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Social impact assessment of wind power generation. An innovative method for decision making processes

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Social impact assessment of wind power generation. An innovative method for decision making processes

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Abstract. This paper explores the social impact for population in the energy sector combining LCA and SIA (social impact assessment). As case study, a new 66 MW wind power plant under development in the countryside of Southern Sardinia has been considered. The innovative method, based on the analysis of the context, aims to empirically analyze some selected sustainability indicators. The proposed method starts from a detailed analysis of the wind power project, with particular reference to the plant site characteristics, technical features of the wind farm, opinions of the stakeholders, environmental and social impacts and expected economic benefits. The acquired data are validated with a Severity statistical method that identifies the KPIs. The indicators are classified into general categories of damage Human life, Safety guarantee, Social resources, Public participation and analyzed through a combined SIA-LCA method to identify indicators damage weights.
This work shows the importance of putting together indicators already explored in the environmental field such as Human health, Ecosystem quality, Resource, Climate Change and as social indicators Renewable Energy with Noise, Visual Impact, Shadow Flichers, the perceptions of the local community.

1. Introduction

The deployment of renewable energies is the key for a successful transition towards a low-carbon energy economy. Wind power development is an increasingly vital source of renewable electricity that significantly contributes globally to reduce greenhouse gas emissions and mitigate climate change. The use of wind turbines to generate electricity is expanding rapidly across the world. According to the International Energy Agency, wind turbines generated around 1265 TWh in 2018 and a rise to 3317 TWh or more is expected by 2030 [1].

Construction of new wind power plants is currently a very complex task. Social acceptance of wind turbines depends on many factors. Peri and Tal [2] highlight that the low environmental impact of wind turbines emerged as the dominant aspect during the planning process and favors public acceptance. However, the opposition of local population is often associated with concerns about changes in landscape, noise, health effects. Dällenbach and Wüstenhagen [1] define the issues of distributional and procedural justice on a public process on Switzerland based on resident' proximity to a planned wind project.

Indeed Perez et Al. [3] discussed how different social, environmental, and institutional factors influence the social opposition to new projects. For instance, according to the considered stakeholder the social effects of a project can be positive or negative (job creation, landowners' compensation, impacts on property value and traditional economic activities, increased inequality, etc.). Peri analysed another set of factors related to the environmental impact of projects, which can directly affect local communities (health risks, noise, water and air pollution, waste production, visual impact, land use change, etc.) [4]. Potential social adverse effects can counteract the benefits of energy production without using fossil fuels, and an optimal balance between pros and cons must be found .In particular, acceptability of wind energy project is influenced by many factors, such as the specific characteristics of the project (number of wind turbines, hub height, rotor diameter, etc.), previous experiences with other wind energy projects, perceived environmental impact, people information, etc. Cranmer et al. [5] demonstrated that virtual reality experience with a wind turbine affects expectations and perceptions of wind energy project. Concerns about the environmental impact of wind turbines mainly involve noise, shadow flickers and visual impact. Previous experience greatly influences the people choices. This is studied, for example, by query theory, which assumes that people evaluate their choice options based on the evidence that they have gained through past experience. Other studies indicate that residents who have financial benefits from a local wind project may be less likely annoyed by wind turbine noise than other people [1].

To be effective, a project must be accepted by the population. If this does not happen, the population becomes the first obstacle to the success of the project. Therefore, it is important to create a method that evaluates the social acceptability of a project, also taking into account the environmental and economic aspects. As well known, the most widely used methodology to evaluate the environmental impact of a renewable energy project is Life Cycle Assessment (LCA). The LCA methodology is based on the ISO 14040 guidelines (a, b) and allows to assess the environmental impact (use of energy and materials, as well as the polluting emissions) of a product or a process throughout its overall life cycle, from raw material extraction to production, use and final disposal.

Literature report different methodologies to consider social aspects and to select specific indicators to be used in the initial assessment phase of a project. For example, the social LCA (S-LCA) follows the four phases of a conventional LCA study (definition of the objectives of the study, life cycle inventory, assessment impact and interpretation) but uses a different way to measure the impacts. In S-LCA, the characterization factors are defined in a more qualitative manner and the impact indicators should be established together with the stakeholders, such employees, the local community, consumers and all the players in the value chain. Carmo et al. [6] highlight that to measure social performance, it is necessary to consider the indicators related to each stakeholder.

Martinez and Komendantova [7] proposed to use the Social Impact Assessment (SIA) method to analyze the socio-cultural effects of a project . SIA design and practice comprises many different approaches, methodologies, and levels of actor involvement (e.g., top-down vs. bottom-up approach). Thus SIA highlights critical aspects related to the social opposition to renewable energy projects, such as whether and how the perspective of local communities is incorporated into projects' decision-making processes, planning, and operations and thereby their future influence on social impacts and interactions [7][8].

A comprehensive approach aimed to integrate the environmental, energy, economic and sociological aspects of renewable energy proposals is not deeply discussed in literature. Therefore, with the aim to fill this gap, a new method based on the evaluation of several environmental, social and economic indicators has been proposed in this paper. This Mixed Environmental, Economic and Social (MEES) method can be used during the participation process of new project with local communities. As case study, a new 66 MW wind power plant under development in the countryside of Sardinia has been considered.

2. MEES methodology

The proposed MEES methodology combines the conventional environmental and economic approach applied to renewable energy projects with a sociological approach. The method is based on the selection of a set of environmental, economic and social indicators and on the analysis of mutual relationships [9].

As known, the life cycle of a project includes 5 main phases: Initiating Processes, Planning Processes, Executing Processes, Controlling Processes and Closing Processes [10-11]. The proposed method applies during the first and second phases (Initiating Processes and Planning Processes) of the project. The general scheme of the proposed MEES method is shown by Figure 1.

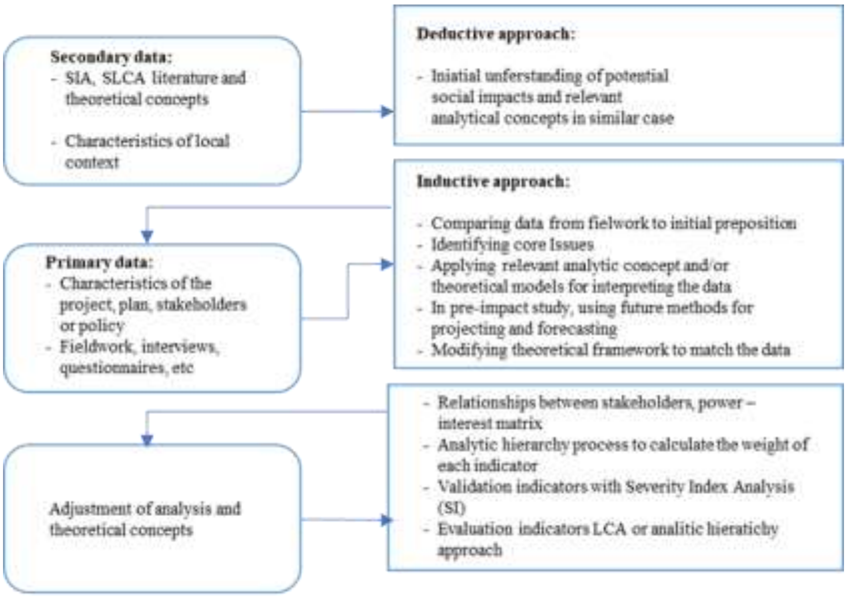


Figure 1. General scheme of the proposed Mixed Environmental, Economic and Social method.

The inductive approach shown in Figure 1 includes:

- *Analysis of the project context*. Geographical specificities, project technical characteristics and stakeholders (primary data) are identified.

- *Analysis of stakeholders relationships*. Stakeholders relationships and their role in the project are detected.

- *Selection of indicators*. Secondary data, as documents and statistics produced by governments, authorities, or companies are of great importance to evaluate the issues related to local services, infrastructure, housing, economy and for determining the key characteristics of the local community. In addition, literature on the social impacts of similar projects can be used in predicting the expected impact scenarios for the project [10]. For each indicator, the weight for each stakeholder can be assigned and results are grouped in a matrix stakeholder indicator.

- *Analysis of indicators*. Using the Severity Index statistical method the indicators are classified according to their relative importance [12]:

$$Severity\ Index\ (SI) = \frac{\left(\sum_{i=1}^{5} \omega_i * \frac{f_i}{n} * 100\right)}{a * 100} \quad (1)$$

where i is the index of the 5 possible answers here considered (1: Least important, 2: fairly important, 3: Important, 4: Very important, 5: Extremely important), ω_i is the weight for each answer, f_i is the frequency of the answers; n is the total number of respondents and α is the highest weight (here a = 5).

Key Performance social Indexes (KPsI) are obtained by project evaluation

- *Classification of indicators*. The KPIs are grouped into 4 categories: economic impact, security guarantee, social resources and public participation. Environmental indicators are evaluated with LCA analysis while social indicators are determined with hieratic methodologies. Last indicators may compared with the technical regulations or present on sociological field literature common values [13].

3. Case study

As case study, the proposal of a new wind farm currently under evaluation in Sardinia has been considered. The wind farm is a private initiative, with capitals of Energy plus S.r.L. The project includes 11 wind turbines, has a rated power of 66 MW, 155.5 GWh/y of estimated net energy production, and 26.9% capacity factor. The energy production of the wind farm will avoid the emission of 74,000 tons of CO_2 every year.

The wind turbines will be installed in private agricultural areas and local farmers will receive a land rental rate. Artichoke is the most widespread cultivation of the area and it is exported all over the world.

3.1. Analysis *of the project*

The selected wind turbines are Vestas V162, with a rated power output of 6 MW. This turbine has a rotor diameter of 162 m and an hub height of 125 m. The blades are made of epoxy resin reinforced with glass fiber . The nacelle hosts the electric generator, the gearbox and the hydraulic and electrical command and control equipment and is mainly made by fiberglass and metal. The tower is a truncated conical steel.

The site is a flat area. The required area is about 35.000 square meters. Spacing of wind turbines is about 900 m. The plant layout has been defined according to the orography of the area and to the existing road network. The considerable power output of wind turbines allows to install few units and reduce land occupation.

Wind turbines noise at a distance of 500 m is expected to be less than 30 dBA, very similar to the background noise of the two nearest towns (1.2 km and 1.3 km away). Moreover, the high spacing between turbines reduces noise and shadow-flickering effects. Rotating blades that interrupt the sunlight shadow generates flicker. The shadow flicker area is determined by distance to the turbine, geographic location, time of the day, season, weather patterns, turbine height and rotor diameter. The electromagnetic emissions are limited by the use of underground and helicorded power lines. Electromagnetic fields can be detected only in the area near the cabin.

3.2. Stakeholders

The knowledge process starts from the identification of the stakeholders. The stakeholder roles are: Provider, Investor, Purchaser, Influencer (Figure 2). The diagram shows the external and internal relationships between providers, investors, purchasers and influencers. The complexity of iterations between the stakeholders depends on different factors: capital inflow, space perception, culture level, role and activity in the community.

Stakeholder interest and power towards the project are defined according to a high/ low qualitative scale and can be reported on a matrix, according to the following classification: stakeholder marginal, stakeholder operational, stakeholder institutional, key stakeholder. The Energy Plus stakeholders project are identified as

A.Energy plus Srl - Investor, **B**.Project Team - Provider, **C**. University - Provider, **D**. Energy buyers – Purchaser, **E.** Regional Administration- Influencer, **F**. Local administrations - Influencer**, G**. Landowners - Investor, **H**. Farmer association -- Influencer / Purchaser**, I.** Farmers - Influencer / Purchaser, **L**. Local community - Influencer, **M.** Environmental associations - Influencer

Figure 3 shows the stakeholder power – interest matrix represented in a high-low scale. According to the combination of the scores, 4 types of stakeholder are defined: Institutional, Marginal, Operational and Key.

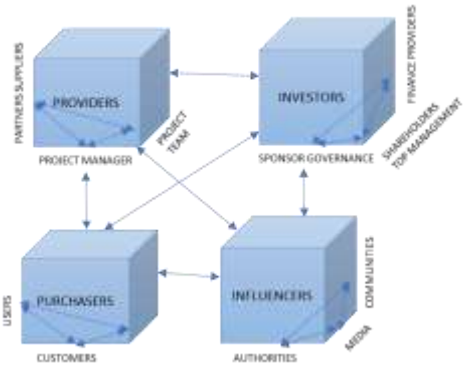


Figure 2. Stakeholders relationship

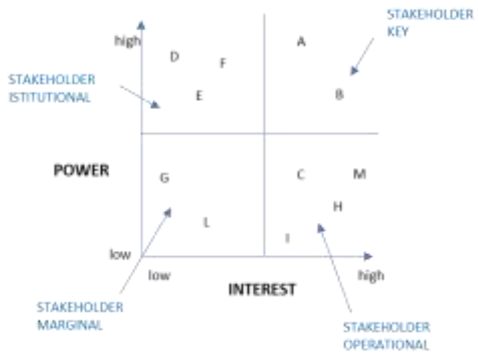


Figure 3. Power / Interest stakeholders matrix.

During the project presentation meetings with the different stakeholders (administration, local communities, farmers, etc.) the different opinions were collected through individual interviews. Once all the indicators have been identified, they are inserted into a matrix that collects the weights that each stakeholder attributes to each indicator. The methods commonly used to determine indicator weights can be divided into objective methods and subjective methods. In this study an analytic hierarchy process is used to calculate the weight of each indicator (Table 1).

Table 1. Analytic hieratic matrix method weight stakeholders – indicators.

		LAND USE	VISUAL IMPACT	GWP	NOISE	AGRICULTURAL AND LAND OCCUPATION	PROFITABILITY	RENEWABLE ENERGY TO COMMUNITY	PRODUCTION RENEWABLE ENERGY	SHADOW FLICKERS	LOCAL EMPLOYMENTS	ENGAGEMENT WITH COMMUNITY	SUSTAINABLE OR ECO-FRIENDLY PRODUCT	USE NON RENEWABLE ENERGY	CLIMATE CHANGE	HUMAN RESOURCES AND RIGHT	STAKEHOLDER COLLABORATION	OCCUPATIONAL HEALTH AND SAFETY	WASTE	INCREASE OF CUSTOMERS
A	Energy plus srl	2	2	4	3	1	5	5	5	2	3	4	5	1	3	2	3	2	5	5
B	Project Team	3	2	4	3	1	4	5	5	3	1	3	5	1	3	2	5	2	5	3
C	University	4	5	5	4	1	3	3	5	5	4	4	5	1	5	4	5	3	5	2
D	Energy buyers	1	2	5	2	1	5	1	5	4	4	2	4	2	4	2	1	1	5	1
E	Regional Administraion	3	3	5	2	1	4	5	5	5	5	5	5	1	4	4	5	4	5	2
F	Local administrations	4	3	3	3	4	4	5	5	4	4	4	3	1	3	4	5	3	3	3
G	Landowners	5	3	2	2	4	5	1	2	4	2	2	4	2	3	4	2	2	5	2
H	Farmer association	4	2	4	3	1	3	5	2	5	4	3	5	2	3	4	5	3	5	2
I	Farmers	4	4	4	3	1	2	4	2	3	5	4	5	2	5	4	5	5	5	2
L	Local community	5	5	5	5	1	4	5	5	5	5	5	5	1	5	5	5	5	5	4
M	Environmental associations	4		4	2	1	0	2	4	3	3	3	4	5	5	4	3	4	4	3

According to the analytic hierarchy method, the weight considered for the stakeholder attribution matrix are : <1> Equally important, <2> Slightly important, <3> More Important, <4>Obviously important, <5> Absolutely important.

3.3. Key Performance Indexes (KPIs)

For the caste study under evaluation, the following Key Performance Indexes are considered.

3.3.1. Noise. The World Health Organization's (WHO) recommends limiting noise exposure to a nightly annual average of 40 dB outside of living rooms, in order to achieve quality sleep. *Usually,* wind farms generate noise averaging around 40 dB threshold at distances of hundreds of meters. Noise measurements in Italy are conducted with the CEI-EN 61400-1 standard. The design value of the wind farm under evaluation is 30 dB.

3.3.2. Shadow flickers. *Several* studies evaluate the impact of flickering, and all confirm that flickering shadows do not pose a health hazard to humans. At the same time, the phenomenon often creates considerable nuisance for residents. Therefore, the maximal hours of flickers per year in the worst case scenario has been calculated. The maximal value of flicker hours per year was multiplied by the shadow flickers risk area. From literature data it can be deduced that for similar wind turbines the shadow flicker percentage is equal to **12%** of the total shading area of the single turbine.

3.3.3. Visual impact. Wind farms produce a dominant visual impact as the turbines can be viewed tens of kilometers away. The nature of this impact is subjective: for some people, a wind turbine represents innovation and sustainability, while for others it reflects the damage to the existing natural landscape. Several studies suggest that unwanted exposure to wind turbines is associated with adverse psychological and physiological effects on residents. The contrasting nature of this impact highlights the importance to quantify the factors that increase the visibility of turbines and to involve the community in the planning process. There are different approaches to quantifying the visual impact factors of wind farms. Here the visual impact has been evaluated through public questionnaires and visual illustrations. The value assigned represents the perception of local community towards the wind farm.The average of the data obtained from the interviews and the literature shows that the perception of damage is equal to 35% in non-precious areas.

3.3.4. Profitability. The profit of the wind farm is determined by adding to the initial investment (I) the discounted cash flows (FCk), calculated for each year k of the useful life of the plant as the difference between the annual revenues (Rk) and the annual management costs(Ck). This allows to calculate the Net Present value (NPV) and the Pay Back Time (PBT). **45 €/MWh** is the global cost assumed by IRENA (2022) [14].

3.3.5. Environmental indicators. The energy and environmental performance analysis of the wind farm was carried out using the life cycle assessment (LCA) methodology. The LCA methodology is based on the ISO 14040 and 14044 guidelines and allows to assess the environmental impact (use of energy and materials, as well as the polluting emissions) of a product throughout its overall life cycle, from raw material extraction, to production, use and final disposal [15,16]. The definition of the goal and scope, the system boundaries and the assumptions of the study are described below. In particular, the analysis aims to evaluate the environmental impact associated with the construction and operation of the wind farm. The system is designed to produce electricity and therefore the functional unit chosen for the LCA study is 1 kWh of electrical energy produced by the wind farm. The attributional life cycle analysis was developed using SimaPro 9.11.7, software and data from literature and from the Ecoinvent 3.7 database. Figure 4 shows the system boundaries. The wind farm comprises 11 wind turbines, each consisting of a tower, a rotor, a nacelle and a foundation, wires, electric panels and transformers. In order to evaluate the environmental impact of the system, the material and energy flows related to the entire life cycle of all the components were defined. The life cycle starts from the extraction of raw materials and ends with the disposal of the components. Materials recycling was assumed for the most common metals, such as steel, aluminium, and copper. In addition, the impact of the transport phase of the wind turbines was taken into account. The wind farm is modelled according to the data published by Vestas [17,18] and by A. Schreiber et al. [19]. The inventory also takes into account direct land occupation according to the data provided by the designers. Recycling of metallic materials has been modelled according to the "avoided impact" approach, that is, one kilogram of recycled material allows for replacing a defined amount of equivalent new material. The steel waste replaces a similar amount of cast iron, the aluminium waste is melted to produce a similar amount of secondary aluminium. The Copper waste is refined ("fire refining" and "electrolytic refining") to remove impurities according to C. Jingjing et al. [20]. The impact evaluation was carried out using the Impact 2002+ method with an intermediate subdivision (midpoint) in 15 impact categories, which are summarized in 4 damage indicators: Human health (carcinogens, non-carcinogens, respiratory organics, respiratory inorganics, ionizing radiation, ozone layer depletion), Ecosystem quality (aquatic ecotoxicity, terrestrial ecotoxicity, terrestrial acidification/eutrophication, aquatic acidification, aquatic eutrophication, land occupation), Climate change (global warming), Resources (non-renewable energy, mineral extraction). The indicator relating renewable energy production is represented by the Cumulative Energy Demand (CED). The cumulative energy analysis aims to investigate the use of energy throughout the life cycle of a good or a service. The CED method is divided into eight categories for the ecoinvent database and no aggregate value. The value is determined by the amount of energy taken from nature. and expressed in MJ-equivalents. Here Renewable energy indicator is only looked.

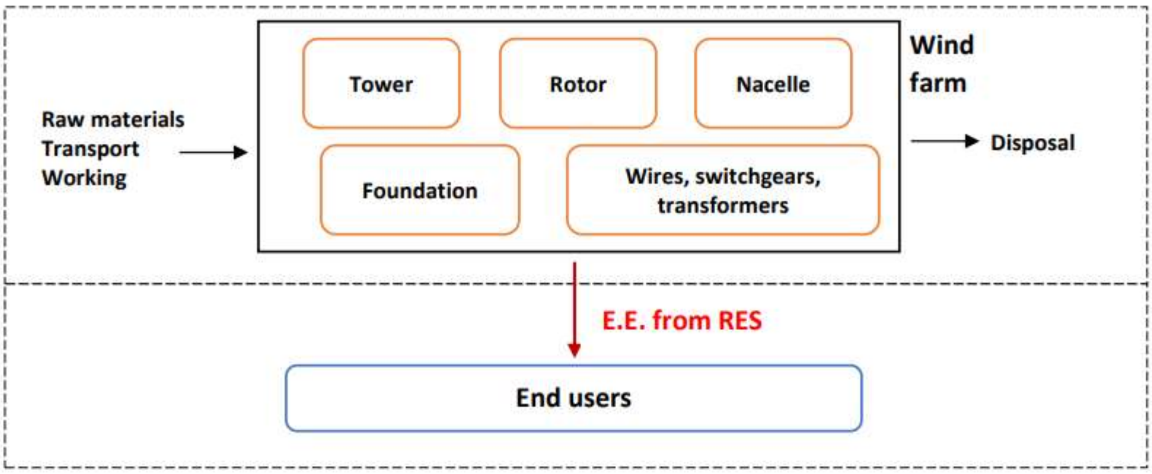


Figure 4. System boundaries.

3.4. Key Performance Indexes analysis

The indicators previously identified are analysed by using the Severity Index analysis method. Figure 5 shows the Severity Index Analysis results.

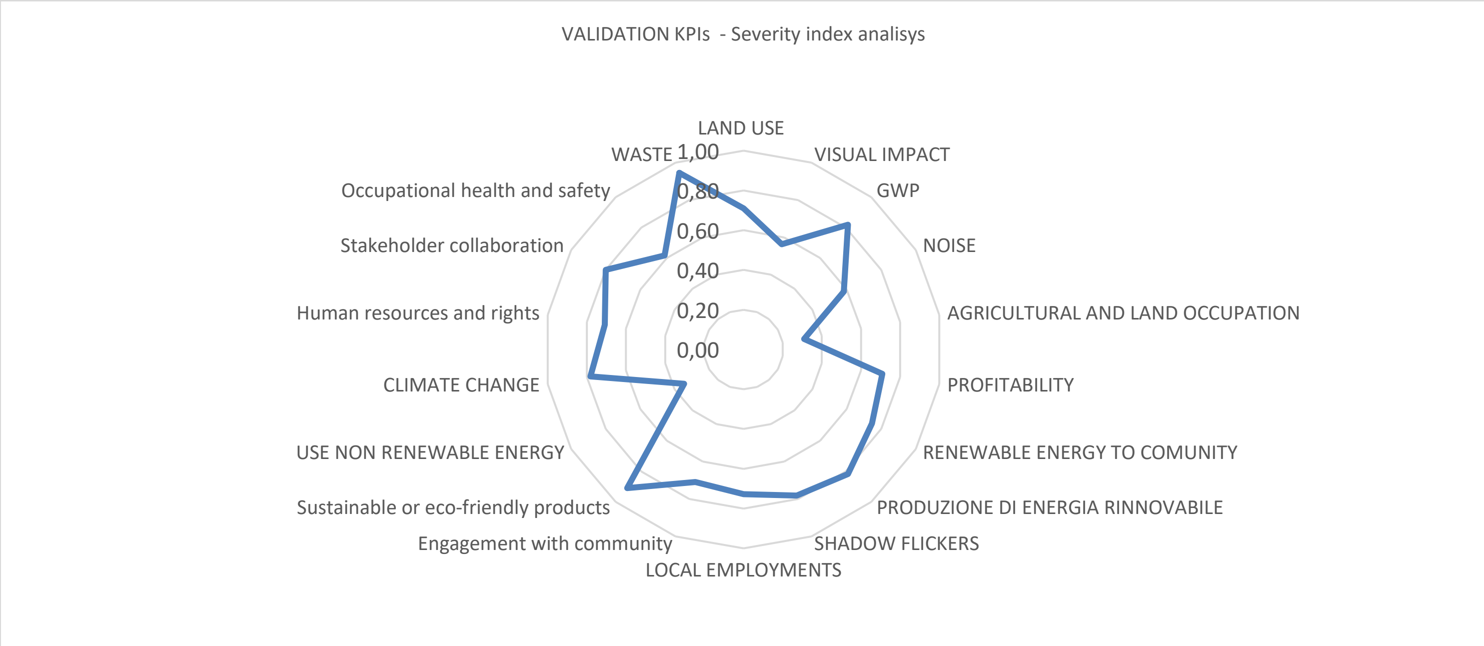


Figure 5. Severity Index Analysis results.

Therefore, the indicators that get a higher score on SI are: Human health, Noise, Climate Change, Ecosystem Quality Shadow Flichers, Visual Impact, Profitability, Resource, Renewable energy and Resource. Subsequently, according to the proposed MEES method, KPI are classified into the 4 categories: Human life, Safety Guarantee, Social Resources and Public Participation (Figure 6).

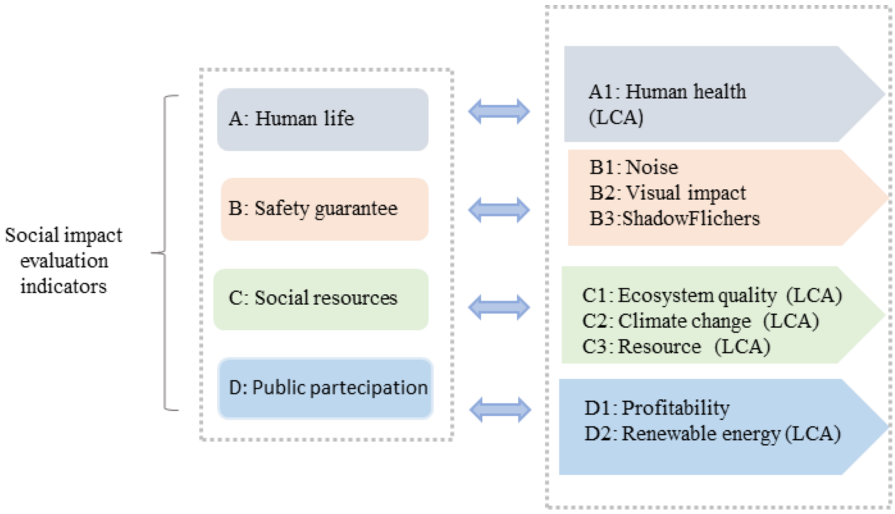
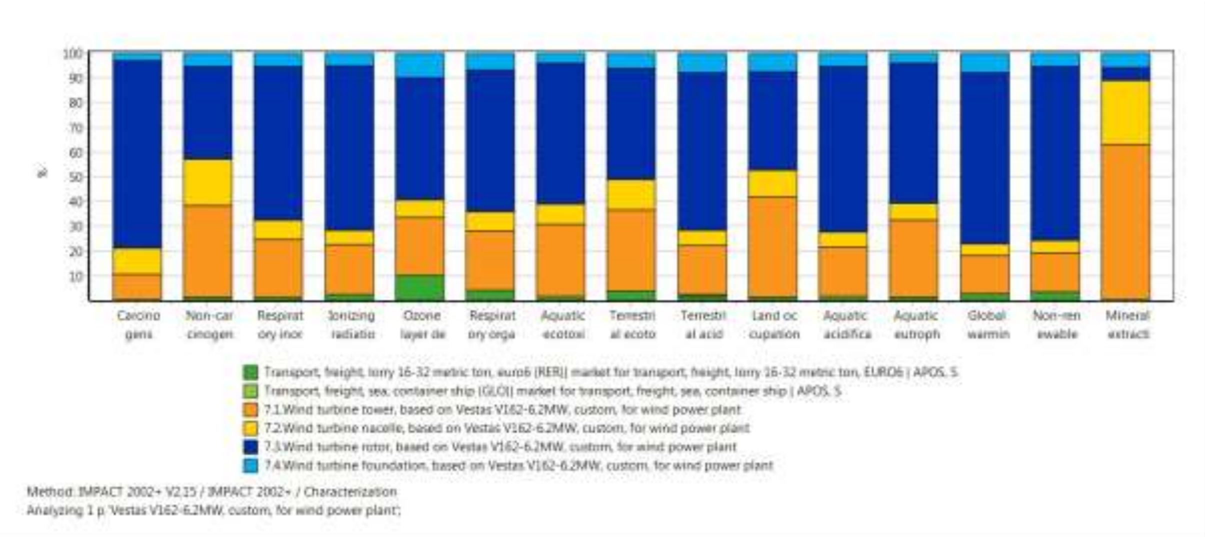


Figure 6. Classification of KPI.

4. Results

Figure 7 shows the results of the LCIA analysis of the wind turbine Vestas V162 by using the Impact 2000+ method.



Impact category	Unit	Total	Transport, freight, lorry 16-32 metric ton, euro6 {RER}| market for transport, freight, lorry 16-32 metric ton, EURO6 | APOS, S	Transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | APOS, S	7.1.Wind turbine tower, based on Vestas V162-6.2MW, custom, for wind power plant	7.2.Wind turbine nacelle, based on Vestas V162-6.2MW, custom, for wind power plant	7.3.Wind turbine rotor, based on Vestas V162-6.2MW, custom, for wind power plant	7.4.Wind turbine foundation, based on Vestas V162-6.2MW, custom, for wind power plant
Carcinogens	kg C2H3Cl eq	0,001418368	4,66287E-06	1,81713E-07	0,00014651	0,000150732	0,001073514	4,27679E-05
Non-carcinogens	kg C2H3Cl eq	0,001236186	1,72774E-05	2,36666E-07	0,000456977	0,000231252	0,000464037	6,64063E-05
Respiratory inorganics	kg PM2.5 eq	4,26699E-05	5,00004E-07	1,11164E-07	9,91117E-06	3,39861E-06	2,63394E-05	2,40953E-06
Ionizing radiation	Bq C-14 eq	0,249654432	0,006219586	0,000153732	0,049894589	0,014919611	0,165506323	0,01296059
Ozone layer depletion	kg CFC-11 eq	1,44839E-09	1,43068E-10	4,20019E-12	3,41128E-10	1,00511E-10	7,13251E-10	1,46237E-10
Respiratory organics	kg C2H4 eq	9,42097E-06	3,75175E-07	2,16824E-08	2,24448E-06	7,48193E-07	5,38614E-06	6,45297E-07
Aquatic ecotoxicity	kg TEG water	5,562331013	0,085715986	0,001199257	1,633691032	0,450688979	3,171339991	0,219695767
Terrestrial ecotoxicity	kg TEG soil	1,650903337	0,063601914	0,000400012	0,539252382	0,203980854	0,741777414	0,101890762
Terrestrial acid/nutri	kg SO2 eq	0,000481593	7,47392E-06	3,35758E-06	9,65859E-05	2,96951E-05	0,000306081	3,83995E-05
Land occupation	m2org.arable	0,006664323	9,10756E-05	5,54096E-07	0,002703371	0,000721339	0,00263706	0,000510923
Aquatic acidification	kg SO2 eq	0,000149178	1,90618E-06	7,28382E-07	2,93711E-05	9,1317E-06	9,98545E-05	8,18609E-06
Aquatic eutrophication	kg PO4 P-lim	5,16821E-06	7,22195E-08	1,92606E-09	1,61184E-06	3,47379E-07	2,929E-06	2,05844E-07
Global warming	kg CO2 eq	0,028229123	0,000771225	2,59697E-05	0,004359109	0,001351725	0,019479609	0,002241485
Non-renewable energy	MJ primary	0,371458853	0,012592477	0,000356756	0,058535976	0,019263275	0,260869891	0,019840478
Mineral extraction	MJ surplus	0,004677309	8,94229E-06	2,50081E-07	0,002936705	0,001213508	0,000243066	0,000274838

Figure 7. Results of the LCIA.

The results of the characterization phase demonstrate that the greatest impact is given by the tower and the rotor. The environmental damage caused by the transport of the blades only affects some indicators such as Ozone layer depletion, and Respiratory Organics. The greatest impact of the tower is related to the amount and the type of used materials. Respiratory inorganics, global warming and non renewable energy indicators are the most important impact categories. Figure 8 shows weight on single turbine Impact 2000+ indicators.

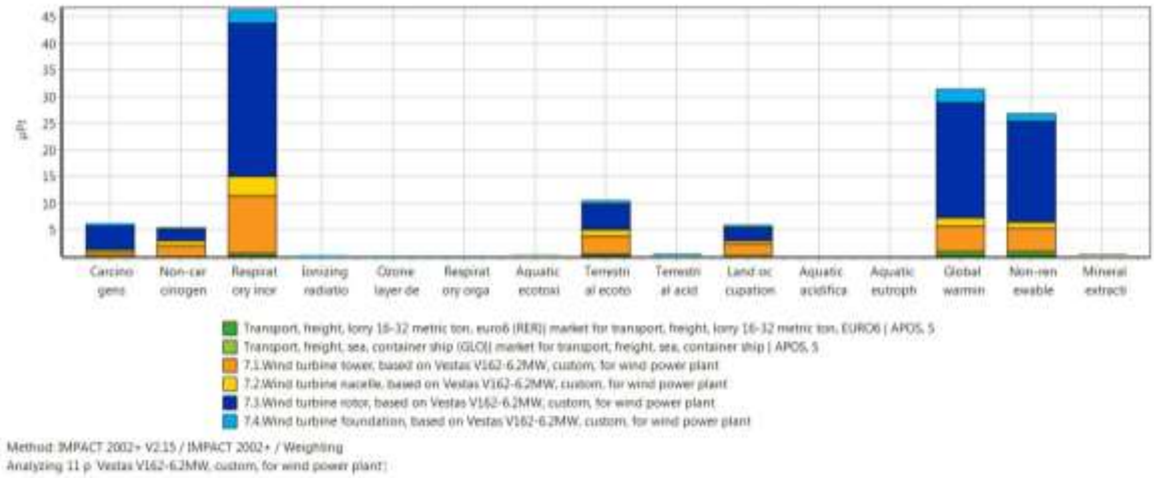


Figure 8 – Weigh damage Vestas V162 impact categories.

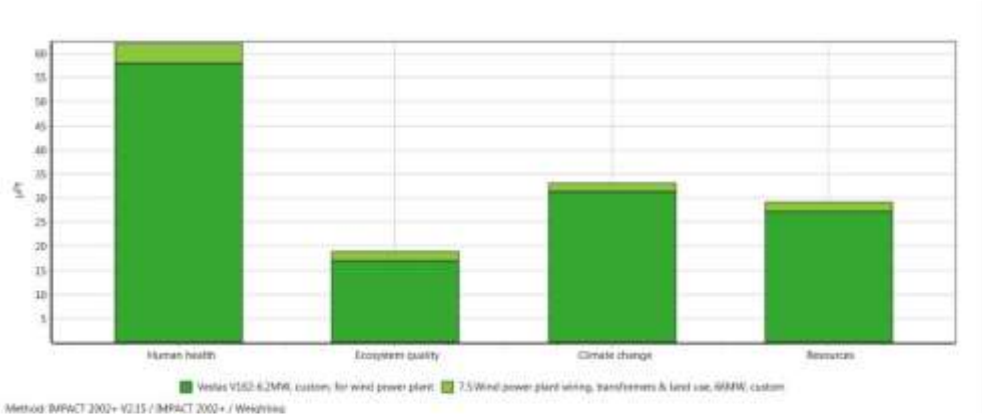


Figure 9 . Wind farm LCA results.

Figure 9 shows the LCIA results for the entire wind farm. The amount of soil occupied is introduced in the analysis. On other hand, quantity of foundations land required, connecting roads, cable ducts and electric equipment are include in the to soil waterproofing occupied.
The most important damage category is Human health with a value of 62.07 mPT, followed by Climate change with 33.04 mPt, Resources with 29.12 mPt and Ecosystem quality with 18.91 mPT. In the four damage categories, the used soil percentage of damage is approximately 6%.

5. Sensitivity analysis

In conclusion, a sensitivity analysis is carried out in which the impacts produced for the production of 1 kWh of electricity from high and medium voltage grid energy and from the previous wind farm are compared. The analysis is carried out by applying the LCA analysis to the three types of energy with the Impact 2002+ method. The energy mix constituting high and medium voltage energy is the one present in the processes of the ecoinvent 3 - consequential system database. The analysis, shown in Figure 11, shows that the energy produced by wind turbines has a minor impact in the Climate change and resource categories.

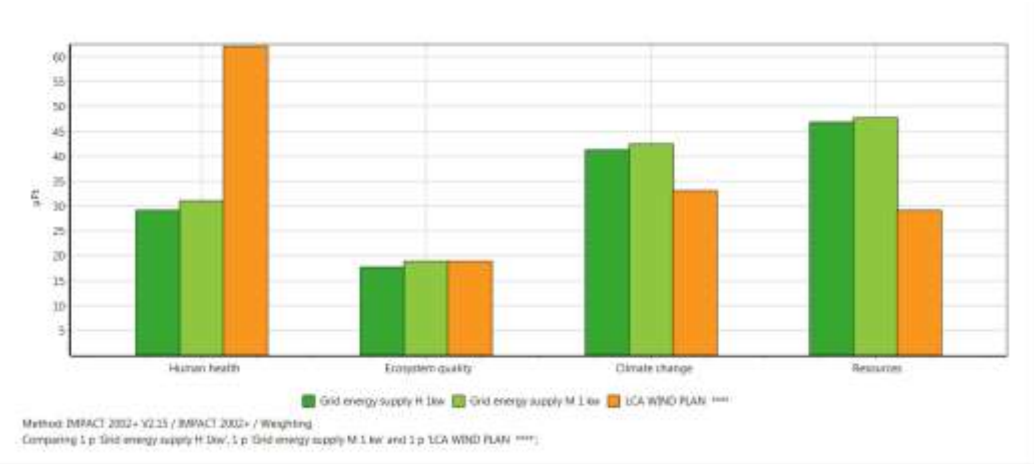


Figure 10 . Wind farm LCA results.

Specifically, as shown in Figure 10-11, the score for the production of electricity from wind turbines has a value of 33.04 against the values of 41.39 and 42.48 for grid energy. Also for the Resources damage category, the value of 29.13 for wind energy is lower than the values of 46.84 and 47.72 for grid energy. The energy distributed in medium voltage has more impact than that distributed in high voltage because the values of the individual indicators Land occupation, Global warmin and Non-renewable energy are higher.

Damage category	Unit	Grid energy supply H 1kw	Grid energy supply M 1 kw	LCA WIND PLAN ****
Total	µPt	134,91	140,08	143,17
Human health	µPt	29,10	31,01	62,08
Ecosystem quality	µPt	17,68	18,86	18,92
Climate change	µPt	41,30	42,48	33,04
Resources	µPt	46,84	47,72	29,13

Figure 11 . Sensitivity analysis weight

6. Discussion

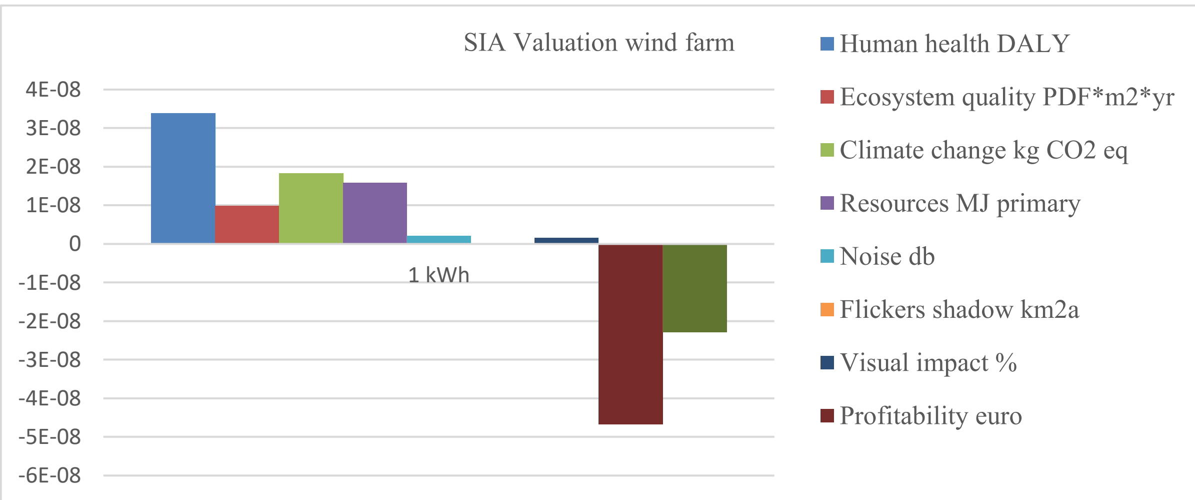


Figure 12 Damage impact 1 kWh energy product

Figure 12 shows the impact damage of 1 kwh of electricity produced by the wind farm. The indicators are weighted by the SimaPro software and related to each other. The indicators with negative values are Profitability and renewable energy, that represent the income obtained from the production of electricity with renewable energy. The indicators obtained from the interaction with the local community however have a noticeable impact.

7. Conclusion

The proposed MEES method allows to identify and include the environmental, economic and social indicators perceived by the local community with respect to the proposal of new renewable energy projects. The novelty of the study refers to the inclusion of different methodologies (LCA, SIA, hieratic analysis) into an overall framework. Using the environmental damage methodology, the indicators were measured and divided into positive and negative ones. The results show which are the indicators perceived by the local community that have the greatest impact in the implementation of the project. For the test case here considered the most important indicators are noise, visual impact, production of renewable energy and profitability. Moreover, looking at the results, human health has a greater negative impact than climate change. Furthermore, noise, visual impact and flickering of shadows are other important issues but their impact is very marginal compared to the achievable benefits indicated by profitability and renewable energy products with the installation of the wind power plant. It can be concluded that the local community accepts new plants if they are a source of economic income and energy availability, and if other impacts are in any case lower than those generated by the supply of energy from the grid. Future research will focus on the influence of these indicators in the operating and decommissioning phases of the wind farm.

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