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The role of prosumers in supporting renewable energies sources

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Abstract. The present study is a part of an on-going Horizon 2020 project, named "SCORE" (Supporting Consumer Co-Ownership in Renewable Energies), which focuses on sustainable cities and communities developments goal. Particularly, this project aims at (1) overcoming usage of energy from fossil sources in favour of renewable sources, (2) increasing the energy efficiency and (3) reducing the energy consumption. Since the first project's task was completed, i.e. identification and description of different case studies, the next one is to propose for each of them several retrofit alternatives, in order to address the above mentioned "SCORE" purposes. In this framework, the main goal of the present study is to select and rank the relevant evaluation criteria, with the aim at building an evaluative matrix, which later makes possible to analyse the feasibility of the different case studies and choice the best retrofit alternative through a Multi-Criteria analysis (MCA). The criteria were pre-selected through a literature reviews, while the final selection took place by organizing a specific working group composed by real stakeholders. The results show how the role of the working groups (one composed by energy experts and the other by evaluation experts) were fundamental since the application of the playing card method allowed to (i) select and rank the set of relevant evaluation criteria and (ii) associate a weight for each evaluation criteria. Finally, it was decided not to aggregate the results of the two expert groups in order to show and consider the difference in stakeholders' point of view.

1. Introduction

In the current context, the implementation of the Agenda 2030 and the achievement of the 17 Sustainable Development Goals (SDGs), contributes to global development, promoting human wellbeing and protecting the environment. In this framework, the on-going Horizon 2020 project, named "SCORE" (Supporting Consumer co-Ownership in Renewable Energies), is focused mainly on the Goal 11 "Sustainable cities and communities", which makes cities and human settlements inclusive, safe, resilient and sustainable [1]. Specifically, "SCORE" aims at (1) overcoming the usage of energy coming from fossil sources by taking advantage of energy from renewable sources, (2) increasing energy efficiency of the building systems (e.g. envelope or energy system) and (3) reducing energy consumption related to building/neighbourhood users' behaviour. Consequently, local and decentralized renewable energy sources (RES) production leads to positive implications, such as

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community self-sufficiency and better air quality, related to CO_2 emissions reduction. In addition, the project lends attention to the dynamics that allow or not the birth of the specific communities, analysing the role of citizens. The intention is to shift the attention from the individual to the community, and consequently, from the consumer to the prosumers. The term “prosumer” is the synthesis of two words: “producer” and “consumer” and indicates an individual strongly independent from the classical economy. In fact, 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. This leads to numerous prosumers of renewable energy (first of all taking advantage of photovoltaic) and the concept of "self-produced energy sharing" is spreading, directing the market towards a decentralized, more democratic and efficient model; a new way of producing and distributing energy, near to consumption places, is emerging. From this, it is clear that another purpose of “SCORE” project is encouraging the consumer to play an active role, contributing himself to the production of energy in the community. Therefore, the identification of segments of the population that are interested or would like to be part of the project, but do not have the possibility (for different reasons such as economic, social, etc.), is the core of the research. The project aims at implementing these communities in three pilot regions: Italy, Poland and Czech Republic. These pilot projects are at the core of “SCORE” as they have to demonstrate the practical feasibility of optimized joint prosumer investments with local municipalities. Once the first task of the project, concerns the identification and the characteristics description of different case studies in each pilot region, is completed, the next step regards their implementation. For each case study, several retrofit alternatives will be proposed in order to address, with different extents, the “SCORE” purposes; but, only one of them will be carried out: the most feasible alternative, evaluated under different perspectives. Accordingly, the feasibility analysis, among different Italian pilot case studies (Susa Valley, in Piedmont region), will be performed through a Multi-Criteria Analysis (MCA), which allows to support the choice of the best project through an analysis of a complex system in which different aspects (social, technical, economic, environmental and administrative) are assessed. In particular, the present study aims at identifying the evaluation criteria and determine the respective weights. This represents an important phase because it allows to analyse and compare different projects through an evaluative matrix, assessing and considering the preferences of different stakeholders’ point of views.
The paper is divided as follows. Section 2 illustrates the methodological approach through which the evaluation criteria were defined and ranked. In section 3, the results will be discussed in detail. The paper lasts giving a few perspectives for the current work (section 4).

2. Methodology and material
This section demonstrates the methodology employed to create a hierarchy rank among the different selected criteria, which will analyse the pilot projects, according to a convenience and feasibility priority. In this regard, a selection process is defined and it consists of five phases. The process begins with the detection of the case study (diagnosis phase) and continues with the selection of the evaluation criteria, taking into account the stakeholders’ objectives and preferences. This last part is started from the pre-selection step and ended by the final selection of a set of criteria. The selection process has been carried out in the following order as shown in figure 1.

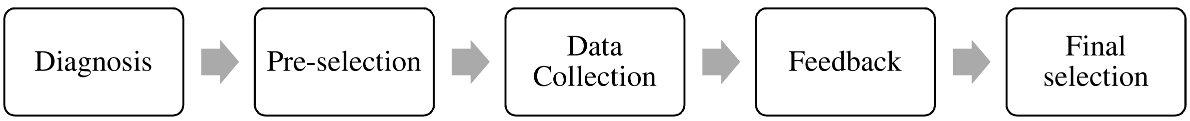

Figure 1. The steps of the selection process

As mentioned above, the main output of the present work allows to later perform the feasibility analysis of different Italian case studies. For this purpose, after having collected and elaborated all the needed information and data, the decision criteria need to be carefully identified and selected in order to rank the different retrofit alternatives.

2.1. Diagnosis

The first step concerns the identification of the different case studies pilots in an Italian selected territory: the Susa Valley. Specifically, the pilots are small municipalities in which some buildings, mostly of public property, have been identified since they are characterized by inefficient and polluting heating plants system, fuelled by diesel or natural gas. In addition, the proximity of the buildings allows their connection to a new plant system, a district heating network supplied by biomass. This project strategy leads to overcome the use of energy from fossil sources in favour of the use of wood chip, coming from the local territory in a controlled and certified perspective of sustainable development. Table 1 shows the different selected case studies indicating the existing heating system and the planned one.

Table 1: List of the Italian case studies

N°	**Case study**	**Existing conventional energy sources for heating**	**Planned RES sources project**
1	Oulx	Oil and natural gas boiler	District heating network (biomass)
2	Novalesa	Oil and natural gas boiler	District heating network (biomass)
3	Salbertrand	Natural gas boiler	Biomass plant
4	Bruzolo	Natural gas boiler	Biomass plant
5	Almese	Natural gas boiler	District heating network (biomass) and centralized solar thermal collectors
6	Perosa Argentina	District heating network (natural gas)	District heating network (biomass)
7	Ala di Stura	Oil boiler	District heating network (biomass)
8	Rueglio	Oil boiler	District heating network (biomass)
9	Caprie	Biomass plant	New biomass plant and solar thermal collectors
10	Villardora	Natural gas boiler	District heating network (biomass) and solar thermal collectors

2.2. Pre-selection

The selection process of the criteria begins with the pre-selection phase. The different criteria are important to identify the most feasible and sustainable project, not only from a technical and economic point of view, but also considering environmental, social and administrative aspects.

The pre-selection step is based primary on two aspects. The first aspect is an existing literature, specially, according to [2], [3], [4]; these studies showed that the efficiency, investment cost, operation and maintenance cost, NO_x emission, CO_2 emission, land use, social acceptability and job creation are the most widely used evaluation criteria in energy planning purposes. The second aspect is setting up five internal teamwork discussions with different expertise in energy engineering, multi-criteria analyst, plant system designer and socio-energetic planner. Considering both above-mentioned aspects, we have classified the criteria into five main categories, so called environmental, economic, technical, social and administrative [5]. Afterward, the first repository of criteria was built up by considering the high frequency used evaluation criteria in the literature [2] and, especially, the criteria which should be affected by energy retrofitting measures. Furthermore, the set of criteria were modified through five internal teamwork meetings and based on the specific particularities of the project (see table 2).

Table 2: Description of the considered pre-selected criteria for "SCORE" project.

	Criteria	Description	Unit
Environmental	Environmental constraints	Environmental restrictions (park or protected area) and constraints such hydrogeological, seismic, etc.	-
	Land use	Surface occupied by the plant.	m^2
	Primary energy saving	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).	$kWh_{primary\ energy}$
	Global emissions CO_2	Reduction of CO_2 emissions guaranteed by the project plant compared to the current one	kg
	Local emissions NO_X, PM_{10}	Reduction of NO_X and PM_{10} emissions guaranteed by the project plant compared to the current one.	kg
Economic	Payback period (PBP)	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.	years
	Investment cost	Investment costs related to refurbishment of the building (efficiency investment) and/or new heating system (infrastructure investment).	euro
	Public incentives	Percentage of savings linked to the share of investment cost covered by administrative incentives	%
	Savings on energy expenditure	Savings on annual expenditure	euro/year
	Economic impact - installation	Money that remains on the territory because of installation.	euro
	Economic impact – operation and maintenance	Money that remains on the territory because of operation and maintenance.	euro/year
Technical	The increase of plant system efficiency	The increase in the efficiency of the new system plant compared to the existing one.	%
	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, etc.	-
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.	-
Admini strative	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.	-

2.3. Data collection

The data on the ten case study pilots (municipalities showed in table 1), in the Susa Valley, is collected using two pre-defined questionnaires provided by project partners. The first survey regards the investments identification of renewable energy sources; the second one regards the energy costs and tariffs for the actual situation, for the use of non-renewable energy sources.

The first survey is composed by five parts which allow a general description of the buildings considered for each case study, describing the current situation (geometry and energy plant system) and the design one (planned project in terms of RES and financial aspects). The first part identifies the

building characteristics (building ownership, building construction year, year of the last refurbishment, gas/energy/heat and DHW distribution system operator, average of gas/energy/heat and DHW expenses, the total number of dwellings or offices, the total official number of inhabitants/employees, number of floors, total usable area and total roof area). In the second part, the existing conventional energy sources or external supplier is investigated (type of energy sources, installed power or purchased power if the district network is present). The third part identifies the existing renewable energy sources (type of energy sources, installed power and active surface if photovoltaics (PV) and solar thermal panels are present). In the fourth part, the planned renewable energy sources are investigated (type of energy sources, installed power and active surface if PV and solar thermal panels are present). Finally, the fifth part identifies the planned structured of financial sources for the renewable energy sources investment (type of financial sources and percentage of overall costs).
The aim of the second survey is to collect information about the use of non-renewable energy sources; specifically, in this questionnaire, the average consumption fee [€/GJ] (annual consumption [GJ] and historical data (from 2013 to 2017) for oil and natural gas cost [€/GJ]) and the average fixed fee [€/month] are investigated. According to the data collected through these two surveys, it will be possible to fill in the evaluative matrix containing the criteria identified in the pre-selection phase.

2.4. Feedback
The final list of the criteria was established through a workshop including stakeholders and experts. In this workshop, the author played a role of analyst who aids Decision Makers (DMs) in making better their decision without expressing any personal preferences [6]. The first half day workshop was set up on 29th January 2019 at Politecnico di Torino (Italy). As said above, the purpose of the workshop was to select and rank the most important criteria to further assess the feasibility analysis of different pilot case studies. Initially, an official email has been sent to the stakeholders, introducing them the material and the structure of workshop and their role. During this first contact, the aims of the workshop were explained to each individual stakeholder. The invited stakeholders were included in two main backgrounds: the energy engineers and plant system designers and the evaluation experts.

2.5. Final selection
To rank and define the importance of the criteria during this research project, it was decided to use the "Playing Cards" method, which is a semi-structured participative procedure proposed by Simos [7]. The "Playing Cards" method is appropriate to support group discussions; this is one of the important reasons why this method has been selected. In fact, one of its specific aims is to stimulate the interactive and constructive discussion between different stakeholders with different backgrounds. The methodology helps the stakeholders to express the way in which they wish to rank the different criteria in a specific context. This method is very easy to use and it consists in associating a "card" with each criterion. Moreover, the stakeholders have a set of "white cards" available, the use of which depends on specific needs. The application of the procedure is very simple: first, the stakeholders should order the "cards" according to the importance of the criteria (from the less important to the most important one) and, if some criteria have the same importance, the stakeholders should build a subset of cards clipping them together; second, according to the fact that the importance of two successive criteria in the ranking can be more or less close, the stakeholders are asked to insert as many "white cards" as much is the distance between two successive criteria, according to the number meaning of white card showed in table 3, and, then, providing a final ranking of the importance; third, the final ranking of criteria is transformed into weights according to Simos' algorithms [7].

Table 3: Description of the meaning of the white cards.

Number of with cards	Importance
0	two following criteria do not have the same weights, but there is a minimal difference
1	two times the minimal difference

2	three times the minimal difference
N	n+1 times the minimal difference

3. Results and discussion

First, an official mail, in which the description and the schedule of the workshop were explicit, has been sent to nine stakeholders with different background and field of interest. Only six stakeholders actually took part in the workshop and they were divided into two main groups according to their backgrounds and interests. The first group (G1) is composed by the energy experts: an external expert in the building energy efficiency field and two academic professors from the energy department. The second group (G2) is composed majority by the evaluation experts: two academic professors who deals with economic evaluation of built environment issues from the urban planning department, and finally, one energy professor in order to guarantee to meet the project energy issues aiding the stakeholders in the specific energy aspects.
The work done by the workshop has been organized in two main steps, according to the following structure: (i) firstly, the authors played the role of moderator and the analyst provided to the two groups of stakeholders two set of colored cards (one for each group) in which were written the pre-selected criteria (described in table 2). Then the analyst asked to discuss the importance of each criteria in order to select them and define a rank, according to their opinion. (ii) Secondly, the main task was the addition of the white cards with the purpose of inserting them (if necessary) between two consecutive cards [8] (according to table 3); in this way, each group was able to define the level of importance of each ranked criterion, determining the weights of each criterion.
Finally, the two performed ranks were illustrated in a plenary session and each group of stakeholders explained the reasons of their selection. Then, according to the Simos' algorithm, the final ranking of criteria was converted into weights and the results are shown in table 4 and table 5.

Table 4: Final results coming from the Playing Cards method - energy experts (G1)

Rank	Subset of Ex-Equo	Number of Cards	Positions*	Non-normalize weights	Normalized Weights	Total**
1	Architectural impact, land use, number of users	3	1, 2, 3	2	0.97	2.91
2	White card	1	[4]	-	-	-
3	Economic impact – operation and maintenance, economic impact – installation	2	5, 6	5.5	2.67	5.34
4	Local emissions, global emissions CO_2, primary energy saving, increase of plant system efficiency	4	7, 8, 9, 10	8.5	4.13	16.50
5	Interest of public administration and opportunities, ownership	2	11, 12	11.5	5.58	11.17
6	Investment cost, public incentives, savings on energy expenditure	3	13, 14, 15	14	6.8	20.39
7	Payback period (PBP), duration of the intervention contract***	2	16, 17	16.5	8.01	16.02

8	Environmental constraints, availability of primary resource****, operational difficulty of installation	3	18, 19, 20	19	9.22	27.67
SUM		**20**	**206**			**100**

*This sum does not include the positions of the white cards (in brackets).
** The total column reports the normalized weights multiplied for the number of cards of each position.
*** This criterion has been recorded between the economic aspects by the energy experts.
**** This criterion has been recorded between the technical aspects by the energy experts.

Table 5: Final results coming from the Playing Cards method - evaluation experts (G2)

Rank	Subset of Ex-Equo	Number of Cards	Positions*	Non-Normalize weights	Normalize d Weights	Total**
1	Environmental constraints, land use	2	1, 2	1.5	0.84	1.68
2	Architectural impact	1	3	3	1.68	1.68
3	White card	2	[4, 5]	-	-	-
4	Economic impact – installation	1	6	6	3.35	3.35
5	Operational difficulty of installation	1	7	7	3.91	3.91
6	White card	1	[8]	-	-	-
7	Investment cost	1	9	9	5.03	5.03
8	Economic impact – operation and maintenance	1	10	10	5.59	5.59
9	Savings on energy expenditure	1	11	11	6.15	6.15
10	White card	2	[12, 13]	-	-	-
11	Payback period (PBP), public incentives	2	14, 15	14.5	8.10	16.20
12	White card	1	[16]	-	-	-
13	Ownership	1	17	17	9.5	9.5
14	Interest of public administration and opportunities	1	18	18	10.06	10.06
15	White card	2	[19, 20]	-	-	-
16	Primary energy saving	1	21	21	11.73	11.73
17	Global emissions CO_2, local emissions	2	22, 23	22.5	12.57	25.14
SUM		**23**	**179**			**100**

*This sum does not include the positions of the white cards (in brackets).
** The total column reports the normalized weights multiplied for the number of cards of each position.

As it is shown in tables 4 and 5, the criteria were ordered from the less important to the most important; in addition, some of the initially considered criteria (table 2) have been removed or added from the stakeholders during the discussion. In detail, the G1 have considered the process in terms of technical aspects. Indeed, they stated that if some criteria such as “environmental constraints”, “operational difficulty of installation” and “availability of primary resource” were not meet the targets, the project is not able to proceed. According to this, they defined these three criteria the most important and ranked the criteria (table 4) according to their technical process importance. In addition, two main criteria, which are “availability of primary resource” (included among the technical aspects) and “duration of the intervention contract” (included among the economic ones), were added by G1 into the final rank. The second rank (table 5) demonstrates the selected criteria by the G2. In particular, this group have removed two aspects “number of users” and “increase of plant system efficiency” since they believed that these criteria were redundant; the first one with respect to the "interest of public administration and opportunities" and the second one respect to the "primary energy saving". Instead, all the criteria related to the global and local "emissions" have been considered as fundamental ones.

Finally, there are similarities among the two rank for the less important criteria. It is notable to say that, even if the literature suggests taking into account the social criteria, the practice neglects this important evidence. Probably one of the reasons why the social aspects are partially ignored such as "architectural impact" is due to their complex and qualitative approach of assessment. Similarly, also the "land use" (in the environmental category) has been considered not essential from the stakeholders.

4. Conclusions and future developments

This study has demonstrated how the evaluation criteria have been selected and ranked through a workshop attended by experts in energy and evaluation. The selected criteria will be used later to analyze the feasibility of different Italian case study within the "SCORE" project. The two groups of experts worked in a parallel way to define the relevant criteria. For this purpose, the playing cards method has been employed; the latter allowed stakeholders to order the criteria in a very intuitive way from the least important to the most important one. Consequently, from the subsequent application of the playing cards, which applies the Simos' algorithm, it was possible to obtain the weights associated to each criterion. In this way, two different sets of ranks and weights were obtained. It was decided not to aggregate the two results in order to have two different stakeholders' point of view. Furthermore, the obtained weights are especially suited to this specific projects where the energy component is predominant and this is evident from the composition of the two groups of experts. The methodology used is robust and usable in wider and different contexts, but it is important that the interest participants of the workshops should meet the project purposes in question. One of the interesting future developments is the use of PROMETHEE method, which is an outranking Multi Criteria Analysis (MCA) in order to rank a feasibility analysis of ten case studies pilots, taking into account the criteria weights defined by this study. This will allow defining the most convenient pilot project in a sustainable perspective.

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