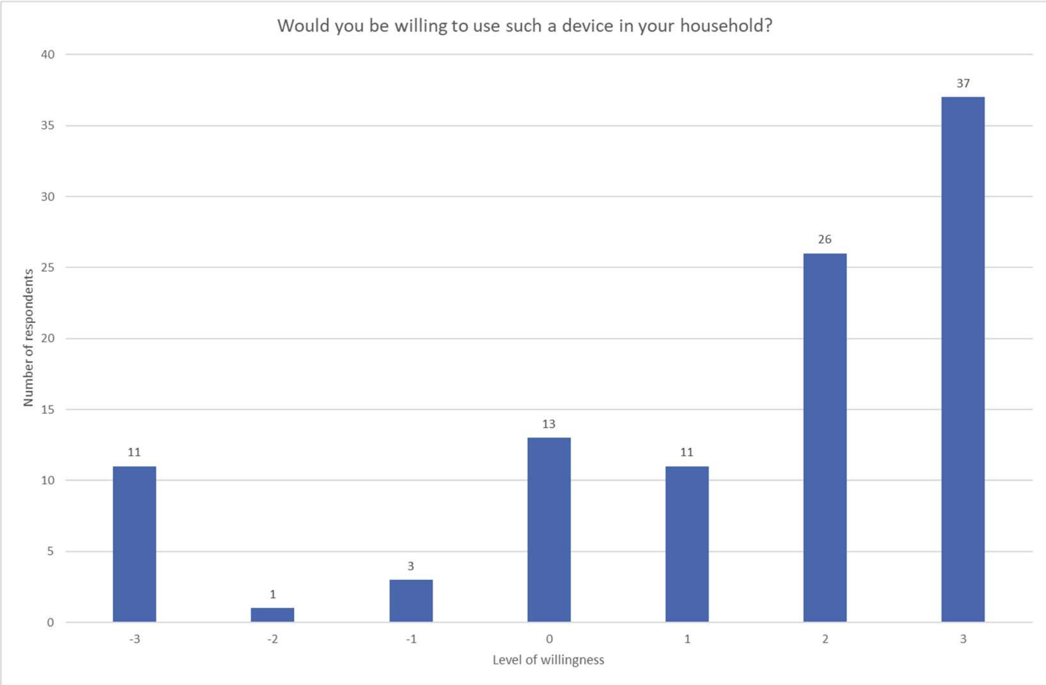

Figure 90. Willingness to device installation (Q20).

(iii) In conclusion, in this first part of the questionnaire, the personal importance of environmental protection and safeguard has been investigated (Q21). The histogram in Figure 91 shows the responses obtained, highlighting how for almost all respondents the environmental protection covers a very important issue; indeed, the 32.0% attribute on importance of +3, the 24.0% attribute an importance of +2 and, finally, the 25.3% attribute an importance of +1.

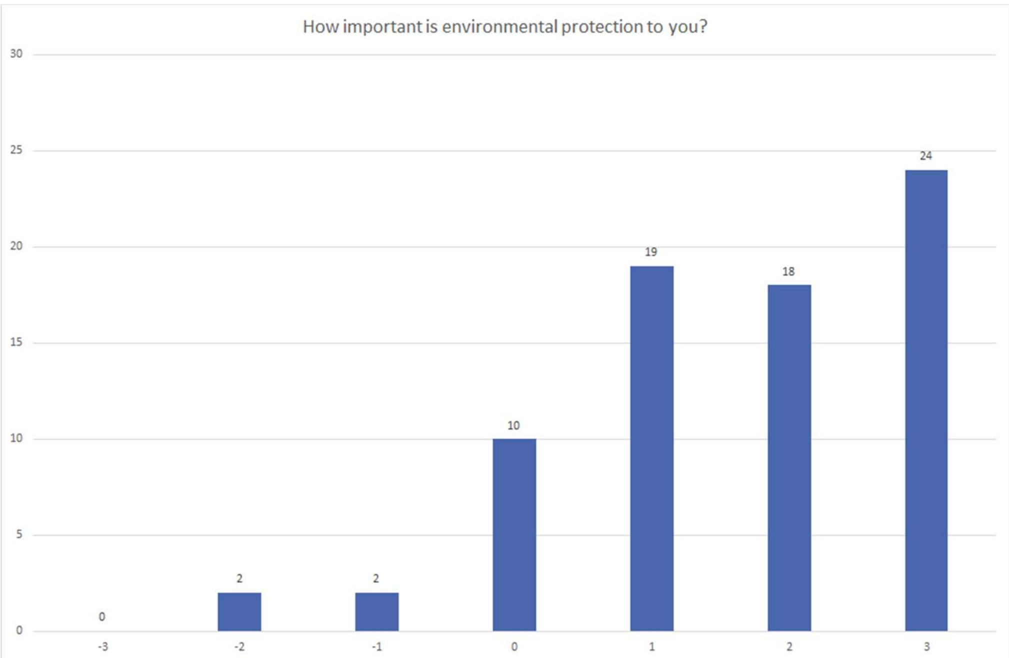

Figure 91. Importance of environmental protection (P1-Q21).

Second part: information on feelings and community identity.

This paragraph shows the results relating to the second part of the questionnaire which deepens the community/territory perception. In Question 22, through three statements, participants were asked to indicate their level of agreement/disagreement, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In general, the answers obtained, presented in Table 44, show a substantial perception of belonging by the respondents to the territory/context in which they live. 46.7% of the respondents stated that they agree or strongly agree to feel connected to the community in which they live. In fact, only 8.0% said they strongly disagree or disagree with that statement. The remaining respondents stated that they are neutral (37.3%) or do not know (8%). In line with what has been described above, 54.4% of respondents agree or strongly agree that they have good friends within their community and 54.7% of respondents often speak about the community in which they live as a great place to live. Also, for these two statements the share of respondents not in agreement is low, the greatest weight is determined by those who hold a neutral position, respectively 29.3% and 24.0%.

Table 44. Statements on community perception (Q22).

Statements	(1) I strongly disagree	(2) I disagree	(3) Neutral	(4) I Agree	(5) I strongly agree	I do not know	I prefer not to answer
I feel strongly connected to the community in which I live.	(3) 4.0%	(3) 4.0%	(28) 37.3%	(29) 38.7%	(6) 8.0%	(6) 8.0%	(0) 0.0%
There are many people in my community that I consider to be good friends.	(3) 4.0%	(4) 5.3%	(22) 29.3%	(31) 41.3%	(10) 13.3%	(5) 6.7%	(0) 0.0%
I often speak of my community as a great place to live.	(4) 5.3%	(5) 6.7%	(18) 24.0%	(27) 36.0%	(14) 18.7%	(7) 9.3%	(0) 0.0%

Third part: technical information.

This paragraph shows the results relating to the third part of the questionnaire which deepens the general building’s characteristics and the energy system characteristics and the energy expenditure information. Questions 23 concerns the building typology and Question 24 concerns the building’s construction year. Most of the respondents (54.7%) reported living in a apartment while 45.3% in a single-family house. Furthermore, 57 respondents (76.0%) are homeowners and 18 (24.0%) are rented out. Furthermore, Question 25, Question 26 and Question 27 focus on energy cost and consumption in buildings. Specifically, the results of relationship between users and the energy costs are shown in Table 45.

Table 45. Energy cost for household (Q25).

Question 25	(1) I strongly disagree	(2) I disagree	(3) Neutral	(4) I Agree	(5) I strongly agree	I do not know	I prefer not to answer
It is difficult to meet the energy demand of my household.	(4) 5.3%	(25) 33.3%	(18) 24.0%	(20) 26.7%	(4) 5.3%	(4) 5.3%	(0) 0.0%
In order to cover the running energy costs, my household does without other expenses (e.g. new purchases, leisure time).	(8) 10.7%	(17) 22.7%	(31) 41.3%	(10) 13.3%	(3) 4.0%	(6) 8.0%	(0) 0.0%
During winter, my household has trouble heating the apartment/ the house sufficiently.	(15) 20.0%	(21) 28.0%	(23) 30.7%	(10) 13.3%	(0) 0.0%	(6) 8.0%	(0) 0.0%
To reduce energy costs, my household limits itself to save energy (e.g. cold water for showering, no heating).	(10) 13.3%	(27) 36.0%	(22) 29.3%	(8) 10.7%	(2) 2.7%	(6) 8.0%	(0) 0.0%

Question 26 and Question 27 examine respectively the quantity of energy (electricity) used annually and the energy expenditure (again only for electricity) incurred for the respondents' home per month. The 13.3% of interviewees said they were aware of how much energy is used in their home, while 86.7% are not aware of it. With further secondary questions it emerged that consumption electricity averages around 3450 kWh, with a maximum of 10000 kWh and a minimum of 500 kWh. In addition, the 25.3% of interviewees said they were aware how much is the energy expenditure while 74.7% are not aware of it. As expected, looking at the percentages of the two previous questions, respondents are a little bit aware of the expenditure they incur to obtain energy than the amount of energy used. This happens because they periodically have to pay their bills to continue receiving the service offered and, therefore, these are expenses that are usually always clear in everyone's mind. With further secondary questions it emerged that spending for electricity consumption average is around 1730 CZK/month (about 68 €/month), with a maximum of 10000 CZK/month (about 391 €/month) and a minimum of 300 CZK/month (about 12 €/month).

Fourth part: socio-demographic information.

This paragraph shows the results relating to the fourth part of the questionnaire which deepens (i) the economic situation/condition of building occupants and (ii) the socio-demographic respondents' characteristics.

(i) The economic situation/condition of building occupants is explored through five questions. Question 28 concerns the respondents' occupation. As shown in Figure 92, the majority of respondents (84.0%) said they were employed while only 2.7% were not employed. 4.0% of respondents are retired while students are 5.3% and the 1.3% of respondents are doing the apprenticeship. Finally, 2.7% said something else or preferred not to answer.

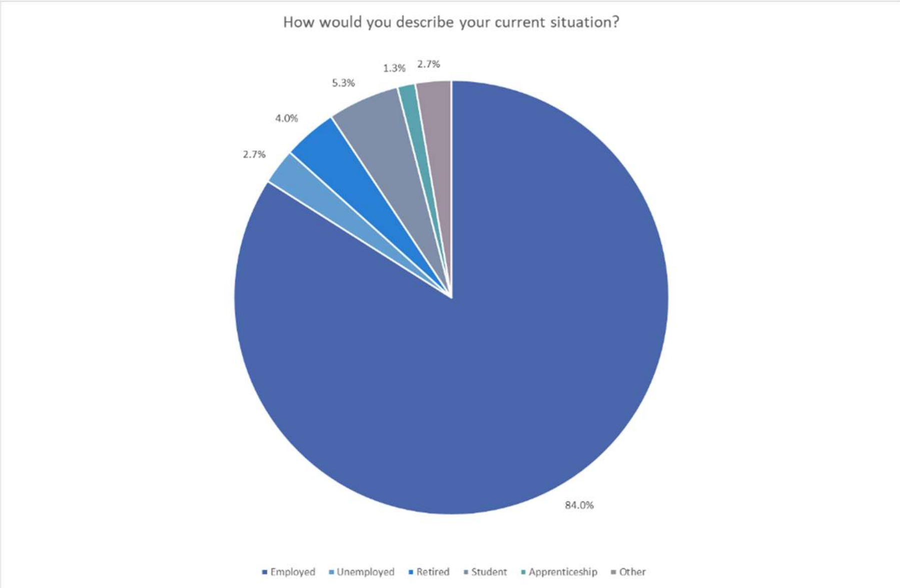

Figure 92. Occupation (Q28).

Furthermore, the economic situation was investigated through Question 32 to whom the interviewees were asked to indicate, on the basis of the total monthly net income of all the people living in their own home, one of the indicated income range. Figure 93 shows how the monthly income with the highest percentage of preferences (16.0%) is between 2001€ and 2500€, followed by 10.7% an income between 1501 and 2000€. Again, 57.3% of respondents said to not want to express their income.

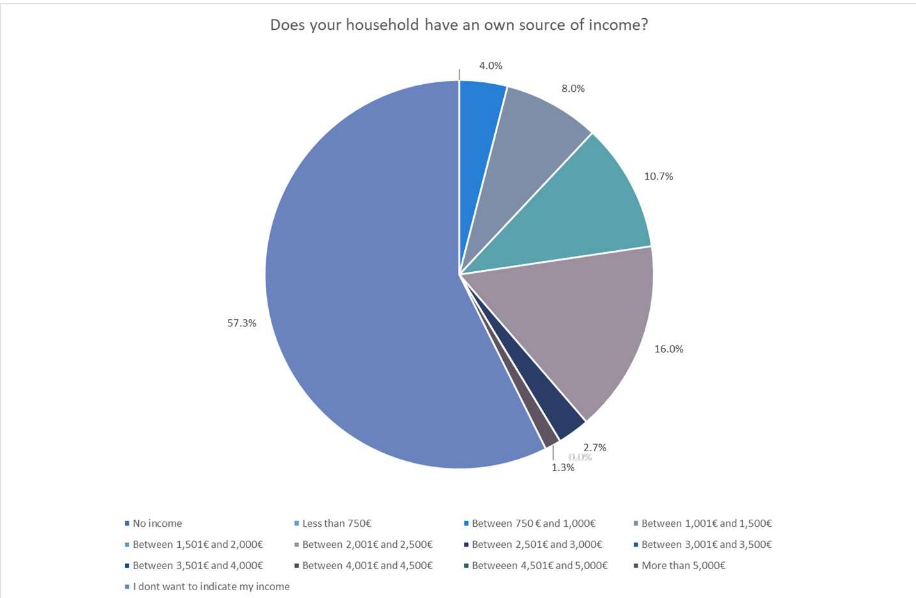

Figure 93. Family net income (Q32).

Figure 94 shows the results relating to home and money management in the family. The respondent was asked to rate their level of management on a 5-point scale from “I strongly disagree” to “I strongly agree”. The radar chart shows how, usually, for the control of the household finances, the respondents are personally involved; indeed 16.0% are strongly agree and 45.3% agree with the request. On the other hand, for the responsible for homemaking, respondents are not actively involved; indeed, they are principally agree (45.3%) and 32.0% cover a neutral position. Finally, analysing the family composition (Question 30 and Question 33), on average the family unit is made up of about two people and half; this does not exclude different cases in which a minimum of 1 component and a maximum of 5 has been detected. In addition, the respondents live, mainly with their spouse or husband (46.7%), with the life partner (29.3%), alone (17.3%) and with friends (4.0%). 2.7% of the respondents declared to live in other conditions.

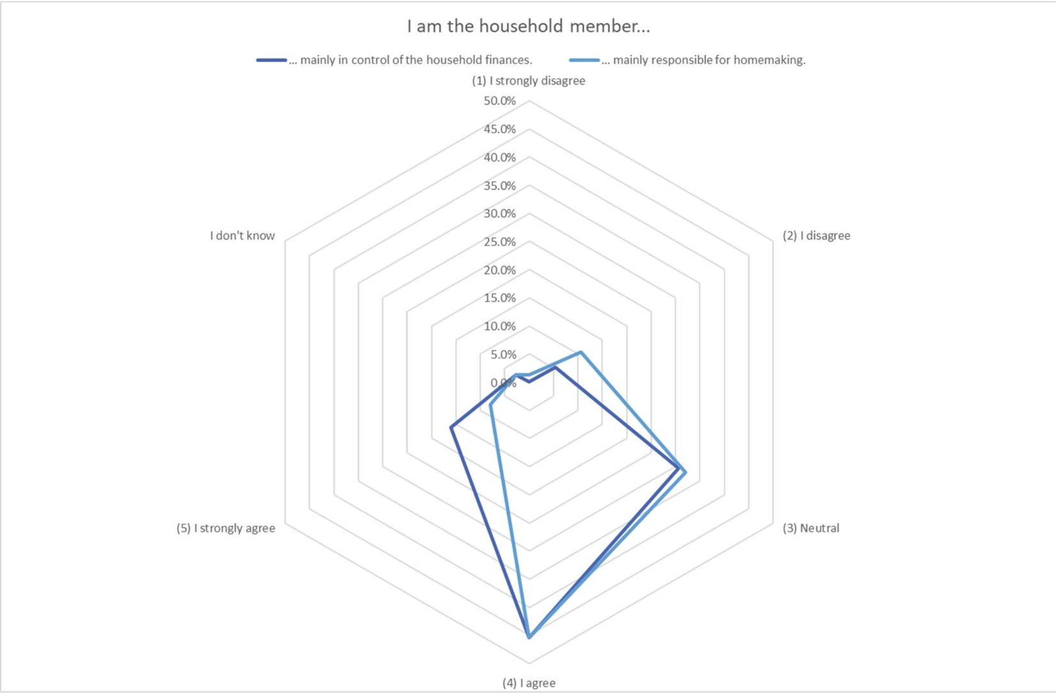

Figure 94. House and money management (Q31).

(ii) Concerning the socio-demographic respondents’ characteristics, the sample is composed by 48.0% of women and the remaining part (33.3%) of men. 18.7% of respondent declared to prefer not answer the question. 37 years is the average age of the respondents (with a standard deviation of about 10 years); the youngest respondent is 19 years old, while the oldest is 70 years old. The following figure (Figure 95) shows the educational status of the respondents. The 20.0% of the respondents completed the PhD, 38.7% the university education and the 4.0% completed the college. Currently, the 33.3% of respondents are doing an apprenticeship and 4.0% declared other qualifications.

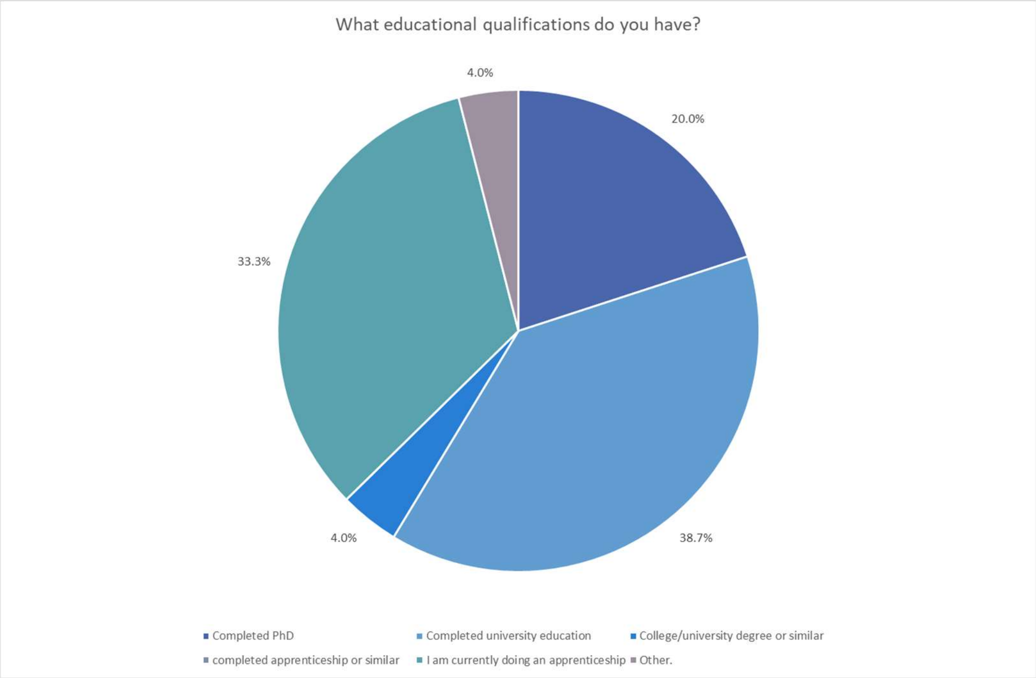

Figure 95. Educational qualification (Q29).

b) Citizens clusters

In this part, through the cluster analysis, homogeneous groups of citizens are identified in order to promote specific inclusion strategies to commit towards an energy community project. The clustering is based on the variables of the first two part of the questionnaire: the variables relating the attitude and availability towards community projects based on renewable energy and the variables relating to feelings and community identity. The variables of these first two parts of the questionnaire are 9 and they are listed below.

- Q01: Participation in RECP.
- Q06: Actual participation in RECP.
- Q12: Investment in RECP.
- Q14: Willingness to energy consumption reduction.
- Q16: Willingness to save electricity.
- Q19: Willingness to electricity grid stabilization.
- Q20: Device installation.
- Q21: Environmental protection.
- Q22: Community connection.

The cluster analysis was performed using R software and, accordingly, the dataset was prepared. To proceed with the cluster analysis it is necessary that the data matrix consists solely of numerical values. The variables investigated are ordinal or dichotomous variables. The sortable variables have been transformed into a score from 1 to 5, where 1 indicates “disagree/not interested/not availability” and 5 indicates “agree/interested/availability”. Instead, the answer options "I prefer not to answer" and "I don't know" have been transformed, after discussion, by assigning a score of 0. The dichotomous variables have been transformed into 0/1, where 0 indicates the absence of the investigated characteristic and 1 its presence. Subsequently, after having prepared the matrix of the observations, the k-means method was applied. The first step was the identification of the number of clusters though the so-called "Elbow" method, then the identification of cluster composition. Table 46 shows the results obtained for the 4 clusters. The clusters obtained are made up of 10, 38, 24 and 3 users.

Table 46. Cluster analysis result.

K-means clustering with 4 clusters of sizes 10, 38,24, 3				
Variable	**Cluser 1**	**Cluster 2**	**Cluster 3**	**Cluster 4**
Q01	0.6480220	-0.1811169	0.2849062	-2.1451763
Q06	1.9074416	-0.1344227	-0.5172723	-0.5172723
Q12	0.3853956	-0.2193675	0.4567651	-2.1601183
Q14	0.4932292	-0.4667055	0.8457273	-2.4983133
Q16	0.5301258	-0.3757128	0.7434470	-2.9556328
Q19	0.6657532	-0.4126807	0.7646097	-3.1087655
Q20	0.6927132	-0.5845135	0.5753989	0.4916029
Q21	0.7691064	-0.6627116	0.6911565	0.3014066
Q22	0.9498188	-0.5343655	0.3014066	-1.2701719
Within cluster sum of squares by cluster : *[1] 27.275628 232.014997 66.634362 9.676009* *(between_SS / total_SS =49.6 %)*				

Cluster 1. This cluster consists of 10 users (13.3% of respondents). In general, this cluster is made up of citizens who are willing and interested in participating in community projects based on renewable energy, probably for two reasons: 1) they currently participate, in some way, in the production of energy from renewable sources; 2) they are characterized by an excellent connection and sense of pride with the community in which they live and by an excellent level of relationships with other citizens. In addition, they are characterized by a good attitude towards reducing energy consumption, towards habitual behavioural practices to save electricity and towards adaptation to the renewable energy production model characterized by volatility. In short, this cluster is composed by users ready to participate fully in a community project based on renewable energy. For them, it is only necessary to take a few pills on the usual practices aimed at saving energy which, in all probability, they will understand without problems. In conclusion, this cluster can stimulate other clusters towards the energy community involvement.

From the observation of the socio-economic data, shown in Table 47, it is evident that within this cluster 60.0% live in a single family house and 40.0% in an apartment; furthermore, 90.0% own the house they live. All members of this cluster have a job and monthly family income, for 40% of respondents it is between € 1500 and € 2500. In addition, the average age of this cluster is 37 years old, 40% male, 50% female and predominantly with an apprenticeship education (70.0%).

Cluster 2. This cluster consists of 38 users (50.7% of respondents). In general, they have a low interest in community projects. The level of connection with the community in which they live is low. Also the attitude towards reducing energy consumption, towards habitual behavioural practices to save electricity and towards adaptation to the renewable energy production model characterized by volatility. For them it is necessary to have adequate training and policies that pay attention and define first of all inclusion policies. In this case, first of all, it is necessary to increase the sense of belonging towards the context of belonging by aiming to transform the actual feeling in pride.

From the observation of the socio-economic data, shown in Table 47, it is evident that within this cluster 50.0% live in a single family house and 50.0% in an apartment; furthermore, 73.7% own the house they live. The employment of this cluster is varied: 73.7% are employed, 5.3% are unemployed, 5.3% are retired, 7.9% are students, 2.6% are apprentices and 5.3% are doing other things. 78.9% did not want to declare their income. In addition, the average age of this cluster is 36 years old, 36.8% male, 34.2% female and predominantly with an university education (55.3%).

Cluster 3. This cluster consists of 24 users (32.0% of respondents). In general, they are respondents who have an enough interest and a willingness to participate in community projects based on renewable energy. The will to participate with an economic investment is high but, actually, these are users who are not currently involved in any form of renewable energy co-production. These users are characterized by a good level of connection and sense of pride with the community in which they live and by a good level of relationships with other citizens. In addition, they are characterized by a good attitude towards reducing energy consumption, towards habitual behavioural practices to save electricity and towards adaptation to the renewable energy production model characterized by volatility. It is possible to say that it is the cluster on which it is essential to pay attention and define inclusion policies. They are proactive but in order for them to be fully committed they should be encouraged, they should be more involved, thinking of targeted actions and tailor-made incentives.

From the observation of the socio-economic data, shown in Table 47, it is evident that within this cluster 33.3% live in a single family house and 66.7% in an apartment; furthermore, 75.0% own the house they live. All members of this cluster have a job and monthly family income, for 40% of respondents it is between € 1500 and € 2500. In addition, the average age of this cluster is 37.5 years old, 20.8% male, 75.0% female and predominantly with an apprenticeship education (50.0%).

Cluster 4. This cluster consists of 7 users (4.0% of respondents). Users are not interested in participating in RECP, they are not interested in actively participating, they are not interested in investing economically, they disagree in undertaking actions aimed at improving energy efficiency and in undertaking new behaviours aimed at energy saving. These users are characterized by a very low level of connection and sense of pride with the community in which they live; in the same way, even the relationships with other citizens are negative. Given their clear position it would seem that there is no way to change their thinking. With a view to optimizing resources, it would be correct to proceed first of all to the formation of clusters with a proactive attitude and at the same time study tailor-made policies for this cluster, not forgetting the help that citizens (e.g. belonging to cluster 1) can give in this sense.

From the observation of the socio-economic data, shown in Table 47, it is evident that within this cluster 33.3% live in a single family house and 66.7% in an apartment; furthermore, 66.7% own the house they live. Members of this cluster or have a job (33.3%) or are retired (33.3%) or are students (33.3%). All the members preferred not to give detail about their net family income. In addition, the average age of this cluster is 43 years old, 66.7% male and predominantly with an university education (100.0%).

Table 47. Statistical analysis of the classes of the variables (Litoměřice).

Variable	Cluster 1 (10)	Cluster 2 (38)	Cluster 3 (24)	Cluster 4 (3)
Are you living...				
… in an apartment?	4	19	16	2
... a single family house?	6	19	8	1
Do you live for rent or are you using your own property?				
Own property	9	28	18	2
For rent	1	10	6	1
Do you know how much electricity your household uses approximately per year?				
Yes.	3	4	3	0
No.	7	34	21	3
Do you know how much your household is approximately paying for electricity (no heat) per month?				
Yes.	5	3	11	0
No.	5	35	13	3
How would you describe your current situation?				
Employed	10	28	24	1
Unemployed	0	2	0	0
Retired	0	2	0	1
Student	0	3	0	1
Apprenticeship	0	1	0	0
Other	0	2	0	0
What educational qualifications do you have?				
completed PhD	3	7	5	0
completed university education	0	21	5	3
college/ university degree or similar	0	3	0	0
completed apprenticeship or similar	0	0	0	0
I am currently doing an apprenticeship	7	6	12	0
Other				
Does your household have an own source of income?				
No income	0	0	0	0
Less than 750€	0	0	0	0
Between 750 € and 1,000€	0	2	1	0
Between 1,001€ and 1,500€	1	3	2	0
Between 1,501€ and 2,000€	2	1	5	0
Between 2,001€ and 2,500€	2	2	8	0
Between 2,501€ and 3,000€	0	0	2	0
Between 3,001€ and 3,500€	0	0	0	0
Between 3,501€ and 4,000€	0	0	0	0
Between 4,001€ and 4,500€	0	0	0	0
Betweeen 4,501€ and 5,000€	0	0	0	0
More than 5,000€	0	0	1	0

I dont want to indicate my income	5	30	5	3
How old are you?				
Age (years)	37	36	37.5	43
What is your gender?				
Female	5	13	18	0
Male	4	14	5	2
I prefer not to answer	1	11	1	1

5.4 Essen (Germany)

Essen is a city of 582760 inhabitants in North Rhine-Westphalia, Germany. It belongs to the Ruhr region, of which it is the second largest centre after Dortmund. The city is linked to the steel industry of the Krupp family, originally from Essen. The city received the European Green Capital Award for 2017.

5.4.1 The energy community project

The city of Essen has been a partner in the SCORE consortium since February 2020; before that, Essen was involved in SCORE only as a "Follower City" since October 2018. Currently, the Essen pilot project concerns the campus of the Franz Sales Haus, which is to be implemented in connection with the adjacent Vocational College East (Berufskolleg Ost) of the City of Essen. The City of Essen has decided to actively participate in the expansion of renewable energies and adopted a re-investment levy (ReInvest) by resolution of 13 December 2019. This provides for the co-financing of planned investments in renewable energy projects with a focus on regional own consumption on the certified green electricity supply of the city.

5.4.2 Social structure

In this paragraph, the application regarding the social structure is described. Specifically, for this case study, only the target group involvement, that concerns all the processes aimed at encouraging the users' inclusion/participation in community projects or promoting a behaviour change, is exposed and in-depth.

Part IV: target group involvement

In this part, the actions related to obtain data about users' characteristics, in order to identify the main drivers that favour/hinder their participation in energy community projects, and, consequently, clustering the population on the basis of one's possibilities, in order to promote specific inclusion strategies to commit towards an energy community project, are addressed. The application context is the whole city of Essen.

a) Questionnaire

Design phase. For the case study of the Essen, a reduced version of the questionnaire was defined, with the possibility, for respondents, to choose one of the following languages: German, Czech or English. The reference questionnaire is the extended version in Italian language but some questions have been deleted or reformulated, after a discussion with a panel of experts, in order to make the questionnaire more streamlined. In addition, the questionnaire was pre-tested with citizens (citizens not necessarily with training in the energy field and knowledge on the topic of energy communities). The final composition consists of 30 questions, always divided into 4 parts: information on attitude and willingness, information on feelings and community identity, technical information and socio-demographic information. It is reported in Appendix C.

Distribution phase. The questionnaire is administered between citizens of the specific context in Essen. The distribution of the questionnaire began on November 4, 2020 and ended on November 30, 2020. The distribution was influenced by the health emergency determined by the risk of infection from Covid-19; for this reason, the dissemination of the questionnaire took place only online. For this reason, an online version was defined using the SoSci Survey platform (https://www.soscisurvey.de/scorepilots/), since this tool allows to implement the question/answer logic. The definition of an Action Plan allows to choose and plan through which channels and how to distribute the questionnaire. The distribution methods are listed below.

- Website and newsletter of City of Essen.
- Volunteers group of the Green Capital Agency Essen. The Green Capital Agency Essen wrote a press release with background information about the SCORE project and a call for participation in the survey. This press release was published on the website of the city of Essen on November 4 and simultaneously distributed via two municipal newsletters. On the website, the press release was accessed more than 300 times. About 180 subscribers were reached via the newsletter 'Rathaus-Report' and about 3,000 subscribers via the 'essen.de-Newsletter'.
- “Stromsparhelfer” (in English: electricity saving helpers) of the welfare association of the protestant church ‘Neue Arbeit der Diakonie Essen’. The Volunteers Group of the Green Capital Agency Essen consists of volunteers who are actively involved in the implementation of climate protection and sustainability measures. Around 150 people from this group were informed and invited to participate via e-mail. The electricity saving helpers of the ‘Neue Arbeit of the Diakonie Essen’ offer free energy saving advice for private households in Essen. An important focus of this initiative is on low-income households. The aim is to help citizens to permanently reduce their energy consumption and make a contribution to environmental protection. Most of the energy saving helpers received state unemployment benefits before working as energy consultants and still have a relatively low income today. The “Neue Arbeit of the Diakonie Essen” asked about 20 electricity saving helpers to participate in the online survey. This was done partly in personal conversations and partly via e-mail.

Data pre-processing and analysis. In this paragraph, a first general analysis on the data is treated. As described for the Susa Valley case study, the action are the dataset cleaning (the removal of unwanted observations, the adjustment of structural errors and the filtering of unwanted outliers) and the first analysis relating to the statistical description of the responses (highlighting maximums, minimums, mode and median values; in addition, the distribution of the answers is shown, mainly through histograms and pie charts).

The questionnaire answers were accepted in the period between November 4, 2020, 2020 and November 30, 2020. Due to the several approaches used for the online dissemination, it is difficult to accurately determine the number of citizens actually reached. Pointing out that the total number of online responses concerns the answers of those who opened the link and started the questionnaire compilation, whether they completed it or did not complete it, the total number of online responses are 169. The completed responses are 102; therefore, the overall response rate is 60.4%. The average time for completing the online questionnaire was 15 minutes. The minimum time recorded was about 4 minutes, while the maximum time was 1 hours and 44 minutes. The interquartile range (IQR) is between 7 minutes (25th percentile) and 13 minutes (75th percentile); the second quartile (50th percentile) is about 9 minutes. Time values greater than 23 minutes (upper whisker) are highlighted as statistically anomalous; on the other hand, for the definition of time as an always positive quantity, any anomalous data, lower than the lower whisker (that is equal to 0) cannot be evaluated. In this specific case, twelve value greater the upper whisker was recorded. A detailed check was carried out and it showed that they are not to be considered anomalous data since the questionnaire allows to save the given answers and continue it later. Consequently, due to this reason, also the average compilation time is influenced by this possibility of save and recovery.

In the following paragraphs, the results obtained are shown maintaining the same structure of the questionnaire: first the information on attitude and willingness, then the information on feelings and community identity, afterwards the technical information, and, finally, the socio-demographic information.

First part: information on attitude and willingness.

This paragraph shows the results relating to the first part of the questionnaire which deepens (i) the interest and the willingness towards renewable energy community projects, (ii) the willingness to energy consumption and (iii) the social influence and the personal environmental judgment.

(i) In the interest and the willingness towards RECPs (renewable energy community projects), questions aimed at exploring first, a general interest (Q01), then, the interest in investing economically (Q12) are analysed and, in Table 48, the main results are summarized. Participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In addition, the possibility to choose the "I don't know" option or to leave the answer blank is given.

Table 48. Main questions relating the willingness towards RECP.

Question	(1) I strongly disagree	(2) I disagree	(3) Neutral	(4) I agree	(5) I strongest agree	I do not know	No answer
Q01: In principle, I am interested in participating in a renewable energy community.	(6) 5.9%	(0) 0.0%	(10) 9.8%	(23) 22.5%	(62) 60.8%	(1) 1.0%	(0) 0.0%
Q12: I would be willing to invest in a renewable energy project.	(5) 4.9%	(3) 2.9%	(17) 16.7%	(41) 40.2%	(34) 33.3%	(2) 2.0%	(0) 0.0%

The comparison of the response percentages of each option shows how, as the effort required of the citizen increases, the preference shifts towards a lower interest level. Indeed, most of the respondents (60.8%) stated that they "strongly agree" and 22.5% stated that they "agree" in participating in community projects based on renewable energy. With regard to investing in a community project, the 33.3% stated that they "strongly agree" and 40.2% stated that they "agree".

To better understand the respondents' point of view, some secondary questions, linked to these main questions, have been posed. Specifically, in these questions, the respondent was asked to choose one or more options among those proposed.

The results related to the in-depth analysis of the participation in community projects based on renewable energy sources are shown in Table 49. Based on the answer given to Question 01, two possibilities arise:

- if the respondent has declared to be “Strongly agree” or “Agree”, was asked the reasons of interest in participating in a renewable energy community (Q02) and how the respondent would like to participate (Q03).
- if the respondent has declared to be “Strongly disagree” or “disagree” was asked the reason(s) (Q04) and the needs of not participation (Q05).

Table 49. Modalities, reasons and needs relating to (not) active participation.

Strongly agree or Agree	
Why are you interested in participating in a renewable energy community?	
I have an economic advantage (e.g. less energy costs)	49
I have an advantage in terms of more efficient services.	25
I have an economic advantage from making a profit.	21
I serve my community.	49
I contribute to the preservation of nature and the planet.	80
Other.	5
How would you like to participate in a renewable energy community?	
I would contribute or invest money.	57
I would contribute my knowledge e.g. in management or energy technology.	14
I would contribute my free time e.g. to take over tasks within the community.	47
I would provide surfaces to install energy production systems (e.g. on a roof or a field).	26
I would take an active role in the management of the renewable energy community.	18
I would spread information about planned projects/ activities in the neighbourhood and	44

recruit new members.	
Other.	4
Strongly disagree, Disagree or Neutral	
What factors make you not interested in participating in a renewable energy community?	
I don’t have enough time.	1
I don’t have enough money.	2
I don’t have enough knowledge or skills.	2
I don’t know and where.	0
I would have other disadvantages from participation (e.g. reduction of social benefits).	1
I prefer conventional energy supply.	0
I think the bureaucratic burden is too high.	4
I do not think that such a project is profitable.	3
I think that such a project is doomed to failure.	1
I mistrust such projects.	2
I generally do not want to invest.	2
I don't know why I don't want to participate.	0
Other.	0
What would convince you to participate in a renewable energy community?	
I want to be actively approached and involved by existing renewable energy communities.	0
I need financial support to participate, e.g. a zero interest loan to finance my participation or tax benefits.	1
I need and easier way to participate in the energy transition	0
I need an incentive for my participation	0
I would like to have the feeling of making a contribution to my social environment through my participation.	0
I want to feel that through my participation I am contributing to a sustainable lifestyle.	0
I need something else.	1
Nothing could convince me to participate.	3
I do not know.	2

In addition, the willingness to invest economically was investigated among all respondents in Question 18. The result shows that 13.7% of respondents expressed a zero-investment quota or did not answer, instead 86.3% of the respondents expressed a sum. No constraints were placed in the question and no reference was deliberately inserted in order not to influence the respondents’ choice. Considering only the latter percentage of respondents, the minimum contribution expressed is 25€, the maximum contribution 50000€; the average is around 10000€. Furthermore, the average of annual return is 3 years and 10 are the average years since the investment is paid for itself. In addition, the reasons for not willingness in renewable energy project investment is analysed in Question 13. The figure below (Figure 96) shows the main barriers and obstacles expressed by respondents.

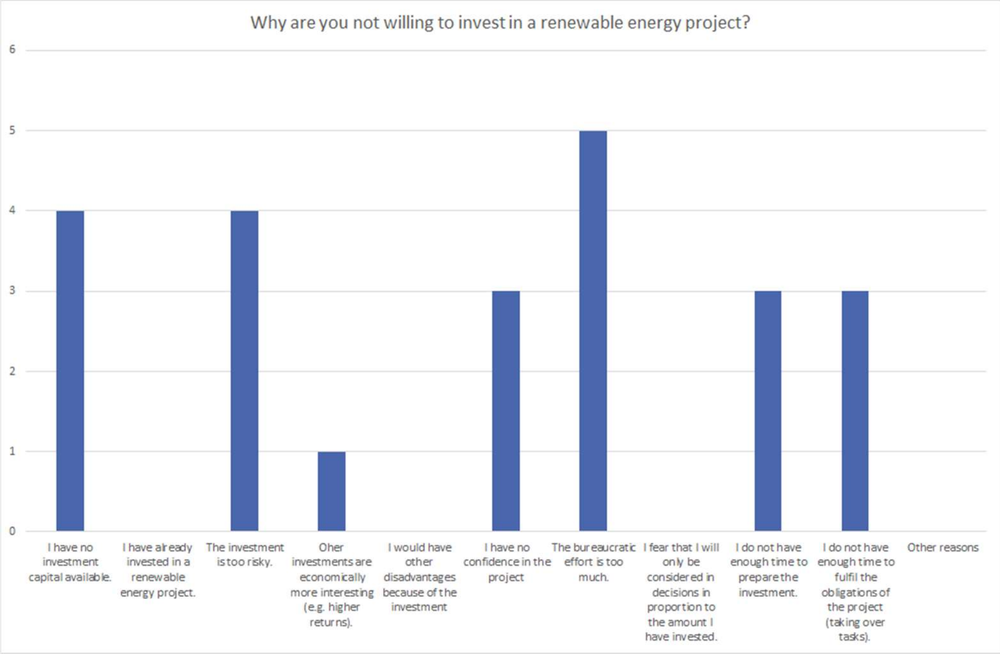

Figure 96. Reasons relating to not invest.

In Question 06, the participation in the production of energy from renewable sources is investigated; as shown in Figure 97, 24.5% of the respondents declared their participation in the production of energy from renewable sources; instead, the remaining part (75.5%) gave a negative answer. Among those who have declared a current participation, 17 respondents are the owner or co-owner of a photovoltaic installation, 4 respondents of a solar thermal installation, 4 respondents of a wind turbine, 1 respondent of a biogas plant and 7 respondents are a co-owner of other installation. In addition, regarding the use of the produced energy through renewable energy installation, 6 respondents use energy only for self-consumption, 8 respondents use energy only for sale, 10 respondents use energy both for self-consumption and for sale and 2 respondents use energy in others way.

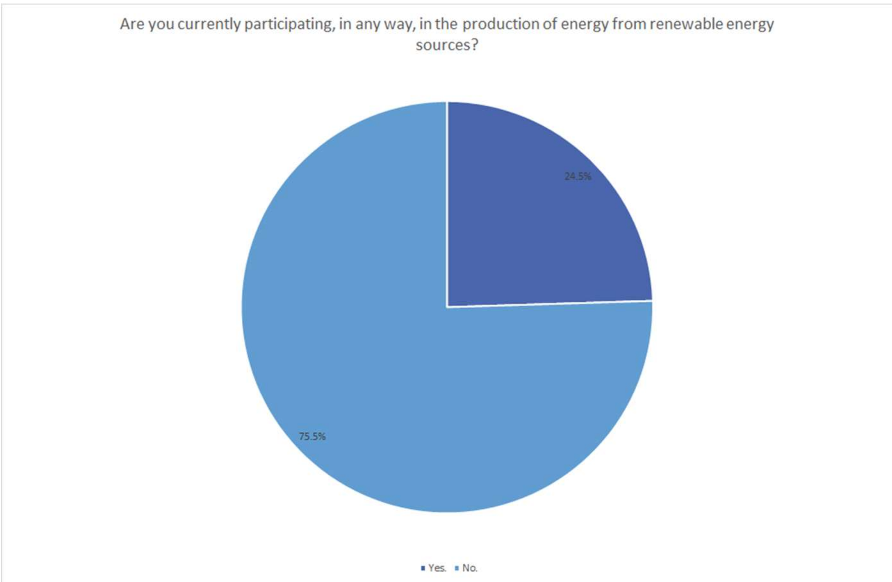

Figure 97. Renewable energy production participation (Q06).

(ii) Inside the first part of the questionnaire the willingness to reduce the energy consumption in buildings, investigating users' actions to increase the efficiency of the building envelope components and of the energy plant system, investigating users' behavioural change and, finally, investigating the energy use adaptation to the renewable energy production model characterized by volatility, is explored. The willingness to improve the building energy efficiency is investigated in Question 14; specifically, in Table 50 the availability by replacing old appliances (big and/or small appliances) with newer models that use less energy is investigated. Participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In addition, the possibility to choose the "I don't know" option or to leave the answer blank is given.

Table 50. Improvement of energy efficiency: replacement of appliances (P1-14).

Question 14: In order to reduce energy consumption, I am willing to...	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I Agree**	**(5) I strongly agree**	**I do not know**	**I prefer not to answer**
a: ...exchange older lighting with LED lamps.	(4) 3.9%	(2) 2.0%	(2) 2.0%	(19) 18.6%	(74) 72.5%	(1) 1.0%	(0) 0.0%
b: ...exchange an older refrigerator or freezer.	(3) 2.9%	(3) 2.9%	(11) 10.8%	(27) 26.5%	(56) 54.9%	(2) 2.0%	(0) 0.0%
c: ...exchange other older household appliances (e.g. dishwasher, washing machine, oven or dryer).	(3) 2.9%	(5) 4.9%	(15) 14.7%	(31) 30.41%	(46) 45.1%	(2) 2.0%	(0) 0.0%
d: ...exchange older consumer electronics (e.g. TV or hi-fi equipment).	(5) 4.9%	(12) 11.8%	(18) 17.6%	(26) 25.5%	(39) 38.2%	(2) 2.0%	(0) 0.0%
e: ...replace an older heating pump.	(4) 3.9%	(0) 0.0%	(12) 11.8%	(25) 24.5%	(41) 40.2%	(20) 19.6%	(0) 0.0%

Furthermore, the 94.1% of the respondents declared that they had already replaced all or some of the listed equipment; the frequency of the interventions carried out is shown in Figure 98.

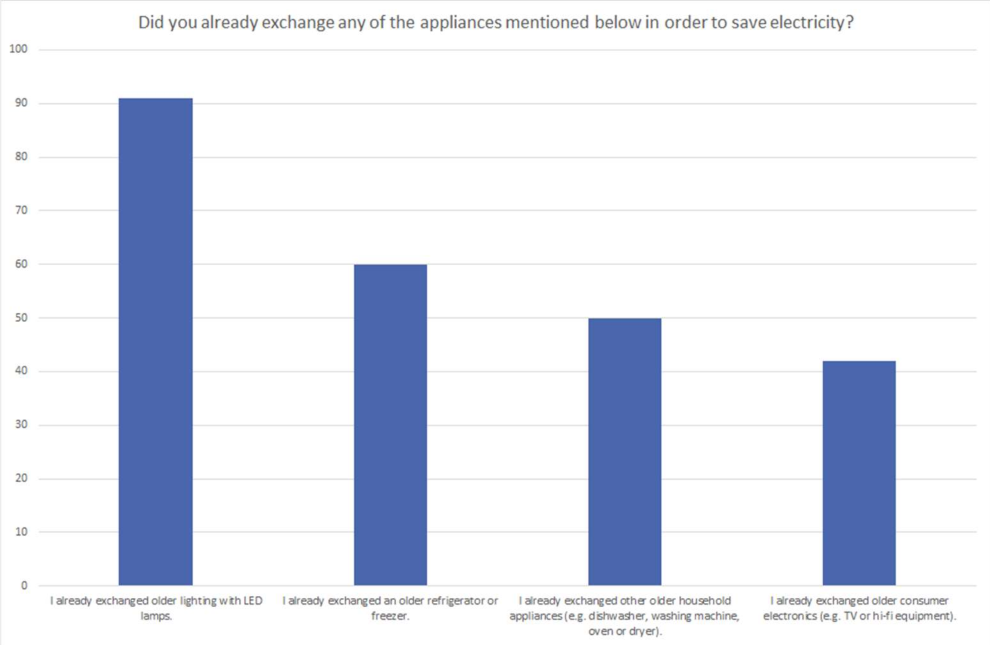

Figure 98. Frequency of appliances replacement (Q15).

Furthermore, the willingness to change the building users' behaviour is investigated in Question 16; specifically, in Table 51 the availability by modifying the use of energy related to the use of household appliances and/or interaction with the systems present in the home and/or applying specific behavioural practices is investigated. Participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In addition, the possibility to choose the "I don't know" option or to leave the answer blank is given.

Table 51. Improvement of energy savings: user's behaviour (Q16).

Question 16: To save electricity, I would be willing...	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I Agree**	**(5) I strongly agree**	**I do not know**	**I prefer not to answer**
f: ...turn off the light, even if I only leave the room for a short time.	(3) 2.9%	(11) 10.8%	(5) 4.9%	(24) 23.5%	(58) 56.9%	(1) 1.0%	(0) 0.0%
g: ...use power strips with an off switch to avoid electrical appliances running in stand-by mode.	(2) 2.0%	(5) 4.9%	(7) 6.9%	(12) 11.8%	(75) 73.5%	(1) 1.0%	(0) 0.0%
h: ...use household appliances (e.g. washing machine or dishwasher) in energy-saving mode.	(3) 2.9%	(8) 7.8%	(7) 6.9%	(16) 15.7%	(67) 65.7%	(1) 1.0%	(0) 0.0%
i: ...use household appliances (e.g. washing machine or	(1) 1.0%	(1) 1.0%	(4) 3.9%	(28) 27.5%	(67) 65.7%	(1) 1.0%	(0) 0.0%

dishwasher) only when they are fully loaded.							
l: ...regularly defrost the refrigerator or freezer to avoid a layer of ice.	(1) 1.0%	(1) 1.0%	(4) 3.9%	(28) 27.5%	(67) 65.7%	(1) 1.0%	(0) 0.0%

Furthermore, 98.0% of respondents declared that they had already applied daily the behaviours aimed to energy saving; the frequency of the interventions carried out is shown in Figure 99.

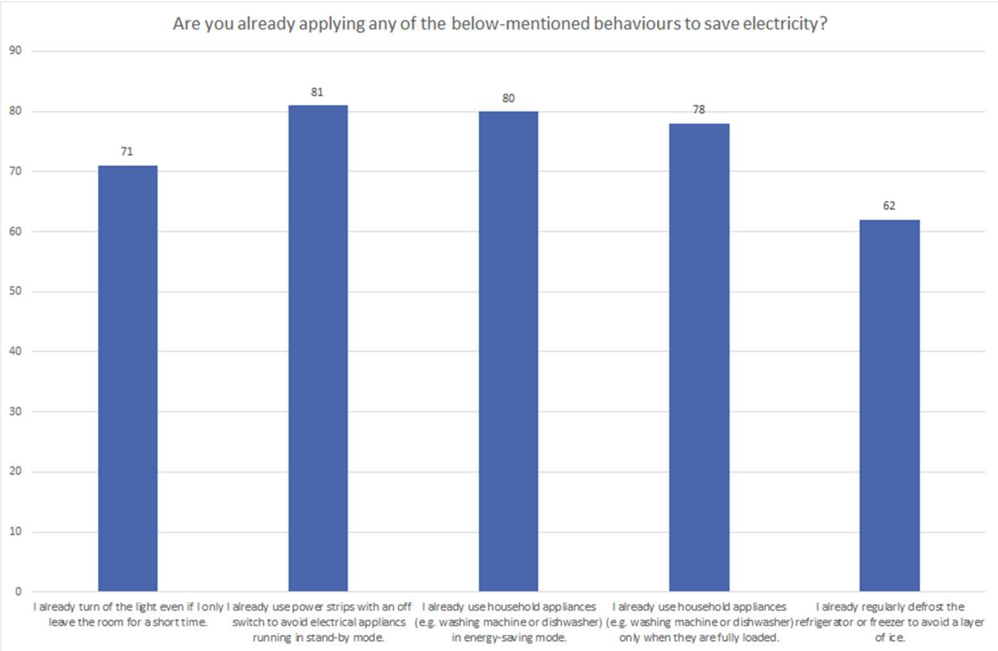

Figure 99. Frequency of behavioural change actions (Q17).

Finally, the energy use adaptation to the renewable energy production model characterized by volatility (Question 19) is investigated and the results are shown in the table below (Table 52). Participants were asked to indicate their level of willingness, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In addition, the possibility to choose the "I don't know" option or to leave the answer blank is given.

Table 52. Energy use adaptation (Q19).

Question 19: To stabilise the electricity grid, I am willing to...	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I Agree**	**(5) I strongly agree**	**I do not know**	**I prefer not to answer**
m: ...use household appliances (e.g. washing machine, dishwasher) mainly when the share of electricity from renewable sources in	(2) 2.70%	(16) 15.7%	(11) 10.8%	(27) 26.5%	(43) 42.2%	(3) 2.9%	(0) 0.0%

the grid is very high.							
n: ...recharge electrical devices (e.g. notebook) mainly when the share of electricity from renewable sources in the grid is very high.	(4) 3.9%	(15) 14.7%	(16) 15.7%	(25) 24.5%	(38) 37.3%	(4) 3.9%	(0) 0.0%
o: ...recharge electrical means of transportation (e.g. electric car/ scooter/ bike) mainly when the share of electricity from renewable sources in the grid is very high.	(5) 4.9%	(4) 3.9%	(9) 8.8%	(25) 24.5%	(45) 44.1%	(14) 13.7%	(0) 0.0%

Furthermore, Question 20 investigated the respondents' willingness to install some devices (e.g. smart meters) for regulating the energy consumption in household. The histogram in Figure 100 shows the responses obtained, highlighting how for almost all respondents the device installation covers a very important issue; indeed, the 36.3% attribute on importance of +3, the 25.5% attribute an importance of +2 and, finally, the 10.8% attribute an importance of +1.

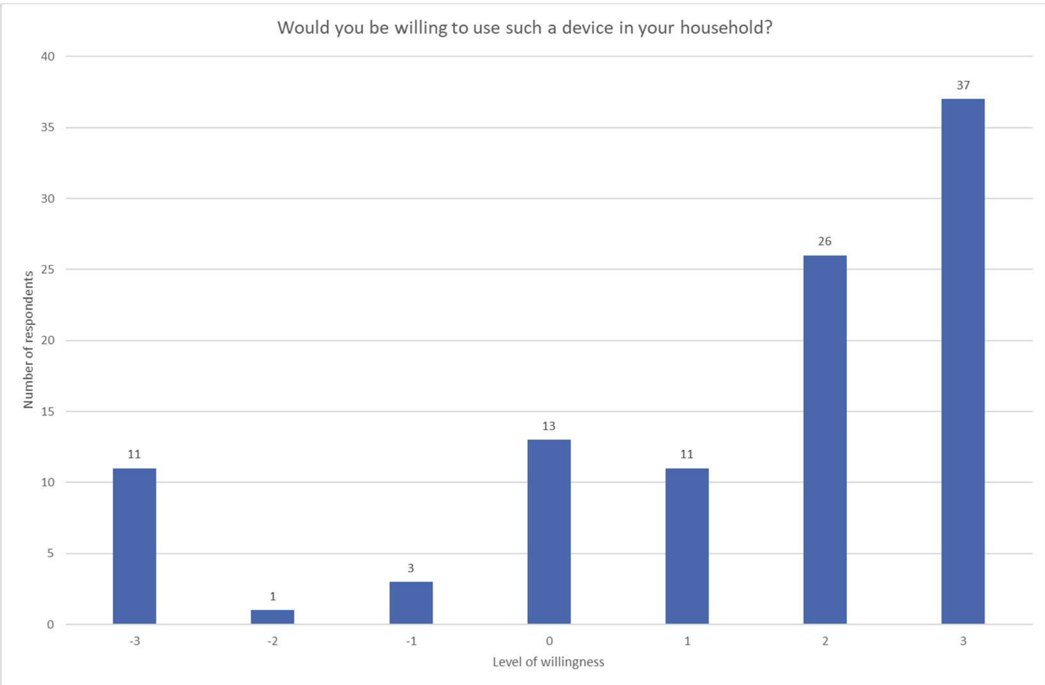

Figure 100. Willingness to device installation (Q20).

(iii) In conclusion, in this first part of the questionnaire, the personal importance of environmental protection and safeguard has been investigated (Q21). The histogram in Figure 101 shows the responses obtained, highlighting how for almost all respondents the environmental protection covers a very important issue; indeed, the 57.8% attribute on importance of +3, the 32.4% attribute an importance of +2 and, finally, the 7.8% attribute an importance of +1.

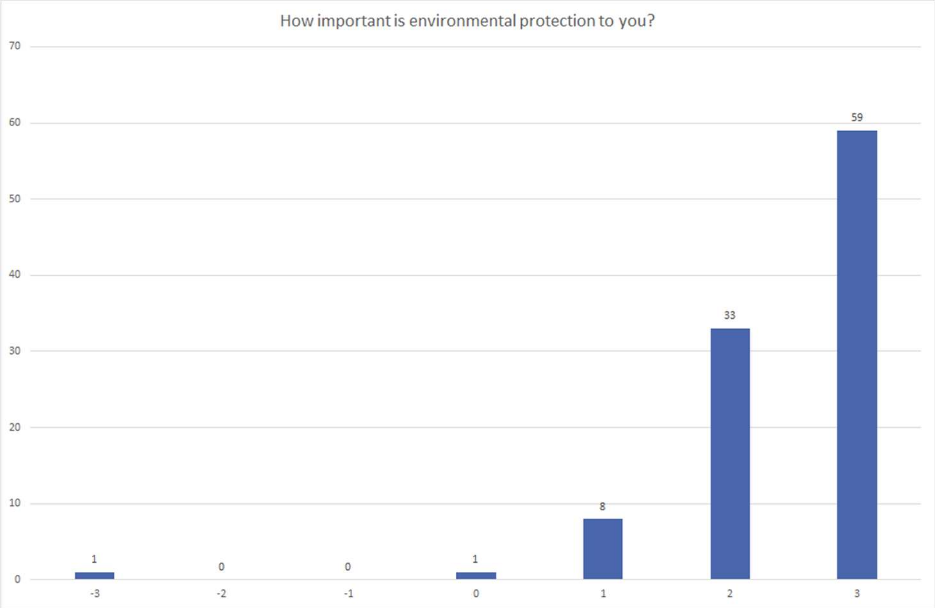

Figure 101. Importance of environmental protection (Q21).

Second part: information on feelings and community identity.

This paragraph shows the results relating to the second part of the questionnaire which deepens the community/territory perception. In Question 22, through three statement, participants were asked to indicate their level of agreement/disagreement, using the 5-point Likert scale, from 1 (I strongly disagree) to 5 (I strongly agree). In general, the answers obtained, presented in Table 53, show a substantial perception of belonging by the respondents to the territory/context in which they live. 58.5% of the respondents stated that they agree or strongly agree to feel connected to the community in which they live. In fact, only 8.1% said they strongly disagree or disagree with that statement. The remainder stated that they are neutral (29.7%), do not know (0.9%) or prefer not to answer (2.7%). In line with what has been described above, 69.3% of respondents agree or strongly agree that they have good friends within their community and 65.5% of respondents often speak about the community in which they live as a great place to live. Also, for these two statements the share of respondents not in agreement is low, the greatest weight is determined by those who hold a neutral position, respectively 17.1% and 22.5%.

Table 53. Statements on community perception (Q22).

Statements	(1) I strongly disagree	(2) I disagree	(3) Neutral	(4) I Agree	(5) I strongly agree	I do not know	I prefer not to answer
I feel strongly connected to the community in which	(3) 2.7%	(6) 5.4%	(33) 29.7%	(36) 32.4%	(29) 26.1%	(1) 0.9%	(3) 2.7%

I live.							
There are many people in my community that I consider to be good friends.	(3) 2.7%	(8) 7.2%	(19) 17.1%	(52) 46.8%	(25) 22.5%	(2) 1.8%	(2) 1.8%
I often speak of my community as a great place to live.	(5) 4.5%	(4) 3.6%	(25) 22.5%	(46) 41.4%	(29) 26.1%	(1) 0.9%	(1) 0.9%

Third part: technical information.

This paragraph shows the results relating to the third part of the questionnaire which deepens the general building's characteristics and the energy system characteristics and the energy expenditure information. Questions 23 concerns the building typology and Question 24 concerns the building's construction year. Most of the respondents (63.7%) reported living in a apartment while 36.3% in a single-family house. Furthermore, 57 respondents (55.9%) are homeowners and 45 (44.1%) are rented out. Furthermore, Question 25, Question 26 and Question 27 focus on energy cost and consumption in buildings. Specifically, the results of relationship between users and the energy costs are shown in Table 54.

Table 54. Energy cost for household (Q25).

Question 25	**(1) I strongly disagree**	**(2) I disagree**	**(3) Neutral**	**(4) I Agree**	**(5) I strongly agree**	**I do not know**	**I prefer not to answer**
It is difficult to meet the energy demand of my household.	(58) 56.9%	(25) 24.5%	(9) 8.8%	(1) 1.0%	(2) 2.0%	(7) 6.9%	(0) 0.0%
In order to cover the running energy costs, my household does without other expenses (e.g. new purchases, leisure time).	(74) 72.5%	(16) 15.7%	(4) 3.9%	(4) 3.9%	(3) 2.9%	(1) 1.0%	(0) 0.0%
During winter, my household has trouble heating the apartment/ the house sufficiently.	(61) 59.8%	(26) 25.5%	(6) 5.9%	(5) 4.9%	(3) 2.9%	(1) 1.0%	(0) 0.0%
To reduce energy costs, my household limits itself to save energy (e.g. cold water for showering, no heating).	(59) 57.8%	(23) 22.5%	(10) 9.8%	(7) 6.9%	(2) 2.0%	(1) 1.0%	(0) 0.0%

Question 26 and Question 27 examine respectively the quantity of energy (electricity) used annually and the energy expenditure (again only for electricity) incurred for the respondents' home per month. The 68.6% of interviewees said they were aware of how much energy is used in their home, while 31.4% are not aware of it. With further secondary questions it emerged that consumption electricity averages around 3520 kWh, with a maximum of 15000 kWh and a minimum of 200 kWh. In addition, the 78.4% of interviewees said they were aware how much is the energy expenditure while 21.6% are not aware of it. As expected, looking at the percentages of the two previous questions, respondents are more aware of the expenditure they incur to obtain energy than the amount of energy used. This happens because they periodically have to pay their bills to continue receiving the service offered and, therefore, these are expenses that are usually always clear in everyone's mind. With further secondary questions it emerged that spending for electricity consumption average is around 85 €/month, with a maximum of 220 €/month and a minimum of 20 €/month.

Fourth part: socio-demographic information.

This paragraph shows the results relating to the fourth part of the questionnaire which deepens (i) the economic situation/condition of building occupants and (ii) the socio-demographic respondents' characteristics.

(i) The economic situation/condition of building occupants is explored through five questions. Question 28 concerns the respondents' occupation. As shown in Figure 102, the majority of respondents (73.5%) said they were employed while only 2.0% were not employed. 17.6% of respondents are retired while students are 1.0% and the 2.0% of respondents are doing the apprenticeship. Finally, 3.9% said something else or preferred not to answer.

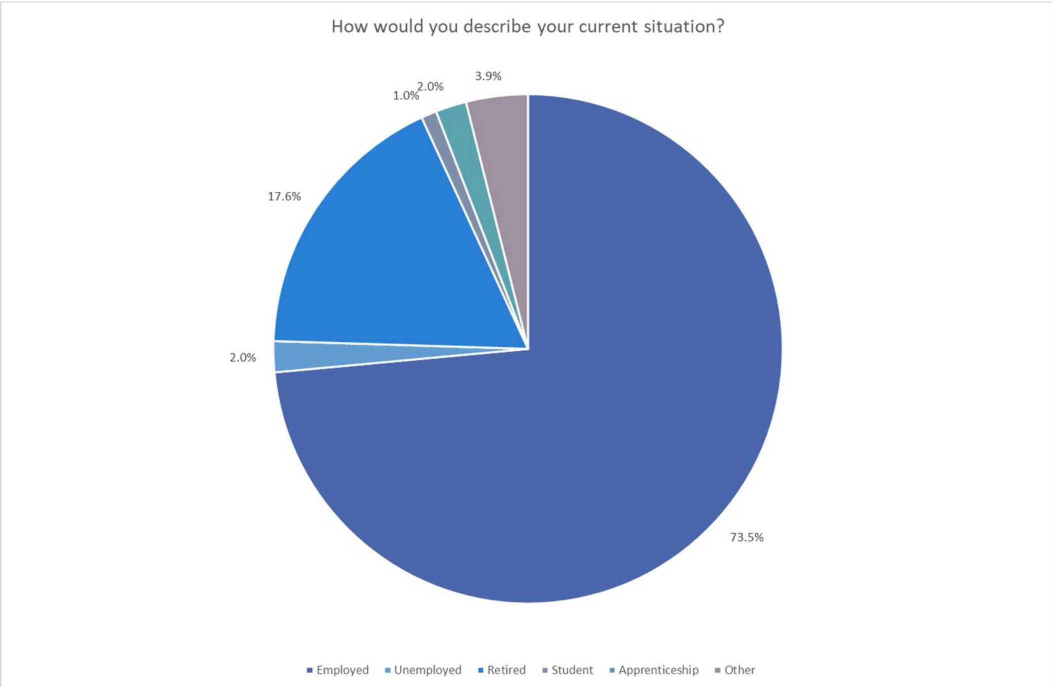

Figure 102. Occupation (Q28).

Furthermore, the economic situation was investigated through Question 32 to whom the interviewees were asked to indicate, on the basis of the total monthly net income of all the people living in their own home, one of the indicated income range. Figure 103 shows how the monthly income with the highest percentage of preferences (15.7%) is between 3001€ and 3500€, followed by 18.6% an income more than 5000€. Again, 14.7% of respondents said to not want to express their income and the other ranges got less consensus.

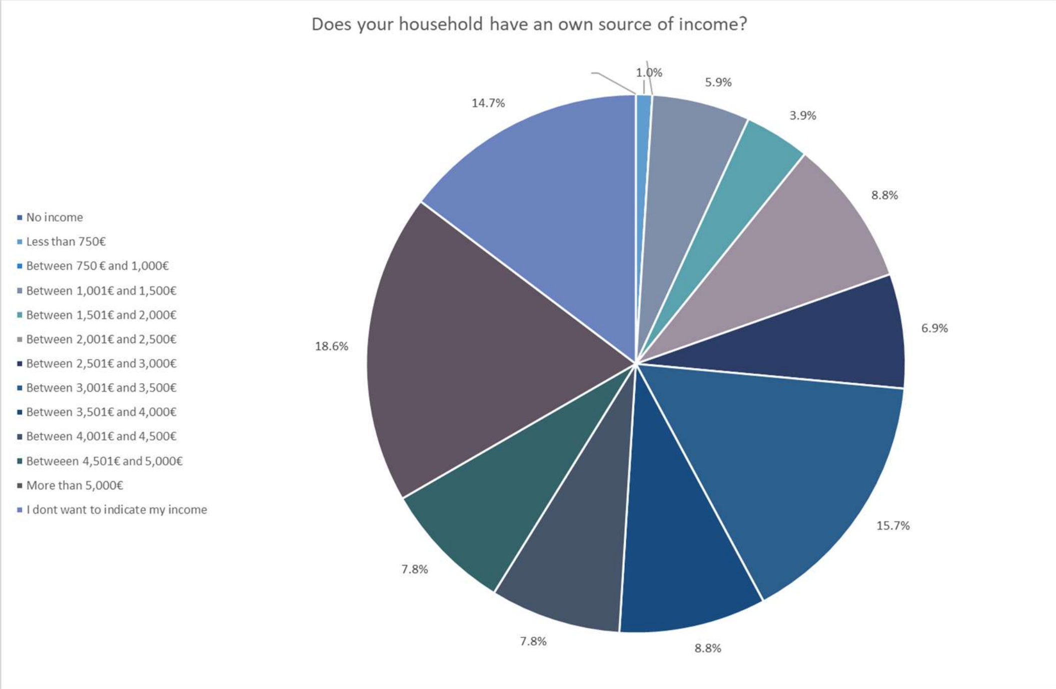

Figure 103. Family net income (Q32).

Figure 104 shows the results relating to home and money management in the family. The respondent was asked to rate their level of management on a 5-point scale from "I strongly disagree" to "I strongly agree". The radar chart shows how, usually, for the control of the household finances, the respondents are personally involved; indeed 38.2% are strongly agree and 22.5% agree with the request. On the other hand, for the responsible for homemaking, respondents are not actively involved; indeed, they are principally a neutral position (35.3%) and also 27.5% of respondents are strongly agree with the request. Finally, analysing the family composition (Question 30 and Question 33), on average the family unit is made up of two people; this does not exclude different cases in which a minimum of 1 component and a maximum of 5 has been detected. In addition, the respondents live, mainly with their spouse or husband (52.9%), alone (23.5%) and with the life partner (12.7%). 10.8% of the respondents declared to live in other conditions.

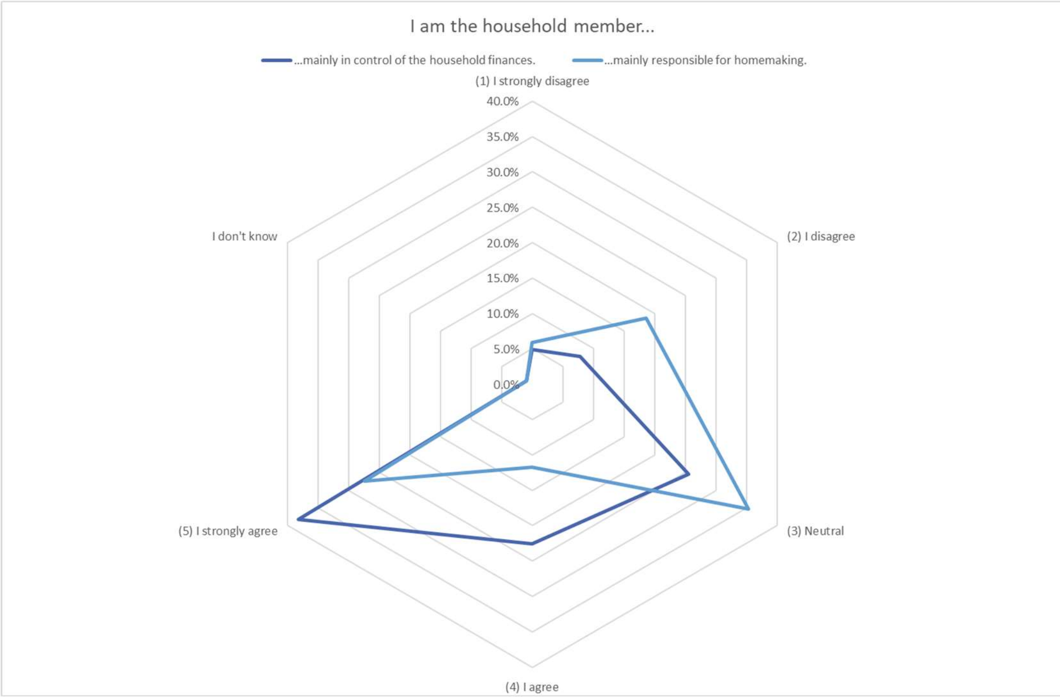

Figure 104. House and money management (Q31).

(ii) Concerning the socio-demographic respondents' characteristics, the sample is composed by 35.3% of women and the remaining part (59.8%) of men. In addition, 4 people preferred not to answer the question and 1 preferred to self-describe describe. 49 years is the average age of the respondents (with a standard deviation of about 13 years); the youngest respondent is 20 years old, while the oldest is 76 years old. The following figure (Figure 105) shows the educational status of the respondents. The 26.5% of the respondents completed the PhD, 17.6% the university education, the 2.0% completed the college and 2.9% apprenticeship. Currently, the 49.0% of respondents are doing an apprenticeship and 2.0% declared other qualifications.

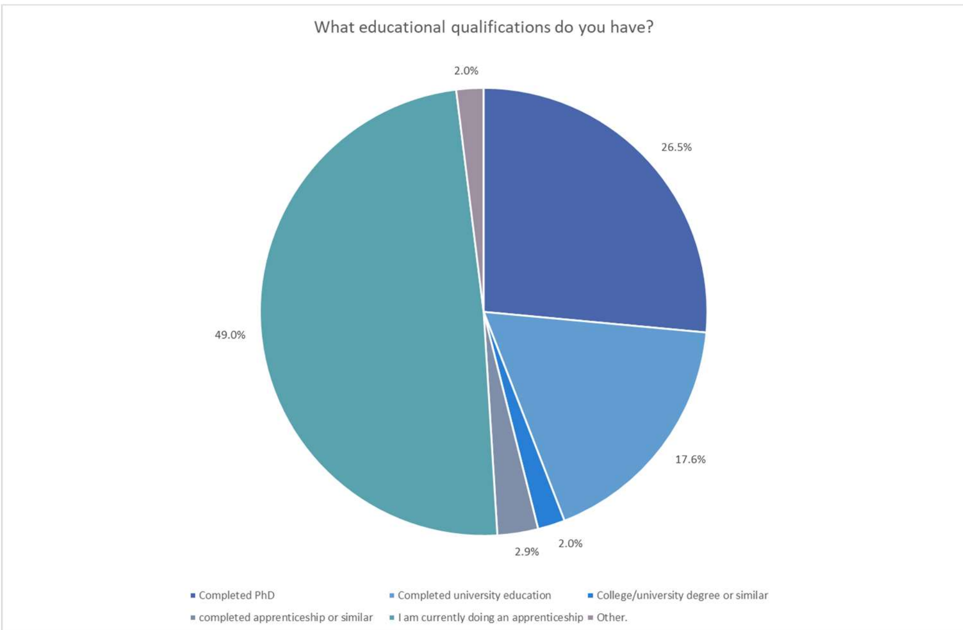

Figure 105. Educational qualification (Q29).

c) Citizens clusters

In this part, through the cluster analysis, homogeneous groups of citizens are identified in order to promote specific inclusion strategies to commit towards an energy community project. The clustering is based on the variables of the first two part of the questionnaire: the variables relating the attitude and availability towards community projects based on renewable energy and the variables relating to feelings and community identity. The variables of these first two parts of the questionnaire are 9 and they are listed below.

- Q01: Participation in RECP.
- Q06: Actual participation in RECP.
- Q12: Investment in RECP.
- Q14: Willingness to energy consumption reduction.
- Q16: Willingness to save electricity.
- Q19: Willingness to electricity grid stabilization.
- Q20: Device installation.
- Q21: Environmental protection.
- Q22: Community connection.

The cluster analysis was performed using R software and, accordingly, the dataset was prepared. To proceed with the cluster analysis it is necessary that the data matrix consists solely of numerical values. The variables investigated are ordinal or dichotomous variables. The sortable variables have been transformed into a score from 1 to 5, where 1 indicates "disagree/not interested/not availability" and 5 indicates "agree/interested/availability". In these questions, "I prefer not to answer" and "I don't know" were among the answer options; these have been transformed, after discussion, by assigning a score of 0. The dichotomous variables have been transformed into 0/1, where 0 indicates the absence of the investigated characteristic and 1 its presence. Subsequently, after having prepared the matrix of the observations, the k-means method was applied. The first step was the identification of the number of clusters though the so-called "Elbow" method, then the identification of cluster composition. Table 55 shows the results obtained for the 4 clusters. The clusters obtained are made up of 14, 63, 23 and 2 users.

Table 55. Cluster analysis result.

K-means clustering with 4 clusters of sizes 14, 63, 23, 2				
Variable	**Cluser 1**	**Cluster 2**	**Cluster 3**	**Cluster 4**
Q01	0.5525186	0.3935526	-1.3920351	-0.2561345
Q06	0.09396047	0.16740084	-0.46642148	-0.56700285
Q12	0.5272759	0.3036918	-0.9017181	-2.8874630
Q14	0.05096611	0.31557226	-0.58796095	-3.53573804
Q16	-0.1196494	0.3978874	-0.6565480	-4.1456041
Q19	0.06709994	0.43414569	-0.88238365	-3.99787671
Q20	-1.9212453	0.4875418	-0.1508972	-0.1735318
Q21	0.0785883	0.3239763	-0.5437725	-4.5019870

Q22	-1.0490039	0.4901784	-0.5141847	-2.1844663

Within cluster sum of squares by cluster :
[1] 65.94553 233.62028 152.75837 22.35531
(between_SS / total_SS =47.8 %)

Cluster 1. This cluster consists of 14 users (13.7% of respondents). In general, they are respondents interested and with a positive willingness to participate in community projects based on renewable energy. The will to participate with an economic investment is high. Some citizens are currently involved in any form of renewable energy co-production. These users are characterized by a very poor connection and sense of pride with the community in which they live and by a low level of relationships with other citizens. In addition, they are characterized by a good attitude towards reducing energy consumption, towards habitual behavioural practices to save electricity and towards adaptation to the renewable energy production model characterized by volatility. It is possible to say that it is the cluster on which it is essential to pay attention and define inclusion policies. In this case, first of all, it is necessary to increase the sense of belonging towards the context of belonging by aiming to transform the actual feeling in pride, thinking of targeted actions and tailor-made incentives.

From the observation of the socio-economic data, shown in Table 56, it is evident that within this cluster 14.3% live in a single family house and 85.7% in an apartment; furthermore, only 28.6% own the house they live. 64.3% of the users cluster have a job, instead, 35.7% are retired. 21.4% of respondents declared an income between € 3000 and € 3500. In addition, the average age of this cluster is 54 years old, 78.6% male, 7.1% female and predominantly with an apprenticeship education on going (42.9%) and a PhD education (42.9%).

Cluster 2. This cluster consists of 63 users (61.8% of respondents). In general, this cluster is made up of citizens who are total willing and interested in participating in community projects based on renewable energy, probably for two reasons: 1) they currently participate, in some way, in the production of energy from renewable sources; 2) they are characterized by an excellent connection and sense of pride with the community in which they live and by an excellent level of relationships with other citizens. In addition, they are characterized by a good attitude towards reducing energy consumption, towards habitual behavioural practices to save electricity and towards adaptation to the renewable energy production model characterized by volatility. In short, this cluster is composed by users ready to participate fully in a community project based on renewable energy. No training is needed for them; being the most populous cluster, on the contrary they can be the ones to spur other clusters.

From the observation of the socio-economic data, shown in Table 56, it is evident that within this cluster 46.0% live in a single family house and 54.0% in an apartment; furthermore 65.1% own the house they live. 79.4% of the users cluster have a job, instead, 9.5% are retired. The users of this cluster declared, in general, to receive a high income. In addition, the average age of this cluster is 48 years old, 52.4% male, 46.0% female and predominantly with an apprenticeship education on going (52.4%) and a PhD education (20.6%).

Cluster 3. This cluster consists of 23 users (22.5% of respondents). In general, they have a low interest in community projects. The level of connection with the community in which they live is low. Also the attitude towards reducing energy consumption, towards habitual behavioural practices to save electricity and towards adaptation to the renewable energy production model characterized by volatility. For them it is necessary to have adequate training and policies that pay attention and define first of all inclusion policies. Indeed, in this case, first of all, it is necessary to increase the sense of belonging towards the context in which the person live by aiming to transform the actual feeling in pride.

From the observation of the socio-economic data, shown in Table 56, it is evident that within this cluster 26.1% live in a single family house and 73.9% in an apartment; furthermore 52.2% own the house they live. 60.9% of the users cluster have a job, instead, 30.4% are retired. The users of this cluster declared, in general, to receive medium level income. In addition, the average age of this cluster is 52 years old, 65.2% male, 26.1% female and predominantly with an apprenticeship education on going (39.1%) and a PhD education (34.8%).

Cluster 4. This cluster consists of 2 users (2.0% of respondents). Users are not interested in participating in RECP, they are not interested in actively participating, they are not interested in investing economically, they disagree in undertaking actions aimed at improving energy efficiency and in undertaking new behaviours aimed at energy saving. These users are characterized by a very low level of connection and sense of pride with the community in which they live; in the same way, even the relationships with other citizens are negative. Given their clear position it would seem that there is no way to change their thinking. With a view to optimizing resources, it would be correct to proceed first of all to the formation of clusters with a proactive attitude and at the same time study tailor-made policies for this cluster, not forgetting the help that citizens (e.g. belonging to cluster 1) can give in this sense.

From the observation of the socio-economic data, shown in Table 56, it is evident that within this cluster all users live in an apartment for rent. The users are employed and with a monthly family income between 2500€ and 3000€. In addition, the average age of this cluster is 44.5 years old; the users are male and are currently doing the apprenticeship.

Table 56. Statistical analysis of the classes of the variables (Essen).

Variable	Cluster 1 (14)	Cluster 2 (63)	Cluster 3 (23)	Cluster 4 (2)
Are you living...				
… in an apartment?	12	34	17	2
... a single family house?	2	29	6	0
Do you live for rent or are you using your own property?				
Own property	4	41	12	0
For rent	10	22	11	2
Do you know how much electricity your household uses approximately per year?				
Yes.	10	43	16	1
No.	4	20	7	1
Do you know how much your household is approximately paying for electricity (no heat) per month?				

Yes.	11	50	18	1
No.	3	13	5	1
How would you describe your current situation?				
Employed	9	50	14	2
Unemployed	0	1	1	0
Retired	5	6	7	0
Student	0	1	0	0
Apprenticeship	0	2	0	0
Other	0	3	1	0
What educational qualifications do you have?				
completed PhD	6	13	8	0
completed university education	0	12	6	0
college/ university degree or similar	0	2	0	0
completed apprenticeship or similar	1	2	0	0
I am currently doing an apprenticeship	6	33	9	2
Other				
Does your household have an own source of income?				
No income	0	0	0	0
Less than 750€	0	0	1	0
Between 750 € and 1,000€	0	0	0	0
Between 1,001€ and 1,500€	0	5	1	0
Between 1,501€ and 2,000€	1	3	0	0
Between 2,001€ and 2,500€	1	4	4	0
Between 2,501€ and 3,000€	2	4	0	2
Between 3,001€ and 3,500€	3	7	6	0
Between 3,501€ and 4,000€	2	4	3	0
Between 4,001€ and 4,500€	1	7	0	0
Betweeen 4,501€ and 5,000€	0	7	1	0
More than 5,000€	1	14	4	0
I dont want to indicate my income	3	8	3	0
How old are you?				
Age (years)	54	48	52	44.5
What is your gender?				
Female	1	29	6	0
Male	11	33	15	2
I prefer not to answer	2	1	2	0

5.5 Conclusion

The aim of this chapter was to apply the methodology, related to the creation of the energy community, described in Chapter 4, in the three European contexts of Susa Valley (Italy), Litoměřice (Czech Republic) and Essen (Germany). The case study of the Susa Valley was the most complete from the applicative point of view, since both the technical structure and the social one are implemented; instead, in the case studies of Litoměřice and Essen only the target group involvement phase, belonging to the social structure, was implemented.

Susa Valley (Italy). The technical structure concerns all the processes aimed at selecting and describing buildings and energy plant systems, defining various energy retrofit scenarios and, finally, choosing the best one; the technical methodology was applied to the Oulx case study. First of all, the building are identified and their physical-thermal characteristics were described, subsequently the critical issues and weaknesses were highlighted and again, on the basis of the evidence found, six retrofit intervention scenarios were proposed, in order to improve the current energy situation and minimize the environmental impact. Finally, in order to sort the different energy retrofit interventions and, consequently, to choose the best refurbishment alternative, the outranking MCA, called PROMETHEE, is applied. In addition, a sensitivity analysis was carried out, modifying the weights with respect to the Baseline alternative of each alternative (according to stakeholders' interests and opinions), in order to observe how their ranking varies and to test the robustness of the model. From the model runs, by changing the weights, the best alternative is always A5 (that concerns the replacement of the boilers with a unique biomass-fired one, the regulation retrofitting and the achievement of the nZEB conditions through the upper-attic slabs and external walls insulation. A5 represents the best solution since the achievement of nZEB conditions leads obtaining great public incentives; instead, the solution A1 represent the worst scenario since provides only a biomass boiler addition. The social structures concerns all the processes aimed at making users aware of energy and environmental issues and to encourage their inclusion/participation in community projects or promoting a behaviour change. The implemented actions are: stakeholders' analysis, informative events and workshops. The stakeholders' analysis allowed the stakeholders (including the vulnerable and the underrepresented groups) identification through a process articulated in two steps: a survey, which allowed to have a situation overview, collecting general information above all on people in vulnerable condition, and an interest/influence matrix, which allowed to map the local actors and produce an Action Plan to reach the stakeholders and to define the contact priority. The informative events concerns meeting with local institutions in order to disseminate materials on energy community principals and to understand in which way involve citizens. Specifically, the event allowed (i) to inform and share the research activities and the project results (mainly related to the technical analysis) with the community; (ii) to raising awareness among stakeholders about the energy community benefits and, finally, (iii) to co-create an action plan for the definition of an energy community in the specific context. The workshops allowed not only to inform the invited stakeholders about a specific topic (the environmental and energy issues and the community energy topic) but also to create a semi-structured debate with them. Workshops were structured in educational moments and practical activities, made *ad hoc* according to the invited stakeholders ((a) vulnerable citizens, (b) citizens in general and mayors and (c) students) in order to verify the learning, to express their thoughts and opinions and to create a constructive debate, ensuring that people feel free to express themselves. (a) The workshop with vulnerable citizens allowed to understand the obstacles and problems in participating in energy community project and to highlight which aspects of the CSOP are perceived as important. Results showed that "environmental commitment" and "low investment and low individual responsibility" represent the main benefits to join an energy community project. Indeed, the main obstacle are the distrust (since energy community is an innovative project and there is still no solid confirmation and feedback of its success), the absence of control and verification actions (in order to avoid that the investment disparity may lead to a different representation, to avoid that only the entities that invest a great amount of money are taken into account) and the bureaucracy (since the topic and the necessary documentation could be complicated for simple citizen not working in the legal, financial and energy fields). (b) The workshop with citizens in general and mayors is based on a storytelling methodology and allowed to define the current energy scenario on the basis of individual experiences related to personal energy use and to co-create the future energy community scenario. The definition of a history of a future context, concerning the energy community, made it possible to extrapolate the strengths and weaknesses perceived by the two types of stakeholders. The shared strengths are use of local resources, rationalization of consumption, increase security in energy management and use, cost reduction, use of different energy sources and improve environmental issues. Instead, the shared weaknesses are technical issues regarding the distance between the buildings and the thermal plant, bureaucratic-normative issues and uncertainty about the project management and decisions with different stakeholders. (c) The workshop with students is based on graphic storytelling activity since students self-identified as urban planners/architects in order to co-create their ideal energy community. The activity was structured in four parts: the preliminary survey (in order to investigate the students' knowledge about energy related keywords), the frontal lesson (in order to educate the students to energy and environmental issues and to renewable energies and energy community), the practical activity (in order to favour a graphic story in which students had to self-identify themselves as urban planners) and, finally, the final meeting (in order to discuss the practical activity results). Students showed a general average familiarity with energy field terms such as sustainability, energy sources, carbon dioxide, climate change, deforestation, pollution, economic investment and territory. All projects represent interesting design ideas for new energy communities, connecting and involving local businesses, private citizens and municipal institutions. Many of them chose to involve school buildings and the participation of the students themselves, some local businesses, connected with sustainable local tourism and the preservation of the environment. In addition students showed great interest in the topic and commitment to their projects and ideas; the workshop was also an opportunity to improve team-work skills. Finally, through the interviews with the citizens, the workshop managed to extend the topics of renewable energies and energy communities also outside the classes.

Susa Valley (Italy), Litoměřice (Czech Republic) and Essen (Germany). The target group involvement phase (social structure) is implemented in all the three case studies. Since citizens' inclusion, participation and investments in community project, based on renewable energy, could be hindered by several drivers, the goal of this phase was define clusters of citizens who share the same characteristics of attitudes and availability towards community projects and feelings towards the context in which they live in order to promote tailor-made environmental and energy policies. In order to collect citizens' information and characteristics, a questionnaire was drawn up and distributed in the three different

European context. The questionnaire was divided into four sections (information on attitude and willingness, information on feelings and community identity, technical information and socio-demographic information) and the purpose was to gather different citizens' opinions regarding the energy community topic and their engagement in local energy initiatives and to understand the relationships between respondents and the community/territory in which they live. The attitude to community projects and to energy behaviour and the study of the perception of the surrounding community/territory represent the core issues of the questionnaire. These information, collected through an online and paper based questionnaire distribution, were analysed through a cluster analyses using the k-means methodology. Within each cluster, individuals are characterized by the same opinion about community projects and by the same feeling towards the context in which they live. The clustering analysis produced 4 clusters for each case studies. In summary:

1. A first cluster is composed by respondents who have an interest in participating in RECP, they are interested in actively participating, they are interested in investing economically, they agree in undertaking actions aimed at improving energy efficiency and in undertaking new behaviours aimed at energy saving. They also have positive feelings toward the community. In short, they are users ready to fully participate in a community project based on renewable energy and no training is needed for them.
2. A second cluster is composed by respondents with a general interest and a willingness to participate in community projects based on renewable energy. Also, the feelings towards the community are, in general, positive. However, they are not entirely convinced and there are some doubts regarding the issue of energy communities. So, they must be encouraged, they must be more involved, thinking of targeted actions and tailor-made incentives.
3. A third cluster is composed by respondents with a similar profile to the previous one but with a lower interest in community projects. Furthermore, they stated that they do not feel completely connected to the community in which they live. Also, for this cluster it is essential to pay attention and define inclusion policies. Specifically, first of all, it is necessary to increase the sense of belonging with the context.
4. The last cluster is composed by respondents not interested in participating in RECP, not interested in actively participating, not interested in investing economically. They often expressed a desire not to want to answer the questions asked. Including them in an energy community represents a great challenge.

The most virtuous pilot case is represented by Essen with 57% of the interviewees belonging to the first cluster and 13% of the interviewees belonging to the second cluster. The case study of the Susa Valley, also, presents optimistic results; indeed, 36% of the interviewees belong to the first cluster and 38% of the interviewees belong to the second cluster. As for the Litoměřice case study, 34% of the respondents belong to the third cluster and 22% to the second cluster. Finally, the respondents belonging to cluster 4, that is the cluster of absolutely not interested, are few: 6% for the Italian case study, 3% for the Czech Republic case study and only 2% for the German case study.

Chapter 6

Conclusions

6.1 Conclusive summary

This Ph.D dissertation tackled different challenges in the field of energy transition and environmental protection through the energy community concept. Against a backdrop of global concerns over climate change and rising greenhouse gas emission, renewable and sustainable energy transition has become a key challenge and opportunity to improve the overall social-ecological resilience of the community worldwide. Solving many of the world's energy-related problems requires technological advances and, above all, changes in human behaviour (a successfully shifting of citizens' behaviour in the desired direction). Specifically, for this purpose, it was necessary: to define which elements make up an energy community and which relationships are established between them (Chapter 2 and Chapter 4), to structure a work path that leads to the creation of energy communities (Chapter 4), to analyse and to study the existing literature in order to define a new classification of the drivers that affects the citizens' energy consumption and behavioural choices relating to three actions type, the energy saving behaviours (ESB), the energy efficiency investment (EEI) and the engagement in renewable energy projects (ERE) (Chapter 3), to define strategies to involve citizens in active participating in an energy community (Chapter 4) and to extrapolate users' profiles who share the same characteristics in order to promote tailor-made environmental and energy policies (Chapter 4 and Chapter 5). The main research question, around which the whole thesis is articulated, is the following: "*is it possible to define and create an energy community as a potential solution to achieve the energy transition?*". Table 57 summarises research gaps, research questions and respective contributions made, in order to address shortcomings in the current research body.

Table 57: Conclusive summary of Ph.D. dissertation.

N°	Research gap	Research questions	Contributions
1	Lack of understanding of the process underlying an energy community.	What elements are necessary for the birth of an energy community?	Definition of a workflow and the basic elements of an energy community.
2a	Absence, scarce or limited participation of all segments of the population in community energy projects.	How can people be included to participate actively, becoming prosumer and/or plays an active role in society?	Understanding of each individual's idea of an energy community and exploration and proposal of inclusion strategies and activity designed for all population segments.
2b	Gap between predicted energy-related and behavioural retrofit scenarios and real situation due to the influence of users' features.	What are the factors that determine the human behaviour related to energy use/consumption and engagement in Renewable Energy (RE) projects?	Study and classification of citizen drivers affecting the energy saving behaviours (ESB), the energy efficiency investment (EEI) and the engagement in renewable energy projects (ERE).
3	Lack of inclusive strategies tailored for each segment of population.	It is possible to define homogeneous groups based on the same characteristics?	Definition of clusters of citizens who share the same characteristics of attitudes and availability towards community projects and feelings towards the context in which they live.

6.2 What elements are necessary for the birth of an energy community?

The deepening of the concept of energy communities (Chapter 2), through the study of the existing literature, has shown that this is an emerging issue and it is being defined in recent times. EC represents an innovative model of energy supply, distribution and consumption with the aim of facilitating the production and exchange of energy generated mainly from renewable sources, as well as improving efficiency and reducing energy consumption. In this regard, in few recent years a legislative framework is being created. At the European and Italian level, the main measures are the Italian law of 2015 with the definition of Oil Free Zone (areas in which, by law, it was possible to carry out and implement actions in the field of energy), the recast of the Renewable Energy Directive (RED II) as part of the European legislation of the Clean Energy for all Europeans Package with the definition of community of prosumer of renewable energy and, finally, the Piedmont region law of 2018 with the promotion and the institution of energy communities. The definition of an energy community is not unique but, in general, there are shared elements. An energy community is created by the desire of different users to unite and cooperate in order to invest in a new or existing plant for the production of energy and to actively participate in its production, exchange and management phases. The user occupies a key and central position since it is not only an energy consumer but becomes a prosumer (producer and consumer) who, through his/her choices, engages in sustainable actions for the environment and for energy. In this context, the prosumer figure is born: it is a citizen who is not a passive consumer but a user who plays an active role, making decisions, self-producing, self-consuming and selling the energy produced through renewable sources. In addition, the EC should be inclusive projects; not just aimed at wealthy citizens but at all segments of the population, including the vulnerable people defined as unemployed, low-income and single mothers. The implementation of energy communities are associated with positive implications, not only related to the energy field: reduction of emissions and pollution, better living conditions for future generations, economic development, self-sufficiency, independence from public service providers or foreign states, independence from variable prices of energy, reduction of energy poverty, community cohesion, creation of new job, etc. Coping with energy poverty is one of the elements on which community projects are focusing their attention. The energy poverty is a problem present throughout Europe and it leads to negative impact not only economic but also on the health and social aspect, for example the isolation condition. The causes related to the occurrence of the problem could be direct or indirect; the most frequent are the decrease of resource available to low-income households, the lower energy efficiency conditions of the building envelope and of the energy plant systems and the energy price where taxes and system charges have high incidence. Since sharing and inclusion is the cornerstone of the energy community, through targeted policies, it is necessary to include all segments of the population, especially the most fragile and vulnerable. Furthermore, inclusion must not be limited to simple participation but it is desirable that it is also aimed at the (co-)ownership of the energy plant system: each user, represented by a trustee, invests economically as much as he/she can; initially with the earnings obtained from the sale of the surplus energy (appropriately distributed among the participants) the bank loan is repaid and, only in a second phase, the surplus become a small source of income. Regarding the characteristics of an EC, it can be very different; they can encompass a small portion of territory such as a neighbourhood or be as large as a city or region; they can use different technologies for energy production such as thermal solar panels, photovoltaic panels, biomass systems, etc.; they can include different users such as citizens, public entities, SMEs or, in any case, users who do not have the energy sector as their main source of income.

In conclusion, an energy community consists of various elements: various entities (citizens, municipalities, small and medium-sized enterprises) co-operate with the desire to co-own, co-manage the energy plant and co-participate in the choices and decisions related to it. This reflection led to the definition of three basic elements. An energy community is defined from synergy of a material component (consisting of buildings and energy plant system), a social component (consisting of users and citizens, private and public entities) and, finally, a regulatory component (consisting of an agreement between the parties regulate its balance and functioning). The social component is the fulcrum: this is precisely the element that, through people involvement, participation and active contribution, allows the effective creation of an energy community. Indeed, the term community is used in order to mark how the union of citizens is the centre of the process without whose presence the energy community would not exist. Consequently, on the basis of this study and research, in Chapter 4, a work path has been defined and the three parts (material, social and legal/financial elements) has been described. The first elements is the technical structure and consists of two parts: a preparation phase, in which the buildings and the energy plant systems are described in their more technical aspects, and a preliminary and feasibility analysis phase, in which the best scenario is chosen from a set of possible energy retrofit solutions. The social structure is the second element and, as already mentioned, it represents the core of the energy community. The objective of this part is to inform and sensitize people and raise their awareness on energy and environmental issue through several events. Furthermore, actions (e.g. questionnaire distribution) aimed at collecting information on the characteristics of citizens are undertaken. Subsequently, on the basis of the obtained answers, the population could be described and citizens' clusters, that share the same features, are defined. The purpose is to outline tailor-made inclusion strategies in order to include more segments of the population in energy community project. Finally, the third element is the legal and financial structure through which the contractual form (that concerns a complex discussion with a panel of lawyers) is defined that binds and defines the balance between different stakeholders and the material elements in order to reach the co-ownership of renewable energy and, therefore, the birth of an energy community.

6.3 How can people be included to participate actively, becoming prosumer and/or plays an active role in society?

Since user participation is the core topic of creation of EC, the purpose in answering this question was to include different segments of the population in activities, tailored to each one, in order to investigate the personal idea about these type of projects. The dissertation contribution is articulated through three phase (Chapter 4): stakeholders' analysis, informative events and workshops.

The first phase was the stakeholders' analysis through which it was possible identify stakeholders, including the vulnerable and the underrepresented groups. The identification process was articulated into two steps: a survey, which allowed to have a situation overview, collecting general information above all on people in vulnerable condition, and an interest/influence matrix, which allowed to map the local actors and produce an Action Plan to reach the stakeholders and to define the contact priority.

The second phase was the informative events, meeting with local institutions. Regarding the organization of meetings with local institutions, once the institutions, in contact with citizens, were identified, a first exploratory contact was established via e-mail before proceeding with the event organization or the participation in events already scheduled in the territory. The informative event allowed to disseminate materials on energy community principals and to understand in which way involve citizens. Specifically, the event allowed (i) to inform and share the research activities and the project results (mainly related to the technical analysis) with the community; (ii) to raising awareness among stakeholders about the energy community benefits and, finally, (iii) to co-create an action plan for the definition of an energy community in the specific context.

The third phase was the workshops that allowed not only to inform the invited stakeholders about a specific topic (the environmental and energy issues and the community energy topic) but also to create a semi-structured debate with them. Workshop, structured in educational moments and practical activities, have been made *ad hoc* according to the invited stakeholders in order to verify the learning, to express their thoughts and opinions and to create a constructive debate, ensuring that people feel free to express themselves. Specifically, the included stakeholders were (a) vulnerable citizens, (b) citizens in general and mayors and (c) students. (a) The workshop with vulnerable citizens allowed to understand the obstacles and problems in participating in energy community project and to highlight which aspects of the CSOP are perceived as important. Results showed that "environmental commitment" and "low investment and low individual responsibility" represent the main benefits to join an energy community project. Indeed, the main obstacle are the distrust (since energy community is an innovative project and there is still no solid confirmation and feedback of its success), the absence of control and verification actions (in order to avoid that the investment disparity may lead to a different representation, to avoid that only the entities that invest a great amount of money are taken into account) and the bureaucracy (since the topic and the necessary documentation could be complicated for simple citizen not working in the legal, financial and energy fields). (b) The workshop with citizens in general and mayors is based on a storytelling methodology and allowed to define the current energy scenario on the basis of individual experiences related to personal energy use and to co-create the future energy community scenario. The definition of a history of a future context, concerning the energy community, made it possible to extrapolate the strengths and weaknesses perceived by the two types of stakeholders. The shared strengths are use of local resources, rationalization of consumption, increase security in energy management and use, cost reduction, use of different energy sources and improve environmental issues. Instead, the shared weaknesses are technical issues regarding the distance between the buildings and the thermal plant, bureaucratic-normative issues and uncertainty about the project management and decisions with different stakeholders. (c) The workshop with students is based on graphic storytelling activity since students self-identified as urban planners/architects in order to co-create their ideal energy community. The activity was structured in four parts: the preliminary survey (in order to investigate the students' knowledge about energy related keywords), the frontal lesson (in order to educate the students to energy and environmental issues and to renewable energies and energy community), the practical activity (in order to favour a graphic story in which students had to self-identify themselves as urban planners) and, finally, the final meeting (in order to discuss the practical activity results). Students showed a general average familiarity with energy field terms such as sustainability, energy sources, carbon dioxide, climate change, deforestation, pollution, economic investment and territory. All projects represent interesting design ideas for new energy communities, connecting and involving local businesses, private citizens and municipal institutions. Many of them chose to involve school buildings and the participation of the students themselves, some local businesses, connected with sustainable local tourism and the preservation of the environment. In addition student showed great interest in the topic and commitment to their projects and ideas; the workshop was also an opportunity to improve team-work skills. Finally, through the interviews with the citizens, the workshop managed to extend the topics of renewable energies and energy communities also outside the classes.

In conclusion, through different actions, different segments of the population have been involved in the process of energy community creation; through specific activities the features of the energy community have been defined, highlighting its strengths and weaknesses.

6.4 What are the factors that determine the human behaviour related to energy use/consumption and engagement in Renewable Energy (RE) projects?

Understanding these drivers has not been an easy task since behaviour is not an easy topic; indeed, human behaviour is unpredictable and depends on numerous drivers, objective and subjective. Currently, a gap between predicted energy-related and behavioural retrofit scenarios and real situation due to the influence of users' features is present. Indeed, in an energy transition perspective, different energy retrofit scenarios, to reach certain environmental targets, are proposed. These scenarios are not necessarily put into practice since the choices of each individual are dictated by different elements, considering that when a behaviour has to be performed, various difficulties arise. In other words, when a user has to take a decision, action or behaviour, various difficulties may arise due to the influence of users' features because they define the users' possibilities in engaging or not engaging this decision/action/behaviour. This dissertation helped answer the research question through a literature review of the elements that determine and affect, directly, indirectly or in interaction way, a user/citizen choice, action and/or behaviour (Chapter 3). Academic journal, conference articles and book chapter have been searched on bibliographic database in energy, social, behavioural and environmental sciences, using keywords and a combination of keywords such as: influencing factors, variables, drivers, energy behaviour, energy investment and renewable energy project. In addition, the interest was focussed on three type of users' actions: (i) the energy saving behaviours (ESB), (ii) the energy efficiency investment actions (EEI) and (iii) the engagement in renewable energy projects (ERE). The review analysed 77 drivers from situational factors in the external environment to person-specific attribute of consumers that influence in an energy and environmental way decision-making and actions. Furthermore a new classification has been produced, grouping the drivers in different 8 categories: (1) individual self-characteristics, (2) personal characteristics, (3) economic characteristics, (4) household characteristics, (5) building characteristics, (6) community and neighbourhood characteristics, (7) government, regulation and policies and (8) external characteristics. The study of the literature allowed to define, in detail, the social component (user and citizen) of an energy community. The identification of the factors, that promote individuals' behaviours and the decision-making choice, is the step preceding the characterization of the population in a given context. Indeed, the research allowed to define (using the individual self-characteristics, the personal characteristics, the economic characteristics, the household characteristics and the community and neighbourhood characteristics) the methodology for a questionnaire.

In conclusion, this study of the literature, on the one hand, made it possible to contribute to the investigation of the drivers that lead users to undertake certain actions/decisions/behaviours in order to reduce the gap between a project situation and a situation of real implementation; on the other hand, it laid the foundations for the creation of a questionnaire to be able to cluster the population in a given context.

6.5 It is possible to define homogeneous citizens' groups based on the same characteristics?

Citizen participation in community projects based on renewable energy is not immediate. The literature and the implementation of the methodology (mainly in the workshop phase in which the thinking of different individuals about participation in this type of projects was investigated) have shown the existence of factors that can hinder their effective inclusion, participation and investment. Since these are pilot projects, there are no inclusive strategies. In this regard, the contribution of this dissertation was the definition of clusters of citizens who share the same characteristics of attitudes and availability towards community projects and feelings towards the context in which they live in order to promote tailor-made environmental and energy policies (Chapter 4 and Chapter 5). In order to collect citizens' information and characteristics, a questionnaire was drawn up and distributed in three different European context (Susa Valley (Italy), Litoměřice (Czech Republic) and Essen (Germany)). The questionnaire was divided into four sections: information on attitude and willingness, information on feelings and community identity, technical information and socio-demographic information. The purpose is to gather different citizens' opinions regarding the energy community topic and their engagement in local energy initiatives. In addition, another questionnaire goal is to collect information in order to understand the relationships between respondents and the community/territory in which they live. The attitude to community projects and to energy behaviour and the study of the perception of the surrounding community/territory represent the core issues of the questionnaire. These information are important for understanding which factors favour/hinder their participation in this type of community project and clustering citizens. The data, collected through an online and paper based questionnaire distribution, were analysed through a cluster analyses using the k-means methodology. Within each cluster, individuals are characterized by the same opinion about community projects and by the same feeling towards the context in which they live. The clustering analysis produced 4 clusters for each case studies (Susa Valley, Litoměřice and Essen). In summary:

- a first cluster is composed by respondents who have an interest in participating in RECP, they are interested in actively participating, they are interested in investing economically, they agree in undertaking actions aimed at improving energy efficiency and in undertaking new behaviours aimed at energy saving. They also have positive feelings toward the community. In short, they are users ready to fully participate in a community project based on renewable energy and no training is needed for them.
- a second cluster is composed by respondents with a general interest and a willingness to participate in community projects based on renewable energy. Also, the feelings towards the community are, in general, positive. However, they are not entirely convinced and there are some doubts regarding the issue of energy communities. So, they must be encouraged, they must be more involved, thinking of targeted actions and tailor-made incentives.
- a third cluster is composed by respondents with a similar profile to the previous one but with a lower interest in community projects. Furthermore, they stated that they do not feel completely connected to the community in which they live. Also, for this cluster it is essential to pay attention and define inclusion policies. Specifically, first of all, it is necessary to increase the sense of belonging with the context.
- the last cluster is composed by respondents not interested in participating in RECP, not interested in actively participating, not interested in investing economically. They often expressed a desire not to want to answer the questions asked. Including them in an energy community represents a great challenge.

In conclusion, through the definition of a questionnaire, its distribution and the analysis of the collected data made it possible to divide the population interviewed into groups that share the same characteristics. Following this division, it is possible to advance, for each of them, strategies that favour participation through incentives, through actions that foster cohesion, trust and a sense of community or that simply encourage people to keep their interest constant toward the energy and environmental issues.

Chapter 7

Key findings, main limitation and future challenges

"Never doubt that a small group of thoughtful, committed citizens can change the world; indeed it is the only thing that ever has"
Margaret Mead

This quote was chosen as it fully embodies the focus of this dissertation, namely the citizens and their human dimension. Nowadays, considering the several environmental issues that are leading to changes, even important ones, in the biosphere, a paradigm shift related to our choices, in different aspect of our life, is necessary. And, as emerged in the course of this dissertation, this change is taking place; a new way of conceiving the energy production, distribution and consumption, no longer according to a one-to-one model but according to a one-to-many model, and a new way of conceiving human relations in a determined context, more or less large, are spreading. In this context, favoured by an emerging national and international legislative framework, the energy community was born, with the aim of facing not only energy and environmental challenges but, also, social ones. In this regard, the thesis work wanted to make a contribution defining the three elements (technical, social and legal/financial structures) that make up an energy community, making explicit the relationships established between these elements, structuring a work path that leads to an effective and practical energy communities creation, analysing in greater detail the role of the user, of the citizen, as an individual with an active role (prosumer), investigating the existing scientific literature on energy saving behaviours, on energy efficiency investment actions and on engagement in renewable energy projects in order to define a new classification of the 77 factors/variables/drivers (grouped in 8 categories: (1) individual self-characteristics, (2) personal characteristics, (3) economic characteristics, (4) household characteristics, (5) building characteristics, (6) community and neighbourhood characteristics, (7) government, regulation and policies and (8) external characteristics) that favour or hinder the citizens' effective inclusion, participation and investment in energy community project and the citizens' making decision and action implementation, defining strategies to actively involve citizens to the debate on energy communities to understand strengths and weaknesses and, finally, extrapolating citizens' profiles (Susa Valley Litoměřice and Essen case studies) who share the same characteristics (paying attention mainly to little-explored elements in literature such as the availability and attitude towards community projects and feelings towards the community and the context in which a person lives) in order to promote tailor-made environmental, energy and social policies aimed at involvement in energy community project.

During the thesis work, some limitations have been found, since it deals with new and emerging issues. The most limiting element concerns the health emergency regarding the risk of infection from Covid-19. Most of the research was carried out in field and, following several discussions with local stakeholders, it was possible to refine the methodology. As mentioned, the issue of energy communities is an emerging theme and the work path has been defined by making hypotheses, verifying them in a context, collecting feedback, recalibrating the methodology and proceeding with the actual application. Obviously, in a global context in which the lockdown, due to the pandemic situation, in order to limit the movement of the population except for necessity, work and health motivations, has been imposed and has led to consequences. Therefore, starting from March 2020, in a situation where meeting people in presence was not allowed, all contacts were made only via email, complicating the achievement and exchange of information with the stakeholders; this situation has determined a limitation. Taking as an example the Italian case study of the Susa Valley, the municipalities are very small entities, made up of people who, in general, know each other and who, also because of their age (average age rather high), prefer an in-person contact. Despite the contribution of the key intermediaries, it was difficult to establish a stable contact with the local entities and stakeholders. In general, the two actions, in which the main difficulties were encountered, were: the workshops organization and the questionnaire distribution. Regarding the workshop organization, initially the citizens and mayors workshop was conceived in presence as a single event in which the two types of stakeholders could have confronted each other. Unfortunately, this was not possible and the way it took place was rethought by dividing the event into two moments since it would have taken place online through the Zoom platform. Furthermore, in organization of the workshop with students delays were encountered because of hope of carry out the activity fully in presence. There were also difficulties regarding the questionnaire distribution. The response rate was low; given the pandemic situation, an online distribution was preferred which, as seen, does not work in small contexts. Moreover, with the relaxation of the restrictive measures even the paper distribution did not lead to significant improvements: the risk of contagion was always present and people were reluctant to attend events and interact with other people.

Managing research in this context was not easy, it was challenging, leading to continually review and rethink the work phases to be carried out. Specifically, the future works and perspectives are listed below.

- *Definition of a workflow and the basic elements of an energy community.*
  - To define in detail the sub-phases concerning the legal and financial structure.
  - To include expert figures in financial and legal field.
  - To implement the inclusion and participation of citizens, through membership campaign promotion in order to sanction with the signing of the contract the creation and the birth of the energy community.

- *Understanding of each individual's idea of an energy community and exploration and proposal of inclusion strategies and activity designed for all population segments.*
  - To organize other inclusive activities through which it is possible to raise awareness of community projects based on renewable energy and to understand further obstacles and strengths of such projects.
  - To include in informative events and workshops other segments of stakeholders such as condominium administrators. Raising awareness of condominium administrators is a key element considering the issue of the 110% bonus. Indeed, by including administrators on the one hand it will be possible to reach users who live in condominiums, on the other it will be possible to connect the procedure for creating an energy community to the energy efficiency actions of the built environment (envelope and energy system).
  - In this phase, workshops and activities were organized designed for a specific segment of the population (vulnerable citizens, citizens in general, public administration and students). It would be advisable to organize activities that favour, at the same time, the comparison between different types of stakeholders in order to appreciate the interaction, the debate and similar and different points of view.
  - To aim for the inclusion of teenagers and students through educational activities. Increasing their awareness and knowledge regarding energy and environmental issues is important for a twofold reason: on the one hand, it will be the future citizens who will take decisions; on the other hand, they can transmit the concepts learned in the family and among their acquaintances.
  - To carry out a posteriori investigations of the events organized to verify, after some time, how much the notions learned have been made their own and how and if they have led to changes in the daily routine.

- *Study and classification of citizen drivers affecting the energy saving behaviours (ESB), the energy efficiency investment (EEI) and the engagement in renewable energy projects (ERE).*
  - To investigate a more comprehensive set of drivers. An example is given by the study of the variables that determine the condition of energy poverty, since energy communities are also born to solve not only environmental and energy problems but also social ones. To investigate the inability to afford proper indoor thermal comfort, the difficulty to reach the necessary energy to meet the basic need in order to reach adequate living condition, the difficulty to be not able to address the economic expenditure for the energy or other running costs are some of the variables to be explored in order to identify difficult situations

- *Definition of clusters of citizens who share the same characteristics of attitudes and availability towards community projects and feelings towards the context in which they live.*
  - To redistribute the questionnaire in the same context but in a non-emergency health situation in order to understand if the low response rate is attributable solely to the restrictions imposed or to other factors, such as lack of general interest in these investigated issues.
  - To obtain a larger sample of responses using other distribution methods.
  - On the basis of the identified clusters, to promote activities that encourage inclusion at city and community level, not necessarily linked to energy issues but taken to integration such as events in the central square, cultural reviews, and other actions that can make citizens feel proud and part of its territory.
  - Implement inclusion strategies in energy communities based on comparison with other users in order to activate the processes underlying social norms.
  - In addition, to define a regression model based on the data collected in the third and fourth part of the questionnaire (technical data of the building and socio-economic data of the respondent) and on the identified clusters. In this way, on the basis of easily available data, through ISTAT at the census section level, it will be possible to have a general idea of the availability of citizens and to understand the feasibility of future interventions.
  - Finally, create an online database (GIS) with an indication of the major results achieved in the scientific field and an indication of the percentage of people adhering to the theme of energy communities or other practices aimed at energy saving and environmental protection. This, on the one hand, would make the work visible to all, on the other

hand, it could generate the birth of a sense of duty and commitment and favour the implementation of good practices, creating a positive challenge between neighbouring contexts.

The research in the context of energy communities has been interesting and challenging, both for the issue that has not yet been investigated and for the difficulties dictated by the current emergency context. A further element of further investigation consists in the quantitative assessment of the main aspects related to the energy community, both before and after the implementation of the project. After all, finally, finally, it is possible to state that the proposed model of creating an energy community and focus attention on the social component (on citizens) has received an important interest to such an extent that the model began to apply in other European contexts, in Follower Cities.

Appendix A

List of journals and conference proceedings.

Lombardi, P.; Torabi Moghadam, S.; **Di Nicoli, M. V.**; Nonelli, A.; Figueiredo Eschholz, B.; Abastante, F.; Toniolo, J. (2021). D 5.1. Report on impacts of consumer co-ownership incl. recommendations on fine-tuning, Supporting Consumer co-Ownership in Renewable Energies (SCORE) project (GA 784960). Deliverable under revision.

Torabi Moghadam, S.; **Di Nicoli, M. V.**; Manzo S.; Lombardi, P. (2020). Mainstreaming Energy Communities in the Transition to a Low-Carbon Future: A Methodological Approach. Energies, 13 (7), 1597.

Lombardi, P.; Torabi Moghadam, S.; **Di Nicoli, M. V.**; Toniolo, J.; Lowitzsch, J.; Talachini, G.; Klusák, J.; Śafařík, M.; Pučelík, L.; Malý, V.; Černý, M.; Szwed, D. (2019). D3.1, Manual on Energy Refurbishing including Mitigation of Rebound Effects, Public Report, Supporting Consumer co-Ownership in Renewable Energies (SCORE) project (GA 784960), D3.1 Report on EE and Avoiding Rebound Effects - 1 VIII 2019.doc (score-h2020.eu).

Torabi Moghadam, S.; **Di Nicoli, M. V.**; Manzo S.; Lombardi, P. (2019). Supporting Consumer Co-Ownership in Renewable Energies: SCORE H2020 project. Sustainable Built Environment (SBE) International Conference, Sustainability and Resilience, 21-22 November 2019, Malta.

Di Nicoli, M. V.; Torabi Moghadam, S.; Lombardi, P. (2019). A framework for selecting the best refurbishment alternative in renewable energies towards consumer stock ownership. 4th Energy for Sustainability (EfS) International Conference, Design a sustainable future, 24-26 July 2019, Turin, Italy.

Torabi Moghadam, S.; **Di Nicoli, M. V.**; Giacomini A.; Lombardi, P.; Toniolo J. (2019). The role of prosumers in supporting renewable energies sources. IOP Conference Series: Earth and Environmental Science Conference, 297. Article presented in Sustainable Built Environment, Emerging concept for Sustainable Built Environment, 22-24 May 2019, Helsinki, Finland.

Appendix B

Questionnaire: the energy community - long version (Italian languages)

QUESTIONARIO LE COMUNITÀ ENERGETICHE

INFORMATIVA PER LA PARTECIPAZIONE AL QUESTIONARIO "LE COMUNITÀ ENERGETICHE" AI SENSI DELL'ART. 13 DEL REGOLAMENTO GENERALE SULLA PROTEZIONE DEI DATI UE 679/2016.

Gentile partecipante, come previsto dal Regolamento Generale sulla protezione dei dati (Regolamento EU 2016/679 - noto anche come "GDPR") ti forniamo le seguenti informazioni che riguardano il trattamento dei tuoi dati personali.

DATI DI CONTATTO

Titolare del trattamento dei dati è il Politecnico di Torino, con sede in Corso Duca degli Abruzzi, n. 24, 10129 - Torino, nella persona del Rettore.
Il dato di contatto del Titolare è PEC: politecnicoditorino@pec.polito.it
Per ulteriori informazioni e chiarimenti: privacy@polito.it

Il Responsabile della protezione dati ("DPO") del Politecnico di Torino, al quale gli interessati possono rivolgersi per questioni relative al trattamento dei loro dati personali e all'esercizio dei loro diritti, è contattabile ai seguenti indirizzi: dpo@polito.it; PEC: dpo@pec.polito.it.

FINALITA' DEL TRATTAMENTO E BASE GIURIDICA

Nel rispetto dei principi di liceità, correttezza, trasparenza, adeguatezza, pertinenza e necessità di cui all'art. 5, paragrafo 1, del GDPR, il Politecnico di Torino, in qualità di Titolare, provvederà al trattamento dei tuoi dati personali ai sensi dell'art. 6, paragrafo 1, lettera e) ("*il trattamento è necessario per l'esecuzione di un compito di interesse pubblico o connesso all'esercizio di pubblici poteri di cui è investito il titolare*") nel perseguimento delle finalità istituzionali connesse al progresso nella ricerca scientifica e alla formazione superiore come previsto dallo Statuto di Ateneo e, con riferimento ai dati personali appartenenti alle categorie particolari di cui all'art. 9 del GDPR (dati relativi allo stato di salute), previo tuo consenso ai sensi dell'art. 9, paragrafo 2, lettera a) ("*l'interessato ha prestato il proprio consenso esplicito al trattamento di tali dati personali per una o più finalità specifiche* [...]").
In particolare, i tuoi dati personali saranno trattati dal Politecnico di Torino, con modalità cartacea e/o informatizzata, per la redazione di una tesi avente ad oggetto "Il ruolo dell'ambiente costruito e della dimensione umana verso una transizione energetica sostenibile".

TRASFERIMENTO DEI DATI

I dati trattati per le finalità di cui sopra verranno comunicati, o saranno comunque accessibili, ai dipendenti e collaboratori assegnati ai competenti uffici del Politecnico di Torino, che saranno adeguatamente istruiti dal Titolare.
La divulgazione dei dati racconti ai fini della redazione della tesi avverrà soltanto in forma anonima e/o aggregata e comunque secondo modalità che non ti rendano identificabile.
La gestione e la conservazione dei dati personali raccolti dal Politecnico di Torino avviene su sistemi ubicati all'interno dell'Ateneo e/o esterni di fornitori di alcuni servizi necessari alla gestione tecnico - amministrativa che, ai soli fini della prestazione richiesta, potrebbero venire a conoscenza dei dati personali degli interessati e che saranno debitamente nominati come Responsabili del trattamento a norma dell'art. 28 del GDPR.
I dati raccolti non saranno oggetto di trasferimento verso un Paese non appartenente all'Unione Europea (c.d. Paese terzo).

PERIODO DI CONSERVAZIONE DEI DATI

I dati personali inerenti il trattamento, compresi quelli appartenenti alle categorie particolari, saranno conservati per il tempo necessario allo svolgimento della tesi.

CONFERIMENTO DEI DATI

Il conferimento dei dati personali è da ritenersi obbligatorio, l'eventuale rifiuto comporta l'impossibilità di assolvere alle finalità indicate.

DIRITTI DELL'INTERESSATO

In qualità di interessato hai diritto di chiedere al Titolare del trattamento, conformemente agli artt. 15 e ss. del GDPR,

- l'accesso ai propri dati personali ed a tutte le informazioni di cui all'art. 15 del GDPR;
- la rettifica dei propri dati personali inesatti e l'integrazione di quelli incompleti;

- la cancellazione dei propri dati, fatta eccezione per quelli contenuti in atti che devono essere obbligatoriamente conservati dall'Ateneo, e salvo che sussista un motivo legittimo prevalente per procedere al trattamento;
- la limitazione del trattamento nelle ipotesi di cui all'art. 18 del GDPR.

Hai, altresì, il diritto:

- di opporti al trattamento dei dati personali, fermo quanto previsto con riguardo alla necessità ed obbligatorietà del trattamento dati per poter fruire dei servizi offerti;
- di revocare il consenso eventualmente prestato per i trattamenti non obbligatori dei dati, senza con ciò pregiudicare la liceità del trattamento basata sul consenso prestato prima della revoca;
- alla portabilità dei dati.

Se desideri esercitare qualsiasi dei tuoi diritti, puoi rivolgerti al Titolare del trattamento.

RECLAMO

Hai il diritto di rivolgerti al Garante per la protezione dei dati personali secondo le modalità indicate al seguente link: https://www.garanteprivacy.it/web/guest/home/docweb/-/docweb-display/docweb/4535524

La presente informativa è aggiornata al 21.11.2019

QUESTIONARIO
LE COMUNITÀ ENERGETICHE

INFORMATIVA AI SENSI DELL'ART. 13 DEL REGOLAMENTO GENERALE SULLA PROTEZIONE DEI DATI UE 679/2016 PER LA PARTECIPAZIONE AL QUESTIONARIO "LE COMUNITÀ ENERGETICHE".

Il Politecnico di Torino ti informa che tratterà i tuoi dati personali unicamente per le finalità di carattere istituzionale connesse al progresso nella ricerca scientifica e alla formazione superiore. I dati verranno trattati in conformità con la normativa e i regolamenti applicabili in materia di privacy, incluso il Regolamento EU 2016/679 ("GDPR") e le leggi di modifica e implementazione dello stesso (la "Normativa Privacy Applicabile").

Partecipando al presente questionario dichiara di aver preso visione dell'informativa e di acconsentire al trattamento dei suoi dati personali appartenenti alle categorie particolari di cui all'art. 9 del Regolamento UE 2016/679 raccolti nell'ambito del presente questionario.

INTRODUZIONE

Considerando l'attuale contesto ambientale, orientato verso la lotta al cambiamento climatico, la **transizione energetica** è uno degli obiettivi da raggiungere e, per tale ragione, si parla di "**Comunità dell'Energia**" o "**Comunità Energetiche**" o "**Comunità Energetiche di energia rinnovabile**" come strumento funzionale a tale transizione.

Per Comunità Energetica si intende un insieme di utenze dell'energia che si associano tra di loro con una forma giuridica (da definire a seconda dei casi) con l'obiettivo di far fronte ai propri bisogni di energia ottimizzando i vantaggi dello "**stare insieme**". In altre parole, si tratta di una **cooperazione di utenti** (municipalità, piccole e medie imprese e cittadini), ubicati in una determinata area, che condividono la volontà di **autoprodurre** ed **autoconsumare** energia proveniente prevalentemente da **fonti rinnovabili**, nonché di favorire forme di efficientamento e riduzione dei consumi energetici.

A livello europeo (Recast of "*Renewable Energy Directive*" del 11/12/2018) e a livello nazionale (Legge 221 del 28/12/2015 "*Disposizioni in materia ambientale per promuovere misure di green economy e per il contenimento dell'uso eccessivo di risorse naturali*") è presente un **apparato legislativo** che promuove la nascita delle comunità energetiche.
Il **Piemonte**, con la Legge Regionale numero 12 del 03/08/2018 ("***Promozione dell'istituzione delle comunità energetiche***"), è la prima regione italiana a recepire la legge nazionale e promuovere ed instituire la formazione di questo tipo di "sperimentazione" sul proprio territorio.

Il tema delle comunità energetiche è attuale e, se dovessero nascere sul territorio in cui vive (la Val di Susa), quale sarebbe la sua opinione a riguardo?

Per la mia ricerca di dottorato è importante **raccogliere le diverse opinioni** riguardo il tema delle comunità energetiche. Per tale ragione questo questionario, da me elaborato, permetterà di raccogliere informazioni riguardo l'**interesse dei cittadini** ad impegnarsi in iniziative energetiche locali e comprendere quali **fattori** favoriscono/ostacolano la loro partecipazione.
Il questionario è costituito da 4 sezioni e la sua compilazione richiederà massimo 30 minuti.

La ringrazio per il suo contributo!

PRIMA PARTE:
INFORMAZIONI SU ATTEGGIAMENTO E DISPONIBILITÀ

01. **E' interessato a progetti "di comunità" fondati sull'utilizzo di energia rinnovabile (es. creazione di comunità energetiche)?**

Per favore, indichi il suo livello di interesse su una scala da (1) per "Per niente interessato/a" a (5) per "Molto interessato/a".

(1) Per niente interessato/a.	(2) Non interessato/a.	(3) Neutrale.	(4) Interessato/a.	(5) Molto interessato/a.	Non so.
☐	☐	☐	☐	☐	☐

02. **A quali condizioni si farebbe coinvolgere in un progetto "di comunità" fondato sull'utilizzo di energia rinnovabile?**

Per favore, tra le seguenti opzioni, indichi una o più risposte.

- ☐ Se avessi un vantaggio economico (es. meno costi energetici).
- ☐ Se avessi un vantaggio in termini di servizi più efficienti.
- ☐ Se contribuissi, a parità di vantaggi economici e di servizi, a prestare un servizio per la mia comunità.
- ☐ Se contribuissi, a parità di vantaggi economici e di servizi, a salvaguardare la natura e salvare il mio Pianeta.
- ☐ Altro (per favore, specificare: ______________________________).

03. **E' interessato a partecipare attivamente in progetti "di comunità" fondati sull'utilizzo di energia rinnovabile?**

Per favore, indichi il suo livello di interesse su una scala da (1) per "Per niente interessato/a" a (5) per "Molto interessato/a".

(1) Per niente interessato/a.	(2) Non interessato/a.	(3) Neutrale.	(4) Interessato/a.	(5) Molto interessato/a.	Non so.
☐	☐	☐	☐	☐	☐

03.1 Se "Molto interessato/a" o "Interessato/a", in che modo vorrebbe partecipare attivamente?

Per favore, tra le seguenti opzioni, indichi una o più risposte.

- ☐ Partecipando agli incontri.
- ☐ Investendo a seconda delle proprie possibilità (es. denaro, risorse naturali da me possedute (es. bosco o legname), etc.).
- ☐ Mettendo a disposizione superfici funzionali per l'installazione di sistemi di produzione di energia.
- ☐ Svolgendo un ruolo attivo nella gestione della comunità energetica.
- ☐ Diffondendo informazioni (es. parlando di comunità energetica ad amici e/o familiari, etc.).
- ☐ Altro (per favore, specificare: ______________________________).

03.2 Se "Per niente interessato/a" o "Non interessato/a", per quale/i motivo/i non può partecipare attivamente?

Per favore, tra le seguenti opzioni, indichi una o più risposte.

- ☐ Non ho abbastanza tempo.
- ☐ Non ho abbastanza soldi.
- ☐ Non ho abbastanza conoscenza sul tema o abilità.
- ☐ Non so in che modo e dove.
- ☐ Sono diffidente nei confronti dei progetti innovativi.
- ☐ Penso ci sia troppa burocrazia a cui far fronte.
- ☐ Altro (per favore, specificare: ______________________________).

03.3 Se "Per niente interessato/a" o "Non interessato/a", di cosa avrebbe bisogno per partecipare attivamente?

Per favore, tra le seguenti opzioni, indichi una o più risposte.

- ☐ Ho bisogno di essere attivamente coinvolto dalle comunità già esistenti fondate sull'energia rinnovabile.
- ☐ Ho bisogno di un sostegno finanziario per partecipare (es. prestito a tasso zero o agevolazioni fiscali).
- ☐ Ho bisogno di un compenso/incentivo per la mia partecipazione (per favore, specificare: ____).
- ☐ Ho bisogno della sensazione di contribuire alla mia comunità locale.
- ☐ Ho bisogno della sensazione di contribuire verso modi di vivere sostenibili.
- ☐ Ho bisogno di altro (per favore, specificare: ____).

04. Sta attualmente partecipando, in qualche modo, alla produzione di energia da fonti rinnovabili?
Le più comuni forme di partecipazione nella produzione di energia rinnovabile sono, ad esempio, un'installazione solare su un tetto, la partecipazione ad una cooperativa energetica, quote di una società coinvolta in altri modelli di business con l'obiettivo di produrre energia rinnovabile, ect.

Per favore, tra le seguenti opzioni, indichi <u>una sola</u> risposta.

- ☐ Sì.
- ☐ No.

04.1 Se sta attualmente partecipando alla produzione di energia da fonti rinnovabili, in che modo è coinvolto/a?

Per favore, tra le seguenti opzioni, indichi <u>una sola</u> risposta.

- ☐ Sono (co)proprietario/a di un impianto fotovoltaico (generazione di elettricità da radiazione solare).
- ☐ Sono (co)proprietario/a di un impianto solare termico (generazione di calore da radiazione solare).
- ☐ Sono (co)proprietario/a di una turbina eolica.
- ☐ Sono (co)proprietario/a di un impianto di biogas.
- ☐ Sono (co)proprietario/a di una centrale idroelettrica.
- ☐ Sono (co)proprietario/a di una centrale termoelettrica rinnovabile.
- ☐ Altro (per favore, specificare: ____).

05. Sarebbe disposto ad investire economicamente in un progetto di "comunità" fondato sull'utilizzo di energia rinnovabile nel suo territorio?

Per favore, indichi il suo livello di interesse su <u>una scala</u> da <u>(1) per "Per niente disponibile"</u> a <u>(5) per "Molto disponibile"</u>.

(1) Per niente disponibile.	(2) Non disponibile.	(3) Neutrale.	(4) Disponibile.	(5) Molto disponibile.	Non so.
☐	☐	☐	☐	☐	☐

05.1 Se "Per niente disponibile" o "Non disponibile" ad investire economicamente, per quale/i ragione/i?

Per favore, tra le seguenti opzioni, indichi <u>una o più</u> risposte.

- ☐ Nessun capitale per l'investimento a mia disposizione.
- ☐ Investimento troppo rischioso.
- ☐ Altri investimenti sono economicamente più interessati (es. rendimenti più elevati, etc.).
- ☐ Diffidenza verso questa tipologia di progetti (assenza di feedback sul loro successo).
- ☐ Troppa burocrazia legale a cui far fronte.
- ☐ Paura di essere rappresentati esclusivamente in relazione allo *share* dell'investimento (in altre parole, se investissi con una piccola quota ho paura che le mie idee non vengano prese in considerazione).
- ☐ Altro (per favore, specificare: ____).

05.2 Considerando la sua disponibilità economica e supponendo un versamento di un contributo *una tantum* per la realizzazione di un progetto comunitario, quanto sarebbe disposto a investire?

Per favore, tra le seguenti opzioni, indichi <u>una sola</u> risposta.

- ☐ Sono disposto ad investire ____________ €.
- ☐ Non sono disposto ad investire.

06. **Se l'intervento non riguardasse nell'immediato l'edificio in cui vive (ma in futuro sì), sarebbe disponibile a partecipare attivamente ad un progetto "di comunità" fondato sull'utilizzo di energia rinnovabile?**

Per favore, indichi il suo livello di interesse su una scala da (1) per "Per niente disponibile" a (5) per "Molto disponibile".

(1) Per niente disponibile.	(2) Non disponibile.	(3) Neutrale.	(4) Disponibile.	(5) Molto disponibile.	Non so.
☐	☐	☐	☐	☐	☐

07. **Le seguenti domande riguardano l'efficienza energetica nella propria abitazione. Il miglioramento dell'efficienza energetica consiste in una serie di azioni riguardanti, per esempio, la sostituzione di alcune apparecchiature e/o l'intervento sull'involucro e/o sul sistema energetico.**

Per favore, per ciascuna opzione, indichi il suo livello di accordo su una scala da (1) per "Non sono assolutamente d'accordo" a (5) per "Sono completamente d'accordo".

07.1 **Una possibilità per essere più efficiente dal punto di vista energetico è quella di sostituire vecchie apparecchiature (grandi e/o piccoli elettrodomestici) con modelli più recenti e che usano meno energia. Al fine di ridurre il consumo di energia, sarebbe disposto a...**

	(1) Non sono assolutamente d'accordo.	(2) Non sono d'accordo.	(3) Neutrale.	(4) Sono d'accordo.	(5) Sono completamente d'accordo.	Non so.
A) ...sostituire l'illuminazione con lampade a LED?	☐	☐	☐	☐	☐	☐
B) ...sostituire grandi elettrodomestici più vecchi come frigorifero, lavatrice, forno, etc.?	☐	☐	☐	☐	☐	☐
C) ...sostituire piccoli elettrodomestici come TV o apparecchiature hi-fi?	☐	☐	☐	☐	☐	☐
D) ...sostituire una vecchia pompa di calore?	☐	☐	☐	☐	☐	☐

07.2 **Ha già sostituito le apparecchiature citate alla domanda precedente?**

Per favore, tra le seguenti opzioni, indichi una sola risposta. Se avesse già sostituito una o più apparecchiature, per favore indichi quale/i indicando la lettera corrispondente (da A a D).

☐ Sì, ho già sostituito ____ .

☐ No (per favore, specificare il perchè: ____).

07.3 **Una possibilità per essere più efficienti dal punto di vista energetico è intervenire sull'involucro e/o sul sistema energetico della sua abitazione.**
Al fine di ridurre il consumo di energia, sarebbe disposto a...

	(1) Non sono assolutamente d'accordo.	(2) Non sono d'accordo.	(3) Neutrale.	(4) Sono d'accordo.	(5) Sono completamente d'accordo.	Non so.
E) ...sostituire i serramenti con altri con doppi o tripli vetri?	☐	☐	☐	☐	☐	☐
F) ...isolare l'edificio con un "cappotto" termico?	☐	☐	☐	☐	☐	☐
G) ...sostituire una vecchia caldaia?	☐	☐	☐	☐	☐	☐
H) ...installare un sistema di produzione energetica da fonti rinnovabili (pannelli fotovoltaici, pannelli solari termici, etc.)?	☐	☐	☐	☐	☐	☐

07.4 Ha già effettuato degli interventi di retrofit (citati nella precedente domanda) sul suo edificio per risparmiare energia?

Per favore, tra le seguenti opzioni, indichi una sola risposta. Se avesse già effettuato degli interventi di retrofit, per favore indichi quale/i indicando la lettera corrispondente (da E a H).

- ☐ Sì, ho già effettuato ______________________________ .
- ☐ No (per favore, specificare il perchè: ______________________________).

08. Le seguenti domande riguardano il comportamento energetico nella sua quotidianità. I comportamenti finalizzati al risparmio energetico consistono in specifiche pratiche quotidiane e abituali che hanno l'obiettivo di ridurre il consumo di energia.

Per favore, per ciascuna opzione, indichi il suo livello di accordo su una scala da (1) per "Non sono assolutamente d'accordo" a (5) per "Sono completamente d'accordo".

08.1 Una possibilità per essere più efficiente dal punto di vista energetico è modificare l'uso di energia correlato all'uso di elettrodomestici e/o all'interazione con i sistemi presenti in abitazione e/o applicando specifiche pratiche comportamentali. Sarebbe disposto a...

	(1) Non sono assolutamente d'accordo.	(2) Non sono d'accordo.	(3) Neutrale.	(4) Sono d'accordo.	(5) Sono completamente d'accordo.	Non so.
I) ...spegnere la luce anche se lascia la stanza per un breve periodo?	☐	☐	☐	☐	☐	☐
L) ...utilizzare prese con interruttore di spegnimento per	☐	☐	☐	☐	☐	☐

	(1) Non sono assolutamente d'accordo.	(2) Non sono d'accordo.	(3) Neutrale.	(4) Sono d'accordo.	(5) Sono completamente d'accordo.	Non so.
evitare che gli apparecchi funzionino in modalità stand-by?						
M) ...utilizzare gli elettrodomestici (es. lavatrice, lavastoviglie, etc.) in modalità eco?	☐	☐	☐	☐	☐	☐
N) ...utilizzare gli elettrodomestici (es. lavatrice, lavastoviglie, etc.) solo quando completamente carichi?	☐	☐	☐	☐	☐	☐
O) ...scongelare regolarmente il frigorifero o il congelatore per evitare la formazione dello strato di ghiaccio?	☐	☐	☐	☐	☐	☐
P) ...in inverno, ad indossare vestiti più pesanti al posto di accendere il riscaldamento?	☐	☐	☐	☐	☐	☐
Q) ...spegnere il riscaldamento, sapendo di lasciare la sua abitazione per più di 4 ore?	☐	☐	☐	☐	☐	☐
R) ...in inverno, ad avere una temperatura in ambiente non superiore i 21°C?	☐	☐	☐	☐	☐	☐
S) ...in estate, ad avere una temperatura in ambiente non inferiore i 26°C?	☐	☐	☐	☐	☐	☐

08.2 Ha già applicato uno dei comportamenti citati nella domanda precedente?

Per favore, tra le seguenti opzioni, indichi <u>una sola</u> risposta. Se avesse già applicato una o più pratiche comportamentali, per favore specifichi il comportamento indicando la lettera corrispondente (da I a S).

- ☐ Sì, applico quotidianamente ______________________________ .
- ☐ No (per favore, specificare il perchè: ______________________________).

09. **In generale, sapendo che cambiare comportamento non implica nessun costo monetario (ma solo un "costo" legato alla volontà) e determina una riduzione dei consumi energetici non trascurabili, sarebbe disposto a modificare le sue pratiche abituali?**

Per favore, indichi il suo livello di interesse su una scala da (1) per "Per niente disponibile" a (5) per "Molto disponibile".

(1) Per niente disponibile.	(2) Non disponibile.	(3) Neutrale.	(4) Disponbile.	(5) Molto disponibile.	Non so.
☐	☐	☐	☐	☐	☐

10. **Uno dei maggiori problemi legati all'espansione del successo dell'energia rinnovabile è la sua volatilità. Ad esempio, quando c'è molto vento o sole, la quota di energie rinnovabili nella rete è molto alta. Ciò pone diversi problemi e ha senso utilizzare quanta più energia possibile.**

Per favore, per ciascuna opzione, indichi il suo livello di accordo su una scala da (1) per "Non sono assolutamente d'accordo" a (5) per "Sono completamente d'accordo".

Dato questo contesto, fino a che punto sarebbe disposto ad adattare il suo consumo di energia ai modelli di produzione da fonti rinnovabili? Sarebbe disposto a...

	(1) Non sono assolutamente d'accordo.	(2) Non sono d'accordo.	(3) Neutrale.	(4) Sono d'accordo.	(5) Sono completamente d'accordo.	Non so.
...utilizzare gli elettrodomestrici principalmente quando la quota di elettricità da fonti rinnovabili nella rete è molto alta?	☐	☐	☐	☐	☐	☐
...ricaricare i dispositivi elettrici (es. laptop, etc.) principalmente quando la quota di elettricità da fonti rinnovabili nella rete è molto alta?	☐	☐	☐	☐	☐	☐
...ricaricare i mezzi di trasporto elettrici (es. bici, auto elettriche, etc.) principalmente quando la quota di elettricità da fonti rinnovabili nella rete è molto alta?	☐	☐	☐	☐	☐	☐

11. **Sarebbe disponibile ad installare nella sua abitazione alcuni dispositivi (es. *smart meter*), a nessun costo e nessun impatto sulla salute e con nessun onere di manutenzione, per il monitoraggio dei consumi energetici e/o della qualità ambientale?**

Per favore, indichi il suo livello di interesse su <u>una scala</u> da <u>(1) per "Per niente disponibile"</u> a <u>(5) per "Molto disponibile"</u>.

(1) Per niente disponibile.	(2) Non disponibile.	(3) Neutrale.	(4) Disponibile.	(5) Molto disponibile.	Non so.
☐	☐	☐	☐	☐	☐

12. **Cosa pensa delle seguenti affermazioni?**

Per favore, per ciascuna opzione, indichi il suo livello di accordo su <u>una scala</u> da <u>(1) per "Non sono assolutamente d'accordo"</u> a <u>(5) per "Sono completamente d'accordo"</u>.

	(1) Non sono assolutamente d'accordo.	(2) Non sono d'accordo.	(3) Neutrale.	(4) Sono d'accordo.	(5) Sono completamente d'accordo.	Non so.
Molti miei conoscenti utilizzano energia proveniente da fonti rinnovabili.	☐	☐	☐	☐	☐	☐
I miei conoscenti si aspettano che io risparmi energia e/o produca energia da fonti rinnovabili.	☐	☐	☐	☐	☐	☐
Le persone a cui tengo approverebbero la mia partecipazione a progetti di "comunità".	☐	☐	☐	☐	☐	☐

13. **Per lei, quanto è importante la protezione e la salvaguardia dell'ambiente?**

Per favore, indichi il suo livello di importanza in <u>una scala</u> da <u>(-3) per "Non importante"</u> a <u>(+3) per "Importante"</u>.

	(-3)	(-2)	(-1)	(0)	(+1)	(+2)	(+3)	
Non importante.	☐	☐	☐	☐	☐	☐	☐	Importante.

SECONDA PARTE:
INFORMAZIONI SU SENTIMENTI ED IDENTITÀ COMUNITARIA

01. Qual è il grado di sentimento da lei provato nei confronti della comunità/territorio di cui fa parte?

Per favore, indichi il suo livello di sentimento su una scala da (1) per "Non sento affatto questo sentimento" a (5) per "Sento questo sentimento fortemente".

	(1) Non sento affatto questo sentimento.	(2) Non sento questo sentimento.	(3) Neutrale.	(4) Sento questo sentimento.	(5) Sento questo sentimento fortemente.	Non so.
Fiducia	☐	☐	☐	☐	☐	☐
Soddisfazione	☐	☐	☐	☐	☐	☐
Orgoglio	☐	☐	☐	☐	☐	☐
Speranza	☐	☐	☐	☐	☐	☐
Disgusto	☐	☐	☐	☐	☐	☐
Vergogna	☐	☐	☐	☐	☐	☐
Paura	☐	☐	☐	☐	☐	☐
Noia	☐	☐	☐	☐	☐	☐

02. Cosa pensa delle seguenti affermazioni?

Per favore, per ciascuna opzione, indichi il suo livello di accordo su una scala da (1) per "Non sono assolutamente d'accordo" a (5) per "Sono completamente d'accordo".

	(1) Non sono assolutamente d'accordo.	(2) Non sono d'accordo.	(3) Neutrale.	(4) Sono d'accordo.	(5) Sono completamente d'accordo.	Non so.
Mi sento fortemente legato alla comunità in cui vivo.	☐	☐	☐	☐	☐	☐
Ci sono molte persone nella mia comunità che considero buoni amici.	☐	☐	☐	☐	☐	☐
Parlo spesso della mia comunità come un ottimo posto in cui vivere.	☐	☐	☐	☐	☐	☐

03. In generale, pensa di potersi fidare della maggior parte delle persone?

Per favore, per ciascuna opzione, indichi il suo livello di fiducia verso le altre persone su una scala da (1) per "Non devo assolutamente fidarmi" a (5) per "Posso fidarmi completamente".

(1) Non devo assolutamente fidarmi.	(2) Non devo fidarmi.	(3) Posso fidarmi abbastanza.	(4) Posso fidarmi.	(5) Posso fidarmi completamente.	Non so.
☐	☐	☐	☐	☐	☐

04. **In generale, pensa che per avere rapporti positivi si debba prestare attenzione ai rapporti con le persone?**
Per favore, tra le seguenti opzioni, indichi una sola risposta.

- ☐ Devo prestare molta attenzione ai rapporti con le persone - molto faticoso.
- ☐ Devo prestare abbastanza attenzione ai rapporti con le persone - abbastanza faticoso.
- ☐ Devo prestare attenzione ai rapporti con le persone - faticoso.
- ☐ Non devo prestare attenzione ai rapporti con le persone - facile.
- ☐ Non devo prestare per niente attenzione ai rapporti con le persone - bello.
- ☐ Non so.

TERZA PARTE: INFORMAZIONI TECNICHE

01. **Qual è la tipologia della sua abitazione?**
Per favore, tra le seguenti opzioni, indichi una sola risposta.

- ☐ Appartamento in condominio.
- ☐ Casa indipendente.
- ☐ Casa semi-indipendente/Villetta a schiera.
- ☐ Altro (per favore, specificare: ____________________).

02. **In che anno è stato costruito l'edificio in cui vive?**
Per favore, tra le seguenti opzioni, indichi una sola risposta.

- ☐ Prima del 1900.
- ☐ Tra il 1900 e il 1920.
- ☐ Tra il 1921 e il 1945.
- ☐ Tra il 1946 e il 1960.
- ☐ Tra il 1961 e il 1975.
- ☐ Tra il 1976 e il 1990.
- ☐ Tra il 1991 e il 2005.
- ☐ Tra il 2006 e il 2014.
- ☐ Dopo il 2014.
- ☐ Non so.

03. **Nella sua abitazione ha installato sistemi di produzione di energia da fonti rinnovabili (es. pannelli fotovoltaici per la produzione di elettricità, pannelli solari termici per la produzione di calore, etc.)?**
Per favore, tra le seguenti opzioni, indichi una sola risposta.

- ☐ Sì.
- ☐ No.

03.1 **Se ha installato dei sistemi di produzione di energia da fonti rinnovabili, come usa l'energia prodotta?**
Per favore, tra le seguenti opzioni, indichi una sola risposta.

- ☐ Per l'autoconsumo.
- ☐ Per la vendita.
- ☐ Sia per l'autoconsumo sia per la vendita.

04. **Qual è la tipologia dell'impianto di riscaldamento? In aggiunta, si tratta di riscaldamento autonomo, centralizzato o teleriscaldamento?**
Per favore, scriva la sua risposta qui sotto.

____

05. Di che anno è l'impianto di riscaldamento?
Per favore, scriva la sua risposta qui sotto.

____

06. Gestisce lei personalmente l'impianto energetico o c'è un addetto alla gestione/manutenzione?
Per favore, tra le seguenti opzioni, indichi <u>una sola</u> risposta.

- ☐ Gestisco l'impianto energetico da solo.
- ☐ Esiste una persona per la gestione e la manutenzione dell'impianto energetico.

07. È a conoscenza, approssimativamente, di quanta energia (calore ed elettricità) viene usata <u>all'anno</u> nella sua abitazione?
Per favore, tra le seguenti opzioni, indichi <u>una sola</u> risposta.

- ☐ Sì...
  - ☐ ... ________________ kWh (chilowattora) per l'elettricità.
  - ☐ ... ________________ kWh (chilowattora) per il riscaldamento.
- ☐ No.

08. È a conoscenza, approssimativamente, a quanto ammonta la spesa energetica (calore ed elettricità) per la sua abitazione?
Per favore, tra le seguenti opzioni, indichi <u>una sola</u> risposta.

- ☐ Sì...
  - ☐ ... ________________ €/mese per l'elettricità.
  - ☐ ... ________________ €/anno per il riscaldamento. (Con anno si intende la stagione invernale ottobre/aprile).
- ☐ No.

09. L'abitazione in cui vive è di sua proprietà?
Per favore, tra le seguenti opzioni, indichi <u>una sola</u> risposta.

- ☐ Sì, sono proprietario/a.
- ☐ No, sono in affitto.

10. Da quanto tempo vive nella sua attuale abitazione?
Per favore, scriva la sua risposta qui sotto, cerchiando l'unità di misura corretta.

____________________ mesi/anni.

11. Tra 3-5 anni, lei si immagina di...
Per favore, tra le seguenti opzioni, indichi <u>una sola</u> risposta.

- ☐ ...vivere nella stessa casa.
- ☐ ...vivere in un'altra casa ma nello stesso comune.
- ☐ ...vivere in un'altra casa ed in un altro comune appartenente alla Valle di Susa.
- ☐ ...vivere in un'altra casa ed in un altro comune non appartenente alla Valle di Susa.
- ☐ Non so.

QUARTA PARTE: INFORMAZIONI SOCIO-DEMOGRAFICHE

In questa sezione, le chiediamo gentilmente di fornirci qualche informazione in più su di lei. Le informazioni raccolte saranno utilizzate esclusivamente per analisi statistiche.

01. Lei è

Per favore, tra le seguenti opzioni, indichi una sola risposta.

- ☐ Occupato/a.
- ☐ Non occupato/a.
- ☐ Pensionato/a.
- ☐ Studente/ssa.
- ☐ Altro (per favore, specificare: ____).

02. Chi è il principale responsabile della gestione della casa (per quanto riguarda, per esempio la cucina, le pulizie, etc.)?

Per favore, tra le seguenti opzioni, indichi una sola risposta.

- ☐ Solo io.
- ☐ Sia io che il mio/la mia partner.
- ☐ Sia io che un altro membro della famiglia (o più membri della mia famiglia).
- ☐ Solo il mio/la mia partner.
- ☐ Solo altri membri della mia famiglia (escluso partner/marito/moglie e io stesso/a).
- ☐ Altro (per favore, specificare: ____).
- ☐ Nessuno si occupa della gestione della casa.
- ☐ Non so.

03. Chi è il responsabile della gestione quotidiana del denaro nella sua famiglia?

Per favore, tra le seguenti opzioni, indichi una sola risposta.

- ☐ Solo io.
- ☐ Sia io che il mio/la mia partner.
- ☐ Sia io che un altro membro della famiglia (o più membri della mia famiglia).
- ☐ Solo il mio/la mia partner.
- ☐ Solo altri membri della mia famiglia (escluso partner/marito/moglie e io stesso/a).
- ☐ Altro (per favore, specificare: ____).
- ☐ Nessuno si occupa della gestione del denaro.
- ☐ Non so.

04. In quale fascia può inserire la somma del reddito netto mensile complessivo di tutte le persone che vivono nella sua abitazione (includendo anche il suo)?

Per favore, tra le seguenti opzioni, indichi una sola risposta. Ricordo che i dati raccolti saranno utilizzati unicamente per fini di ricerca scientifica.

- ☐ 0€, nessuna delle persone che vivono nella mia abitazione lavora o ha sussidi/pensioni.
- ☐ Meno di 750€.
- ☐ Tra 750€ e 1000€.
- ☐ Tra 1001€ e 1500€.
- ☐ Tra 1501€ e 2000€.
- ☐ Tra 2001€ e 2500€.
- ☐ Tra 2501€ e 3000€.
- ☐ Tra 3001€ e 4000€.
- ☐ Tra 4001€ e 5000€.

- ☐ Tra 5001€ e 6000€.
- ☐ Tra 6001€ e 8000€.
- ☐ Tra 8001€ e 10000€.
- ☐ Più di 10000€.
- ☐ Preferisco non rispondere.

05. Considerando le sue entrate mensili ed escludendo le spese fisse (es. affitto o rata mutuo, spesa, bollette, etc.), a quanto ammonta la "disponibilità mensile" della sua famiglia?

Per favore, tra le seguenti opzioni, indichi una sola risposta. Ricordo che i dati raccolti saranno utilizzati unicamente per fini di ricerca scientifica.

- ☐ 0€.
- ☐ Meno di 200€.
- ☐ Tra 200€ e 400€.
- ☐ Tra 401€ e 600€.
- ☐ Tra 601€ e 800€.
- ☐ Tra 801€ e 1000€.
- ☐ Più di 1000€.
- ☐ Preferisco non rispondere.

06. Riferendosi alla condizione economica del suo nucleo familiare e all'attuale costo della vita, può affermare di...

Per favore, tra le seguenti opzioni, indichi una sola risposta.

- ☐ ...vivere molto comodamente.
- ☐ ...vivere comodamente.
- ☐ ...nè avere difficoltà nè vivere comodamente (riesco giusto a far fronte alle spese correnti).
- ☐ ...avere piccole difficoltà.
- ☐ ...avere grandi difficoltà.

07. Qual è la composizione degli occupanti l'abitazione in cui vive (incluso lei)?

Per favore, per ciascuna delle seguenti voci indichi il numero di persone. Se non vi sono componenti appartenenti ad una fascia scriva 0.

Bambini (età inferiore o uguale i 12 anni): ____________________
Ragazzi (13-18 anni): ____________________
Giovani adulti (19-30 anni): ____________________
Adulti (31-64 anni): ____________________
Anziani (età maggiore o uguale i 65 anni): ____________________

08. Quanti anni ha?

Per favore, scriva la sua risposta qui sotto.

____

09. Qual è il suo genere?

Per favore, tra le seguenti opzioni, indichi una sola risposta.

- ☐ Femminile.
- ☐ Maschile.

10. Qual è l'ultimo titolo di studio da lei conseguito?

Per favore, tra le seguenti opzioni, indichi una sola risposta.

- ☐ Licenza elementare.
- ☐ Diploma di scuola media inferiore.
- ☐ Diploma di scuola media superiore.
- ☐ Laurea (triennale/magistrale/ciclo unico).
- ☐ Dottorato di Ricerca/Master.

- ☐ Nessun titolo di studio.

11. Qual è il suo stato civile?
Per favore, tra le seguenti opzioni, indichi <u>una sola</u> risposta.

- ☐ Celibe/nubile.
- ☐ Sposato/a.
- ☐ Separato/a o divorziato/a.
- ☐ Vedovo/a.

12. Qual è il suo comune di residenza?
Per favore, scriva la sua risposta qui sotto.

____

13. Come è venuto/a a conoscenza di questo questionario?
Per favore, tra le seguenti opzioni, indichi <u>una o più</u> risposte.

- ☐ Tramite la Cooperativa Sociale Amico.
- ☐ Tramite il Consorzio Forestale Alta Valle Susa (CFAVS).
- ☐ Tramite la Cooperativa La Foresta.
- ☐ Tramite amici/conoscenti.
- ☐ Tramite il sindaco del mio comune.
- ☐ Tramite familiari.
- ☐ Tramite social networks.
- ☐ Tramite volantini.
- ☐ Tramite giornali locali.
- ☐ Altro (per favore, specificare: ____).

GRAZIE PER LA PAZIENZA E PER IL TEMPO DEDICATO ALLA COMPILAZIONE DEL QUESTIONARIO!

Sarebbe interessato/a a ricevere aggiornamenti...
...sui risultati di questa indagine?
...sull'evoluzione dei progetti di comunità in Valle di Susa?

Se sì, questi sono i miei contatti:
mariavalentina.dinicoli@polito.it
011 0904551 (ufficio)

Appendix C

Questionnaire: the energy community - reduced version (english languages)

EUROPA-UNIVERSITÄT VIADRINA FRANKFURT (ODER)

SCORE
Co-own. Prosume. Renew.
Supporting Consumer Ownership in Renewable Energies

scorepilots → base 30.11.2020, 10:43

Seite 01
AA

AA27

Survey on renewable energy communities and energy consumption

This survey is being carried out as part of the European Horizon 2020 research project SCORE (Supporting Consumer Ownership in Renewable Energies). SCORE deals with different ways to involve citizens in energy transition through simple and inclusive financing mechanisms. To this end, households across Europe are being surveyed on their attitudes towards participation in renewable energy production and individual energy consumption behaviour. The survey is completely anonymous and the data collected will be used exclusively for scientific purposes.

AA02

1. Membership in renewable energy communities

In renewable energy communities, often in the form of energy cooperatives, citizens and other local actors come together to invest jointly in renewable energy. The electricity generated in this way can be consumed or sold by the members of the community themselves, thereby generating profits. They also protect the climate by generating their own green electricity.

You can grade your answer on a scale from 1 for “I do not agree at all” to 5 for “I fully agree”.

	I strongly disagree 1	I disagree 2	neutral 3	I agree 4	I strongly agree 5	I don’t know
In principle, I am interested in participating in a renewable energy community.	○	○	○	○	○	○

Seite 02

AAja

PHP-Code

```
if (value('AA02_02') == 1) {
  goToPage('AAnein');
}
if (value('AA02_02') == 2) {
  goToPage('AAnein');
}
if (value('AA02_02') == 3) {
  goToPage('AAnein');
}
if (value('AA02_02') == -1) {
  goToPage('AAerzeugung');
}
if (value('AA02_02') == -9) {
  goToPage('AAerzeugung');
}
```

AA03

2. Why are you interested in participating in a renewable energy community?

Please chose one or more of the following answers. If you are already participating in a renewable energy community, please indicate the reasons for your participation here.

- [ ] I have an economic advantage (e.g. less energy costs)
- [ ] I have an advantage in terms of more efficient services.
- [ ] I have an economic advantage from making a profit.
- [ ] I serve my community.
- [ ] I contribute to the preservation of nature and the planet.
- [ ] Other: __________

AA04

3. How would you like to participate in a renewable energy community?

Please chose one or more of the following answers. If you are already participate in a renewable energy community, please indicate the type of your participation here.

- [ ] I would contribute or invest money.
- [ ] I would contribute my knowledge e.g. in management or energy technology.
- [ ] I would contribute my free time e.g. to take over tasks within the community.
- [ ] I would provide surfaces to install energy production systems (e.g. on a roof or a field).
- [ ] I would take an active role in the management of the renwable energy community.
- [ ] I would spread information about planned projects/ activities in the neighbourhood and recruit new members.
- [ ] Other: __________

Seite 03
AAnein

PHP-Code

```
if (value('AA02_02') == 3) {
  goToPage('AAerzeugung');
}
if (value('AA02_02') == 4) {
  goToPage('AAerzeugung');
}
if (value('AA02_02') == 5) {
  goToPage('AAerzeugung');
}
if (value('AA02_02') == -1) {
  goToPage('AAerzeugung');
}
if (value('AA02_02') == -9) {
  goToPage('AAerzeugung');
}
```

AA05

4. What factors make you not interested in participating in a renewable energy community?

Please chose one or more of the following answers.

- [ ] I do not have enough time.
- [ ] I do not have enough money.
- [ ] I do not have enough knowledge or skills.
- [ ] I do not know how and where.
- [ ] I would have other disadvantages from participation (e.g. reduction of social benefits).
- [ ] I prefer conventional energy supply.
- [ ] I think the bureaucratic burden is too high.
- [ ] I do not think that such a project is profitable.
- [ ] I think that such a project is doomed to failure.
- [ ] I mistrust such projects.
- [ ] I generally do not want to invest.
- [ ] Ich weiß nicht wieso ich nicht teilnehmen möchte.
- [ ] Other: ______

AA06

5. What would convince you to participate in a renewable energy community?

Please chose one or more of the following answers.

- ☐ I want to be actively approached and involved by existing renewable energy communities.
- ☐ I need financial support to participate, e.g. a zero interest loan to finance my participation or tax benefits.
- ☐ I need and easier way to participate in the energy transition, please specify here: _____
- ☐ I need an incentive for my participation, please specify here: _____
- ☐ I would like to have the feeling of making a contribution to my social environment through my participation.
- ☐ I want to feel that through my participation I am contributing to a sustainable lifestyle.
- ☐ I need something else: _____
- ☐ Nothing could convince me to participate.
- ☐ I do not know.

Seite 04

AAerzeugung

AA07

6. Are you currently participating, in any way, in the production of energy from renewable energy sources?

Typical participation in the production of renewable energy is for example

- a solar system on the roof
- Participation in a renewable energy community
- Shares in a company involved in other business models with the aim of producing renewable energy, etc.

Please select only one of the following answers.

- ○ Yes
- ○ No

Seite 05
AAerz

PHP-Code

```
if (value('AA07') == 2) {
  goToPage('AAinvest');
}
```

AA08

7. In what way are you involved in the production of renewable energy?

Please select one or more of the following answers. As a member of an energy community you are also a co-owner of the respective plant.

- ☐ I am (co-)owner of a photovoltaic installation (generation of electricity from solar radiation).
- ☐ I am (co-)owner of a solar thermal installation (generation of heat from solar radiation).
- ☐ I am (co-)ower of a wind turbine.
- ☐ I am (co-)owner of a biogas plant.
- ☐ I am (co-)owner of a hydropower plant.
- ☐ I am (co-)owner of a renewable thermal power station.
- ☐ Other: ________

1 aktive(r) Filter

Filter AA08/F1
Wenn eine der folgenden Antwortoption(en) ausgewählt wurde: **7**
Dann Seite(n) **AAA** des Fragebogens anzeigen (sonst ausblenden)

Seite 06
AAerz2

AA09

8. How can you use the energy produced?

Please chose only one of the following answers.

- ☐ Only for self-consumption
- ☐ Only for sale
- ☐ Both for self-consumption and for sale
- ☐ Other: ________

Seite 07

AA23

9. Are you also a member of a renewable energy community through your participation in renewable energies?

- ◯ Yes
- ◯ No

1 aktive(r) Filter

Filter AA23/F1
Wenn eine der folgenden Antwortoption(en) ausgewählt wurde: **1**
Dann Seite(n) **AAA** des Fragebogens anzeigen (sonst ausblenden)

Seite 08

AAA

AA21

10. Please state the kind of renewable energy community below.

- ◯ Renewable energy cooperative
- ◯ Limited liability company
- ◯ Association
- ◯ No formal organisation
- ◯ Other: ________

AA22

11. The renewable energy community is active in the following areas:

Please select one or more options.

- ☐ Supply of renewable energy
- ☐ Energy efficiency measures
- ☐ Renewable supply of heat
- ☐ Energy consulting
- ☐ E-mobility
- ☐ Aggregation of renewable energies
- ☐ Storage of renewable energies
- ☐ Other: ________

Seite 09
AAinvest

AA01

12. Please assess your willingness to invest (again) in a renewable energy project.

Please rate your answer for the following statement from 1 for ''I strongly disagree'' to 5 for ''I strongly agree''.

	I strongly disagree	I disagree	neutral	I agree	I strongly agree.	I don't know
	1	2	3	4	5	
I would be willing to invest in a renewable energy project.	○	○	○	○	○	○

Seite 10
AAinvestnein

PHP-Code

```
if (value('AA01_01') == 3) {
  goToPage('AAEE1');
}
if (value('AA01_01') == 4) {
  goToPage('AAEE1');
}
if (value('AA01_01') == 5) {
  goToPage('AAEE1');
}
if (value('AA01_01') == -1) {
  goToPage('AAEE1');
}
```

AA11

13. Why are you not willing to invest in a renewable energy project?

Please chose one or more of the following answers.

- [ ] I have no investment capital available.
- [ ] I have already invested in a renewable energy project.
- [ ] The investment is too risky.
- [ ] Oher investments are economically more interesting (e.g. higher returns).
- [ ] I would have other disadvantages because of the investment, please specify here: ______
- [ ] I have no confidence in the project (no feedback regarding the success of financing renewable energy community projects).
- [ ] The bureaucratic effort is too much.
- [ ] I fear that I will only be considered in decisions in proportion to the amount I have invested.
- [ ] I do not have enough time to prepare the investment.
- [ ] I do not have enough time to fulfil the obligations of the project (taking over tasks).
- [ ] Other reasons, please specify here: ______

Seite 11
AAEE1

AA13

Energy efficiency in your own household

It is all about electrical energy, i.e. electricity. One way to use less electricity is to replace older household appliances with newer models that use less energy. Please estimate how far you are willing to replace one of the following appliances with a newer, more energy-efficient one in order to save electricity

Please rate the following statements. You can rate your answers on a scale from 1 for ''I don't agree at all'' to 5 for ''I fully agree''.

14. In order to reduce energy consumption, I am willing to... AA12

	I strongly disagree	I disagree	neutral	I agree	I strongly agree	I don't know
...exchange older lighting with LED lamps.	○	○	○	○	○	○
...exchange an older refrigerator or freezer.	○	○	○	○	○	○
...exchange other older household appliances (e.g. dishwasher, washing machine, oven or dryer).	○	○	○	○	○	○
...exchange older consumer electronics (e.g. TV or hi-fi equipment).	○	○	○	○	○	○
...replace an older heating pump.	○	○	○	○	○	○

Seite 12
AAEE3

15. Did you already exchange any of the appliances mentioned below in order to save electricity? AA14

Please chose one or more of the following answers.

- ☐ No.
- ☐ Yes, I already exchanged older lighting with LED lamps.
- ☐ Yes, I already exchanged an older refrigerator or freezer.
- ☐ Yes, I already exchanged other older household appliances (e.g. dishwasher, washing machine, oven or dryer).
- ☐ Yes, I already exchanged older consumer electronics (e.g. TV or hi-fi equipment).

Seite 13

AAEE4

AA25

By adapting one's own behaviour, electricity can also be saved. Please indicate to what extent you would be willing to implement the following measures.

Please evaluate the following statements. You can grade your answers on a scale from 1 for "I don't agree at all" to 5 for "I agree fully'.

AA16

16. To save electricity, I would be willing...

	I strongly disagree 1	I disagree 2	neutral 3	I agree 4	I strongly agree 5	I don't know
...turn off the light, even if I only leave the room for a short time.	○	○	○	○	○	○
...use power strips with an off switch to avoid electrical appliances running in stand-by mode.	○	○	○	○	○	○
...use household appliances (e.g. washing machine or dishwasher) in energy-saving mode.	○	○	○	○	○	○
...use household appliances (e.g. washing machine or dishwasher) only when they are fully loaded.	○	○	○	○	○	○
...regularly defrost the refrigerator or freezer to avoid a layer of ice.	○	○	○	○	○	○

Seite 14

AAEE5

AA17

17. Are you already applying any of the below-mentioned behaviours to save electricity?

Please chose one or more of the following answers.

- ☐ No.
- ☐ Yes, I already turn of the light even if I only leave the room for a short time.
- ☐ Yes, I already use power strips with an off switch to avoid electrical applianсs running in stand-by mode.
- ☐ Yes, I already use household appliances (e.g. washing machine or dishwasher) in energy-saving mode.
- ☐ Yes, I already use household appliances (e.g. washing machine or dishwasher) only when they are fully loaded.
- ☐ Yes, I already regularly defrost the refrigerator or freezer to avoid a layer of ice.

Seite 15
AA invest

AA10

18. Now please imagine that you would invest in renewable energy projects.

How much would you be willing to invest?		Euro
What would the annual return have to be for you to invest this amount?		Years
After how many years should this investment have paid for itself?		Years

Seite 16
AAEE61

AA26

Flexibility in power consumption

One of the biggest problems in successfully developing renewable energy is the fluctuation of production and consumption. To stabilise the grid it is necessary to compensate for these fluctuations.

Against this background, how willing are you to adapt your energy consumption to the production of renewable energies?

You can grade your answers on a scale from 1 for ''I don't agree at all'' to 5 for ''I agree fully'.You can rate your answers on a scale from 1 for ''I do not agree at all'' to 5 for ''I fully agree''.

AA18

19. To stabilise the electricity grid, I am willing to...

	I strongly disagree 1	I disagree 2	neutral 3	I agree 4	I strongly agree 5	I don't know
...use household appliances (e.g. washing machine, dishwasher) mainly when the share of electricity from renewable sources in the grid is very high.	○	○	○	○	○	○
...recharge electrical devices (e.g. notebook) mainly when the share of electricity from renewable sources in the grid is very high.	○	○	○	○	○	○
...recharge electrical means of transportation (e.g. electric car/ scooter/ bike) mainly when the share of electricity from renewable sources in the grid is very high.	○	○	○	○	○	○

Seite 17
AAEE6

AA24

20. A SMART meter can be used to regulate electricity consumption in a household. Depending on the amount of electricity available on the grid, electricity is either saved or consumed, which ensures stability on the grid.

Would you be willing to use such a device in your household?

Please indicate your willingness on a scale from -3 for ''unwilling'' to +3 for ''willing''.

○	○	○	○	○	○	○
3	2	1	0	+1	+2	+3

Seite 18
AAEE7

AA20

21. How important is environmental protection to you?

Please indicate the importance on a scale from -3 for ''unimportant'' to +3 for ''important''.

○	○	○	○	○	○	○
3	2	1	0	+1	+2	+3

Seite 19
BB

BB02

22. How strongly do you feel connected to where you live?

Please rate your answer for the following statement from 1 for ''I strongly disagree'' to 5 for ''I strongly agree''.

	I strongly disagree	I disagree	neutral	I agree	I strongly agree	I don't know
I feel strongly connected to the place where I live.	○	○	○	○	○	○
There are many people in my neighbourhood that I consider good friends.	○	○	○	○	○	○
I often talk about my neighbourhood as a great place to live.	○	○	○	○	○	○

CC01

23. Are you living...

Please chose only one of the following answers.

- … in an apartment?
- ... a single family house?
- Other:

CC02

24. Do you live for rent or are you using your own property?

Please chose only one of the following answers.

- Own property
- For rent
- Other:

CC05

25. Energy costs of my household

Please rate your answer for the following statement from 1 for ''I strongly disagree'' to 5 for ''I strongly agree''.

	I strongly disagree	I disagree	neutral	I agree	I strongly agree	I don't know
It is difficult to meet the energy demand of my household.	○	○	○	○	○	○
In order to cover the running energy costs, my household does without other expenses (e.g. new purchases, leisure time).	○	○	○	○	○	○
During winter, my household has trouble heating the apartment/ the house sufficiently.	○	○	○	○	○	○
To reduce energy costs, my household limits itself to save energy (e.g. cold water for showering, no heating).	○	○	○	○	○	○

CC03

26. Do you know how much electricity your household uses approximately per year?

Please select only one of the following answers and, if applicable, state additional information.

○ Yes, the electricity consumption of my household in kWh (kilowatt hours) per year amounts to:

○ No

CC04

27. Do you know how much your household is approximately paying for electricity (no heat) per month?

Please chose only one of the following answers and, if applicable, state additional information.

○ Yes, my household pays for electricity per month (in euros):

○ No.

DD02

Further Information

Please state additional information about yourself. Information that is collected in this section will be used exclusively for statistical analysis. The statistical evaluation is completely anonymous.

DD01

28. How would you describe your current situation?

Please select only one of the following answers and, if applicable, state additional information.

- Employed
- Unemployed
- Retired
- Student
- Apprenticeship
- Other:

DD10

29. What educational qualifications do you have?

Please chose only one of the following answers.

- completed PhD
- completed university education
- college/ university degree or similar
- completed apprenticeship or similar
- I am currently doing an apprenticeship
- Other:

DD09

30. I live...

Please chose only one of the following answers.

- ...alone.
- ...with my spouse or husband.
- ...with my life partner.
- ...with friends.
- Other: _____

DD04

31. I am the household member...

Please rate your answer for the following statement from 1 for ''I strongly disagree'' to 5 for ''I strongly agree''.

	I strongly disagree	I disagree	neutral	I agree	I strongly agree	I don't know
...mainly in control of the household finances.	○	○	○	○	○	○
...mainly responsible for homemaking (e.g. cleaning, cooking, laundry).	○	○	○	○	○	○

DD05

32. Does your household have an own source of income?

Please chose only one of the following answers.

- No income
- Less than 750€
- Between 750 € and 1,000€
- Between 1,001€ and 1,500€
- Between 1,501€ and 2,000€
- Between 2,001€ and 2,500€
- Between 2,501€ and 3,000€
- Between 3,001€ and 3,500€
- Between 3,501€ and 4,000€
- Between 4,001€ and 4,500€
- Betweeen 4,501€ and 5,000€
- More than 5,000€
- I dont want to indicate my income

DD06

33. What is the composition of your household?

Please indicate the respective number of people (including yourself) for each of the following options. If one of the groups is not represented, indicate a ‘‘0”.

- Children (under 12 years):
- Teenagers (12-18 years):
- Young adults (19-30 years):
- Adults (31-64 years):
- Elderly (age over 65):

Seite 25
DD3

DD11

34. Please enter the first three digits of your postcode.

DD07

35. How old are you?

Please indicate your age in years.

Jahre

DD08

36. What is your gender?

Please chose only one of the following answers.

- Female
- Male
- I prefer not to answer
- I prefer to self-describe:

Seite 26
EE

EE01

37. If you would like to tell us more, you can leave your contact details here and we will contact you for another interview. Your contact details will be collected separately from your answers to this survey. Your previous answers are therefore completely anonymous. Click on Continue if you are not interested in this.

- I would like to be contacted for further surveys.
- I would like to be contacted for a personal telephone interview.

Letzte Seite

Thank you very much for your participation!

We want to thank you for your assistance.

Your answers have been saved, you can close the browser window now.

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