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Big Data Analysis for Optimising the Decision-Making Process in Sustainable Energy Action Plans: A Multi-Criteria Evaluation Approach Applied to Sicilian Regional Recovery and Resilience Plans

Umberto Di Matteo [1,*] and Sofia Agostinelli [2]

[1] Department of Engineering Sciences, Università degli Studi Guglielmo Marconi, 00193 Rome, Italy
[2] CITERA Research Centre, Sapienza University of Rome, 00196 Rome, Italy
* Correspondence: u.dimatteo@unimarconi.it

Abstract: Keeping the global temperature rise below 2 degrees Celsius, as foreseen by the Paris Agreement, requires a new global roadmap for the energy transition. For this reason, the European Commission decided to directly involve local municipalities in reaching these objectives through multilevel, bottom-up actions for sustainable energy. The Covenant of Mayors is a very concrete demonstration of this trend of development and adoption of sustainable energy action plans (SEAP), rethinking the way cities operate and bringing them closer to energy self-sufficiency, with measures favouring local economic development and improving citizens' quality of life. The numerous RES/RUE actions included in SEAPs at the regional level have led both to the request for huge funding and to increased complexity for regional managers to identify the best projects to be financed. To manage the multitude of data (emissions, energy consumption, cost, etc.) present in the SEAPs at a regional level, a web-based platform called Lex-energetica was developed. In this context, this paper aims to present a participatory supportive framework for the decision-making process involved in financing the SEAPs' actions, considering the selection of sustainable Renewable Energy Sources (RES) and Rational Use of Energy (RUE) technologies. This study proposes a methodology based on two macro-phases: the first phase consists of a ranking evaluation of categories of areas of intervention based on the analytic hierarchy process, while the second identifies nine criteria, according to the domains corresponding to the three pillars of sustainability, to compare the most appropriate RES/RUE actions.

Keywords: energy planning; multi-criteria analysis; multi-level actions; sustainable energy action plan; renewable energy

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1. Introduction

The ongoing negotiations on climate within the United Nations Framework Convention on Climate Change (UNFCCC) have highlighted that to keep the global temperature increase to well below 2 °C, an extraordinary effort by all states is needed to review their NDCs (Nationally Determined Contributions). This extraordinary effort must be concretised in ambitious political plans by the various states, mainly focused on mitigation policies that decrease the concentration of greenhouse gases in the atmosphere [1]. Investing in sustainable energy systems allows the reduction of burdens on the environment and consequently provides an effective instrument for fighting climate change. To address the current energy challenges, a clear energy policy must be developed at all levels. Municipal policies have frequently been ignored due to the greater emphasis given at the centralised level [2].

However, to achieve the goal of containing the temperature growth, an improvement in the commitments by governments is not enough. The active involvement of the so-called "non-governmental actors" is also essential, including regions, cities, companies, and organisations of the civil society.

The EU has played a leading role at a global level in contrasting climate change since 1990, especially in 2008 with the launch of the largest movement named "Covenant of Mayors" for local climate and energy actions. This movement aims to engage and support mayors to reach the EU climate and energy targets.

The Covenant of Mayors initiative is focused on the adoption of the Sustainable Energy Action Plan (SEAP). This initiative has grown over the years and today brings together over 10,000 local and regional authorities, involving over 300 million citizens in 61 countries. In 2014, the EU launched Mayors Adapt, another initiative based on the same principles as the Covenant of Mayors but focused on adapting to climate change. With the Mayors Adapt, local governments have been invited to demonstrate leadership in adapting their territory to climate change, supporting them in developing and implementing local adaptation strategies.

In 2015, the two initiatives—Covenant of Mayors and the Mayors Adapt—were officially joined together, creating the new "Covenant of Mayors for Climate & Energy (SECAP)". This represents the largest movement of local governments to actively support the implementation of the EU objective of reducing greenhouse gas emissions. The local authorities now pledge to support the adoption of an integrated approach to mitigate and adapt to climate change and to guarantee all safe access to sustainable energy.

Over the years, Italy has introduced several initiatives aimed at systematising the commitment of cities to reduce climate-altering emissions [3]. The Sicily region, for instance, has financed two initiatives to raise awareness among local authorities of the Covenant of Mayors and the drafting of SEAPs since 2014. To date, 364 Sicilian municipalities have joined the Covenant of Mayors, equal to 93.3% of the total, but only 271 (74.2%) have completed the approval process with the Covenant of Mayors. This figure indicates a success for the Sicilian region, which is second only to the Andalucía Region among the coordinators of the pact, representing an example of excellence in Europe.

From the analyses conducted on the SEAPs of the province of Messina, a large volume of structured and unstructured data emerges [4,5]. This data includes consumption and type of energy sources, specific and total CO_2 emissions, predictive scenarios, categories of intervention, descriptions of numerous energy savings actions and RES (Renewable Energy Sources) plant projects, and technical and economic parameters of the reduction actions. Another emerging fact is that most of the projects planned by local authorities to reduce CO_2 emissions are without financial coverage, in correspondence with the item "Financing" on each Action sheet, the desire to acquire financial resources from the State or the European Commission is often declared, or alternatively to resort to financing through third parties or to contracts with the E.S.C.O. (Energy Service Companies). In this context, national or regional authorities must identify on the one hand which categories of action envisaged by the Covenant of Mayors to prefer, and on the other hand, select—for each category of action—the best projects presented in the SEAPs, to achieve the planned long-term CO_2 reduction objectives; this a typical decision-making problem.

Furthermore, the COVID-19 pandemic has taken place, causing a serious shock to the European and world economy, with a strong impact on the global energy system and CO_2 emissions. We are at a turning point, in which it is necessary to drive the recovery by directing investments in the medium term towards the decarbonisation of the production system. This crisis must therefore constitute a challenge for the economy of European countries and to improve the living conditions of citizens. it is extremely important not to undermine the efforts made to date toward sustainable development, but rather to take the great opportunity offered by the Next-Generation-EU plan (also known in Italy as the Recovery fund) to strengthen the energy transition required by the EU.

To benefit from the Recovery and Resilience Facility, national or regional authorities should select and invest in projects in line with the green transition [3]. With the implementation of SEAPs sustainable projects, local authorities will increase local job creation and will grow their economic potential and social resilience.

This paper aims to present a two-macro-phase methodology—based on transparent multicriteria decision support—in order to support both regional authorities for the allocation of resources in the various action fields envisaged for CO_2 emission reduction and to help regional managers to identify the best technological projects to be financed. The developed methodology incorporates two levels: (i) at the first level, it has developed the decision-making criteria weights to rank the several categories of actions for CO_2 emission reduction; (ii) at the second level, multicriteria decision support is developed, to evaluate the ranking of CO_2 reduction local eligible technological projects. Particularly, the target sectors of this study are public transport and urban mobility, public and private buildings, industrial equipment, and facilities. The rest of the paper is structured as follows: the next section provides a literature review concerning the analysis of the most used and reliable planning approaches. Section 3 presents an extensive description of the methodological approach used, while in the next section, the results of the pilot assessment of the proposed methodological approach to a "real" case in the province of Messina (Italy) are presented and discussed.

2. Literature Review

As above mentioned, to achieve the targets called the 20-20-20 package, the European Commission launched the Covenant of Mayors to support the efforts of local authorities in the implementation of the strategy to fight climate change and energy efficiency [6]. Water and energy conservation, sustainable transportation, and low emission technology are among the main variables playing a key role in the transformation towards climate-resilient economic growth [7–9]. The successful development of a Sustainable Energy Action Plan (SEAP) by the local authorities [10] constitutes an important decision-making problem as well as one of the main challenges for the implementation of sustainable energy planning. Both academic and practitioner studies show that in this context the choice of the most convenient and appropriate method of analysis is crucial since the local managers have to identify the most suitable fields of actions and opportunities for implementing their long-term CO_2 reduction target before making their investment strategies [11,12]. In the renewable energy literature, multi-attribute decision-making (MADM) methods have been widely used for different purposes: (1) as evaluation of sustainable energy policies [13–16], (2) as a selection of the most sustainable energy source for electricity generation, (3) as evaluation of renewable energy sources, and (4) as identification of the best site for an energy facility among possible alternatives identified. These methods represent systematic procedures that define how the information on a single attribute is processed to support the decision of the best possible choice among the existing alternatives. MADM methods deal with the evaluation and selection of different alternatives under multiple criteria that may be conflicting with each other. The recent work of Ilbhar et al. (2019) [17] presents a review of about 150 studies implementing MADM methods in the domain of sustainable energy, providing details on the specific purposes of these methods that can be used and in the presence of which specific factors they can be preferred. Based on the given classification, the most common MADM methods in the literature are classified as (i) methods based on the pairwise comparison—e.g., Analytic Hierarchy Process (AHP) [18], Analytic Network Process (ANP), Decision Making Trial and Evaluation Laboratory Model (DE-MATEL); (ii) methods based on scoring—e.g., Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS); and (iii) methods based on outranking—e.g., ELimination Et Choix Traduisant la REalité (ELECTRE) and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE).

For instance, in the study of Dall'O et al. (2013) [19], a methodology is presented to support the municipalities for the preparation of SEAP. This study is based on a multi-criteria methodology in which the authors focused on the actions needed for the refurbishment of the existing building stock to improve their energy and environmental quality. A diagram is shown in which the actors involved are shown on the left-hand side, while on the right-hand side data from some different information sources are reported. The different steps of the proposed methodology can be divided into two macro-phases: in the first macro-phase, the energy data are acquired and processed for identifying mitigation actions, and multi-criteria analysis is applied in the second macro-phase. To apply this methodology, we need a working group of energy and environmental audit experts but also multi-criteria analysis experts. First, the requested data of existing urban scale buildings can be easily provided by the Municipality Technical Department through its archives or cadasters. Afterwards, a field survey must be organised to observe and define the thermo-physical characteristics of building stock. Once all the data requested by the methodology are acquired, the energy retrofit interventions that are feasible from a technical, legal, and economic point of view can be identified.

Another example of a multi-criteria approach is that described by Marinakis et al. (2017) [12]. This paper illustrates a participatory methodology to support local authorities in the implementation of sustainable energy planning. This methodology consists of two main levels: the first involves the development of RES and RUE action scenarios for local authorities and interventions for citizens. First, a design of alternative scenarios is carried out based on the development of RES/RUE actions in the different sectors of interest based on selected criteria. Through a participatory approach, feasible scenarios for the local community are filtered using an aspiration level. In the second level, direct and transparent multi-criteria decision support is introduced to evaluate the feasible scenarios. A multi-criteria ordinal regression methodology is implemented to estimate the best and worst possible scenarios.

In addition, Delponte et al. (2017) [20], analysing the case of a SEAP implemented in the Italian city of Genova, noted that to obtain operational monitoring of the SEAP and then favour an effective environmental energy policy at the local level, it is necessary to deepen the cost-benefit analysis of the interventions proposed in the plan, deepening their economic feasibility.

Furthermore, Howick et al. (2017) [21] proposed a risk identification and quantification procedure for the Northern Isles New Energy Solutions (NINES) project. The project foresees to monitor the effectiveness of the plan through interviews with workshop participants and project managers.

Cinelli et al. (2014) [22] presented the performance of five multi-criteria decision analysis (MCDA) methods (i.e., MAUT, AHP, PROMETHEE, ELECTRE, and DRSA). These methods have been chosen because they are suitable for following sustainability assessments that offer flexibility and the possibility of facilitating dialogue between stakeholders, analysts, and scientists. The performance of the methods was assessed based on ten main criteria that sustainability assessment tools should meet. The criteria taken into consideration are the following: ease of use, implementation of the life cycle, management of uncertainty, and computerisation.

Furthermore, the recent study by de Oliveira Neto et al. (2018) [23] proposed a framework of actions toward strong sustainability (SS), based both on the replacement of non-renewable natural resources with renewable ones and on the efficient use of resources, to preserve the environmental, economic, and social capital. The authors identified eight key actions, constituting their conceptual framework, which can be used in the multi-criterion analysis. The eight actions are: to increase the efficiency of resource consumption; limit the consumption of renewable resources according to their regeneration rates; reduce greenhouse gas emissions; reuse waste as input in other processes; replace toxic inputs with organic materials; replace non-renewable energy resources with renewable alternatives; increased convenience of basic items; and increase sustainable producibility.

Based on the literature reviewed in this section and the experiences of the authors [14], the present paper aims to empirically develop and assess a multi-attribute decision-making method suitable for the in-depth analysis of mitigation actions of several Sustainable Energy Action Plans. Such methodology is described in the following sections.

3. Material and Methods

To better support national and regional authorities in selecting the most appropriate and effective key actions of the SEAP for reducing CO_2, this study proposes an integrated approach that consists of a two-level decision support system process. The first one consists of the Analytical Hierarchy Process (AHP), which requires the identification of the weights for each categorisation of the SEAPs actions. The second one, based on multi-criteria decision analysis, requires the identification of utility functions and weights covering the three sustainability pillars, assembled in a unique synthesising ratio of scale preferences [24,25], with the additive and multiplicative aggregations model [26].

A flowchart of the integrated methodology adopted, combining both the AHP method and the MCDA process, is presented in Figure 1.

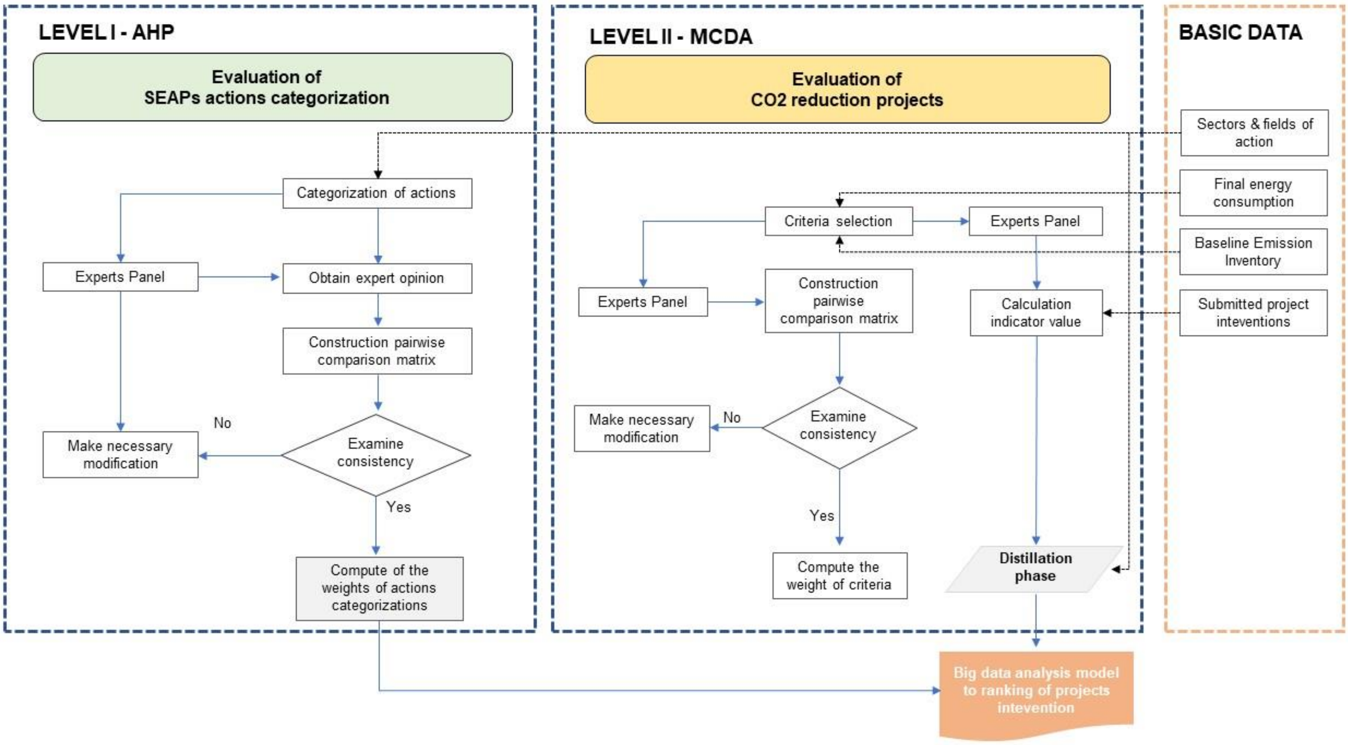

Figure 1. The logical framework of the proposed integrated methodology.

The proposed methodology represents an effective tool for dealing with complex decision-making circumstances and may aid the decision makers to set priorities and take the best decisions.

Sustainability assessments of SEAP projects require many types of information, parameters, and uncertainties. Thus, multi-criteria decision analysis (MCDA) represents a suitable method to perform sustainability evaluations as a result of its flexibility and the possibility of facilitating the dialogue between stakeholders, analysts, and experts. Given its nature, it perfectly suits the SEAP key actions aimed at improving the energetic and environmental quality of human activities occurring in the local authority territory. As shown in Figure 1, all the activities included in the methodology can ideally be split into two macro-phases, as described in the following paragraphs.

3.1. Level I—Ranking Evaluation of Categories of Areas of Intervention Based on Analytic Hierarchy Process

The process starts from the set of criteria concerning the categories of areas of intervention [27,28]. Through a hieratic process, a weight for each criterion is generated by the decision maker according to the pairwise comparisons of the criteria. Therefore, the authors required a working group including not only energy and environmental experts but also experts in the planning and development of the territory. The use of the AHP, developed by Saaty (2013) [29], is illustrated below.

The first step requires modelling the decision problem as a hierarchy and constructing a pairwise comparison matrix. Next, the pairwise comparisons of experts of the working group need to be obtained, thus determining the global score for each criterion. The priorities of each factor in terms of its contribution to the objective are calculated through eigenvalues and eigenvectors of each pairwise comparison matrix.

The final stage consists of calculating a Consistency Ratio (CR) to measure how consistent the judgments have been about samples of purely random judgments. The use of AHP allows for the calculation of the inconsistency index. This value is obtained from the ratio of the decision maker's inconsistency and randomly generated index. The value of CR allows the decision maker to assess that the judgments are consistent and that the final decision is well made. In case of results of a higher value of the inconsistency index, a new re-evaluation of pairwise comparisons of decision makers is required. Thus, with this type of approach, the results obtained are reliable.

Finally, the elements of the consolidated decision matrix (all participants/experts) are calculated as the weighted geometric mean of all individual workgroup participants. This part of the methodology allows for distribution, in a transparent and traceable way, of the sums allocated by the national/regional/local authorities on the different categories of areas intervention.

3.2. Level II—Sustainability Evaluations of SEAP's Projects

In the evaluation of projects, the "business as usual" approach considers only the economic aspects. In several cases, this strategy is the most cost-effective related to CO_2 reduction projects. However, better, and more comprehensive, approaches to financing these projects should rely on a complete sustainability assessment through a concrete and operational approach that defines and derives the building blocks of sustainability to make this concept operational.

To compare the different key actions proposed, a multiplicity of aspects must be considered: from economic and social issues to technological, environmental, and energy issues. This systematic approach is of greater complexity since it requires knowledge about all the different aspects as well as the consequences of the key actions. Yet, the final result will be more consistent with local policies to promote workers' interests. Thus, we developed a multi-criteria decision analysis (MCDA) model based on the environmental, economic, and social pillars. This methodology provides a ranking for all the SEAP's key actions proposed, including both the criteria and the preference system (weights) given by the expert panel. The proposed methodology is described in detail below.

Once it is established that the decision-making process is based on the three pillars of sustainability, we identify appropriate criteria for the decision process. The criteria selection must be consistent with the indicators proposed by the Covenant of Mayors (CoM). These indicators are 'structurally independent'—namely, the range of possible ratings of a criterion is independent of (i.e., not constrained by) ratings of other criteria (even if the criteria are correlated), and vice versa. Furthermore, these criteria must be relevant to decision-makers of regional authorities. To that end, for each sustainable alternative (environmental, economic, social), three indicators are defined, which form the final set of nine evaluation criteria that satisfy the following requirements: monotony; exhaustiveness; cohesiveness; and non-redundancy.

The third step involves scoring the SEAP's proposed actions on the selected criteria, that is, converting each action performed on each criterion into a numerical score. The scores are normalised so the lowest performance on the criterion gets a score of zero (0) and the highest performance gets a score of one (1).

The fourth step consists of carrying out a weighting of the criteria through the analytic hierarchy process (AHP method), which indicates the relative importance that expert panels give to the indicators of the three pillars that have been chosen. The final step of the developed methodology consists of calculating the "total scores". Each action's scores on the criteria are multiplied by the identified weights, and then the weighted scores are summed across the criteria to obtain each SEAP's action total score.

3.2.1. Level II—Criteria Selection

As mentioned above, the nine selected criteria have been selected according to the domains corresponding to the three pillars of sustainability (Table 1). The criteria selection aims to choose comprehensible, meaningful, and controllable criteria, which make it possible to verify the relevance and effectiveness in evaluating the three dimensions of sustainable development of the individual projects presented. The selected criteria meet the following requirements: monotony, completeness, cohesion, and non-redundancy. Furthermore, the selected criteria are preferentially independent. This means that, for instance, the trade-offs between criteria g_i and g_j are not dependent on the values of the rest of the criteria. More specifically, the hypothesis needed to validate an additive value function for a given decision maker (DM) is the preferential independence of all the criteria.

Table 1. Selected Criteria.

Dimensions	Criteria	Unit
Social	c1—Risk of failure	Very High, High, Medium, Low
	c2—average lifetime employment impact of SEAP actions	Very High, High, Medium, Low, Very Low
	c3—Third Party Equity Financing	%
Economic	c4—Ratio Cost Investment/Energy Saving	EUR/kWh
	c5—Price Variance in standard Cost Accounting	number
	c6—Investment Cost for the Municipality	EUR/inh
Environmental	c7—% Energy reduction	%
	c8—% CO_2 Emission Reduction	%
	c9—CO_2 Emissions Reduction Cost	EUR/ton

Particularly, the criteria identified are the following:
In more detail, the identified criteria are the following.

3.2.2. Social Criteria

c1—Risk of Failure

Allocating sums to project actions still in an embryonic state represents a condition of high risk of failure and social damage to the community. With this criterion, the authors want to weigh the progress of the interventions planned by the public administration (PA) in such a way as to prefer the financing of actions already supported by a planning and study process. Therefore, a high score will be attributed to those actions that result in a more advanced level of design. Two risk scales have been developed: one for structural projects (see Table 2) and the other for knowledge development, training, and planning activities. The judgment scale is as follows:

Table 2. Structural project failure risk.

Structural Projects	Scale	Score	Knowledge Development. Training/ Awareness Raising. Planning	Scale	Score
Feasibility study	Very High	0.0			
Preliminary design	High	0.5			
Final design	Medium	0.7	Pre-Feasibility study	Medium	0.7
Construction design	Low	1.0	Preliminary design	Low	1.0

c2—Average Lifetime Employment Impact of SEAP Actions

This criterion reflects the impact on the social dimension regarding the creation of new jobs. In this criterion, two macro-categories of employment are identified: manufacturing, construction, installation (the most intensive employment area), and operating/maintenance (which last for the entire project's lifetime) [30–34]. The criterion aims to assess whether the SEAP's project actions to be carried out can have effects on employment.

The performance of this criterion is assigned based on a 5-Point qualitative scale (Table 3), namely: "very low" (lower than 1 n.jobs./M EUR investment), "low" (higher than 1 and lower than 3), "medium" (higher than 3 and lower than 6), " high" (higher than 6 and lower than 15) and "very high" (higher than 15 n.jobs/M EUR investment).

Table 3. The employment impact of SEAP actions.

SEAP's Project Actions Type	New Jobs/M EUR Investment	Scale	Score
Advice, training	0–1	Very Low	0.00
Energy Audit, Analysis, Study, Plan	1–3	Low	0.25
Biomass/wind Plant	3–6	Medium	0.50
Solar PV Plant	6–15	High	0.75
Building Retrofitting, Mobility, Street lighting	>15	Very High	1.00

The scores were assigned as follows:

c3—Third Party Equity Financing

This criterion aims to reward the financial participation of third parties in the implementation of the action. It is consistent with the criterion of efficiency and usefulness as the reduction of public funding involves the maximisation of the number of projects that can be financed, and, consequently, of the energy-saving objectives envisaged by the SEAP.

The score is assigned in direct proportion to the participation fee by Third Parties according to the following formula:

$$TPEF_j = \frac{\%TPEF_j}{Max|\%TPEF|} \tag{1}$$

$\%TPEF_j$ is the % of third-party equity financing of the j-th project.

$Max\,|\,\%TPEF\,|$ is the maximum value of third-party equity financing of all the Municipality actions.

The higher the Third-Party Equity Financing of the examined action, the higher its performance for this criterion.

3.2.3. Economic Criteria

c4—Ratio Cost Investment/Energy Saving

This criterion aims to reward those interventions that have a minimum ratio between the IC investment cost of the j-th project (EUR) and the energy saving ES_j (kWh) estimated over the technical life of the intervention.

$$RCI_j = 1 - \left(\frac{\left(\frac{IC}{ES}\right)_j - Min\left|\left(\frac{IC}{ES}\right)\right|}{Max\left|\left(\frac{IC}{ES}\right)\right| - Min\left|\left(\frac{IC}{ES}\right)\right|} \right) \tag{2}$$

IC is the investment cost of the project j-th (EUR).

ES is the energy saving of the j-th project (kWh) estimated over the technical life of the intervention.

$Min\,|\,(IC/ES)\,|$ is the lowest of all Investment Cost/Energy Saving ratios.

$Max|(IC/ES)|$ is the maximum value of all Cost Investment/Energy Saving ratios.

The lower the ratio (Investment Cost/Energy Saving) of the examined action, the higher its performance for this criterion.

c5—Price Variance in Standard Cost Accounting

This criterion defines the range of variation of the considered cost driver and is aimed at comparing the costs incurred in the different projects to achieve a specific goal.

For each categorisation area, the estimated Price Variance in the standard Cost Accounting can be calculated with the following equation:

$$VCA_{jk} = 1 - \left(\frac{IC_j - 0.85 \times IC_{std,k}}{IC_{max,k} - 0.85 \times IC_{std,k}} \right) \quad (3)$$

IC_j is the cost of investment per ton of CO_2 of the j-th project in the k-th categorisation action (EUR/ton).

$IC_{std,k}$ is the standard cost per ton of CO_2 of investment in the k-th categorisation action.

All the costs are presented in Table 4.

Table 4. The standard cost of investment.

Types of Action	Standard Cost (EUR/ton CO_2)
Public buildings refurbishment	13,200.00
Energy efficiency interventions for public lighting systems	1750.00
Energy efficiency interventions for public school buildings	2600.00
Refurbishment and energy requalification of private houses and hotels	2600.00
Energy efficiency in the industrial electrical sector	2400.00
Energy efficiency in the industrial thermal sector	1650.00
Combined heat and power (CHP)	3000.00

$IC_{max,k}$: is the maximum cost of investment per ton of CO_2 of projects in the k-th categorisation action (EUR/ton).

c6—Investment Cost for the Municipality (Quantitative Criterion)

The economic magnitude expresses the cost of the implementation of actions by the local authorities. This cost may include actions in categorisation areas. The estimated investment cost for the municipality can be calculated by the following equation:

$$ICM_j = 1 - \left(\frac{\left(\frac{IC}{INH}\right)_j - Min\left|\left(\frac{IC}{INH}\right)\right|}{Max\left|\left(\frac{IC}{INH}\right)\right| - Min\left|\left(\frac{IC}{INH}\right)\right|} \right) \quad (4)$$

IC_j: is the investment cost due to the implementation of the j-th action by the local authorities.

INH is the total number of inhabitants of the Municipality.

$Min|(IC/INH)|$ is the lowest value of all the investments for the Municipality.

$Max|(IC/INH)|$ is the maximum value of all the investment costs for the Municipality.

The lower the ICM_j ratio of the examined action, the higher its performance for this criterion.

3.2.4. Environmental Criteria

c7—% Energy Reduction—(Quantitative Criterion)

This criterion estimates the % of energy reduction (kWh) that will be achieved through the implementation of the proposed action.

The calculation of this criterion is based on the following data:

- Development of the baseline year energy inventory, namely, the benchmark year against which the achievements of the energy reductions are measured.
- Estimation of the total energy reduction of the proposed action using the calculations for the energy saving and production.

And can be obtained with the following equation:

$$ER_j = \frac{\frac{ER_{redj}}{ER_{red-base}}}{Max\left|\frac{ER_{redj}}{ER_{red-base}}\right|} \quad (5)$$

ER_j: energy reduction index due to the implementation of the j-th action.

ER_{redj}: the total amount of energy reduction due to the implementation of the j-th action (kWh).

$ER_{red\text{-}base}$: total energy reduction in the baseline year (kWh).

$Max\left|\frac{ER_{redj}}{ER_{red-base}}\right|$ is the maximun value of the energy reduction index.

The higher the energy reductions of the examined action, the higher its performance for this criterion.

c8—% CO_2 Emission Reduction—(Quantitative Criterion)

This criterion estimates the % of reduction of the CO_2 emissions that will be achieved through the implementation of the proposed action.

The calculation of this criterion is based on the following data:

- Development of the baseline year emission inventory, namely, the benchmark year against which the achievements of the emission reductions are measured.
- Estimation of the total CO_2 emissions reduction of the proposed action using the calculations for the energy saving and the related emissions factors.

And can be obtained with the following equation:

$$CO2_j = \frac{\frac{CO2_{redj}}{CO2_{red-base}}}{Max\left|\frac{CO2_{redj}}{CO2_{red-base}}\right|} \quad (6)$$

$CO2_j$: CO_2 emissions reduction index due to the implementation of the j-th action (%).

$CO2_{redj}$: the total amount of CO_2 emissions reduction due to the implementation of the j-th action (tCO_2).

$CO2_{red\text{-}base}$: total CO_2 emissions reduction in the baseline year (tCO_2).

The higher the emissions reduction of the examined action, the higher its performance for this criterion.

c9—CO_2 Emissions Reduction Cost (Quantitative Criterion—€/ton)

This criterion estimates the cost of reduction of the CO_2 emissions [35] that will be achieved through the implementation of the action proposed.

This criterion can be calculated by the following equation:

$$RC_{CO2,j} = 1 - \left(\frac{\left(\frac{IC}{CO2_{red}}\right)_j - Min\left|\left(\frac{IC}{CO2_{red}}\right)\right|}{Max\left|\left(\frac{IC}{CO2_{red}}\right)\right| - Min\left|\left(\frac{IC}{CO2_{red}}\right)\right|}\right) \quad (7)$$

$$RC_{CO2} = \frac{IC_j}{CO2_{redj}}$$

IC_j is the cost of investment of the *j*-th project in the *k*-th categorisation action.

$CO2_{redj}$: the total amount of CO_2 emissions reduction due to the implementation of the j-th action (tCO_2).

$Min\,|(IC/(CO2_{red})|$ is the lowest value of all the CO_2 Emissions Reduction Costs.

$Max\,|(IC/(CO2_{red})|$ is the maximum value of all CO_2 Emissions Reduction Costs.

The lower the cost of the emissions reduction in the examined action, the higher its performance for this criterion.

4. Data Source—Province of Messina SEAPs In-Depth Analysis

Following the awareness-raising initiatives carried out by the Region of Sicily, 68 out of 108 municipalities of the Province of Messina have adopted a SEAP, involving 511,373 inhabitants, equal to approximately 78% of the population of the entire Province (649,824 inhabitants) (see Figure 2).

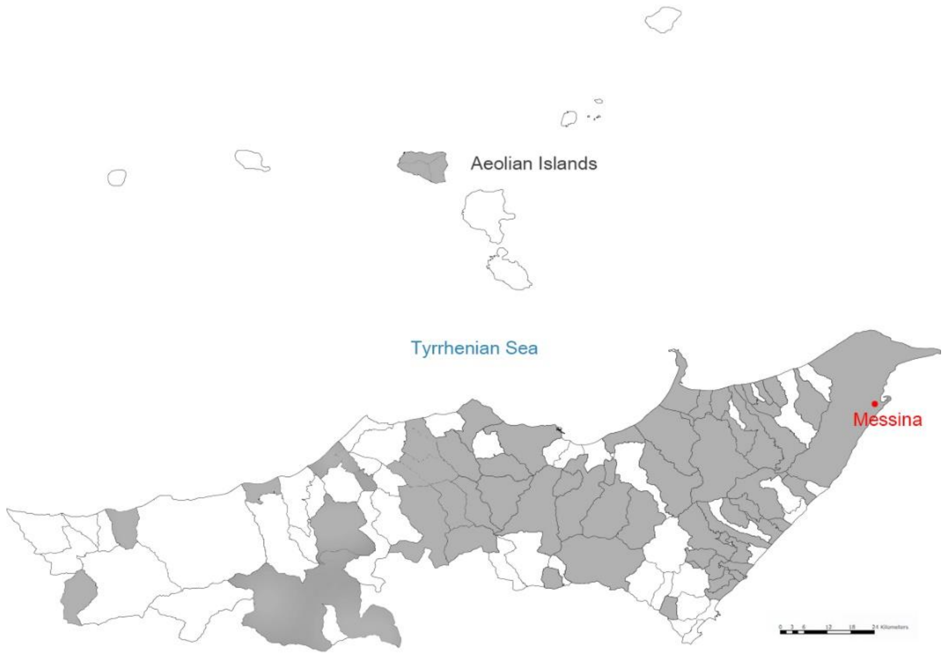

Figure 2. Territorial area covered by the SEAP in the province of Messina.

All the data analysed came from the SEAPs in the province of Messina and have been collected in the "LEXenergetica" web portal, a web-based tool designed for the management and monitoring of energy balances and CO_2 emissions. The software platform enables the following activities:

- To build the basic inventory of CO_2 emissions—Baseline Emission Inventory (BEI), and subsequent updating of the inventories—Monitoring Emission Inventory (MEI), both in terms of final energy consumption and CO_2 emissions detailed by year and sector;
- To visualise, through graphs and tables, the consumption and CO_2 emissions of the BEI and subsequent years (absolute or per capita), as well as the production of local electricity and heat in the BEI's reference year and subsequent years;
- To identify and monitor the objective in terms of CO_2 emissions reduction through the construction of the Action Plan and its monitoring through a GANTT Diagram;
- To periodically check the percentage of achievement of the objective during the implementation phase of the SEAP through special web dashboards.

The platform allows also to group and extrapolate large amounts of data to calculate the potential energy savings or greenhouse gas reductions per type of intervention. For only the province of Messina, this means analysing over 10,000 data points and 1800 projects for CO_2 reductions, energy efficiency, etc.

Based on the analysis of the data from the BEI, referring to the benchmark year 2011 (64 municipalities out of the total of 68 in the province of Messina), the overall emissions of greenhouse gases amount to 1,237,971.29 tCO_2/year, equal to about 20% of those estimated for the Sicilian Region (6,175,145 tCO_2/year).

CO_2 emissions, deriving from electricity consumption, are equal to 659,726.6 tCO_2 (51.9%), while those deriving from thermal energy consumption are 612,197.7 (48.1%). The distribution of CO_2 emissions in the various sectors is as follows.

In the provincial territory, as shown in Table 5, the most contributing sectors to greenhouse gas emissions are public and private transport (28.04%), residential buildings (32.76%), the tertiary sector (18.76%), and industry (15.05%). The sum of all consumption by local authorities, on the other hand, only accounts for about 5%, while agriculture, fishing, and forestry represent 0.5%. Figure 3 shows the distribution of energy consumption of the municipalities of the province of Messina for the benchmark year 2011.

Table 5. CO_2 emissions by sector.

Sector	tCO_2/year	%
Municipal buildings, equipment/facilities	32,955.68	2.66%
Public lighting	26,394.67	2.13%
Tertiary (non-municipal) buildings, equipment/facilities	232,195.75	18.76%
Residential buildings	405,498.86	32.76%
Industry (non-ETS)	186,364.96	15.05%
Agriculture, Forestry, Fisheries	5817.49	0.47%
Municipal fleet	1668.54	0.13%
Public transport	5093.99	0.42%
Private and commercial transport	341,981.35	27.62%
Total	1,237,971.29	100.00%

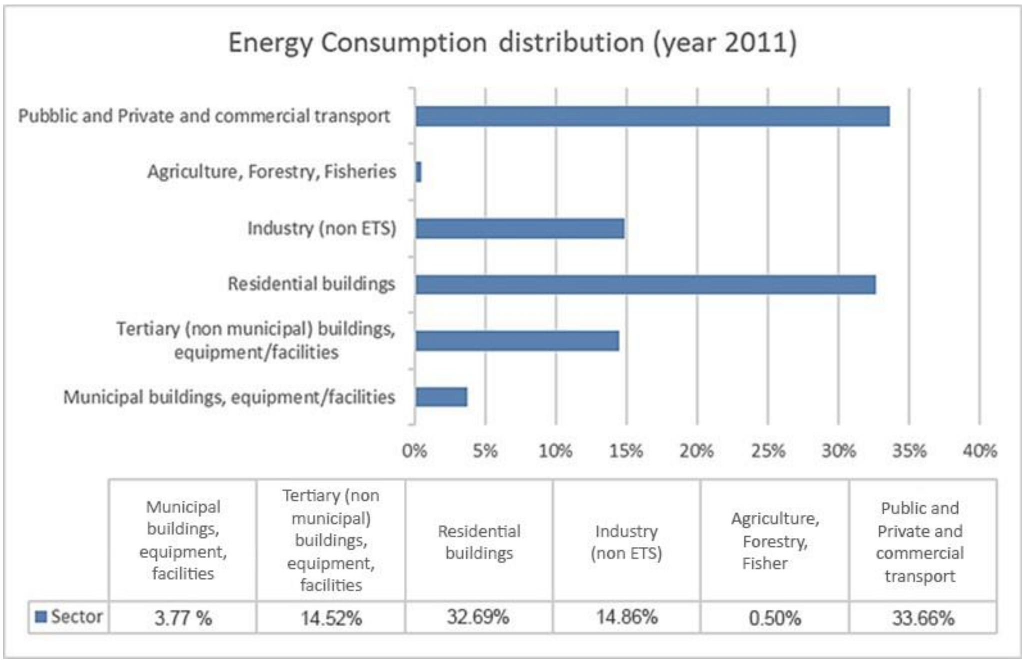

Figure 3. Energy consumption distribution by sector (2011).

As shown in Table 6, the energy consumption of the municipalities in the analysed sample amounts to 3,999,757.68 MWh per year.

Table 6. Energy consumption distribution (MWh/year).

Sector	MWh/y	%
Municipal buildings, equipment/facilities	150,622.77	3.77%
Tertiary (non-municipal) buildings, equipment/facilities	580,938.31	14.52%
Residential buildings	1,307,580.91	32.69%
Industry (non-ETS)	594,399.87	14.86%
Agriculture, Forestry, Fisheries	20,137.51	0.50%
Public, private, and commercial transport	1,346,078.31	33.66%
Total	3,999,757.68	100.00%

As shown in Table 7, the analysis of emissions corresponding to fuel consumption shows a clear prevalence of electricity consumption (49.1%) and consumption of natural gas (14.3%), diesel and heating oil (18.7%), and gasoline (11.5%); these are followed by consumption of LPG (2.8%), other fossil fuels (2.2%), and coking coal (0.6%).

Table 7. CO_2 Emissions by fuels.

Fuels	tCO_2	%
Electricity	617,470.98	49.9%
Natural gas	176,629.82	14.3%
Diesel fuel	222,569.76	18.0%
Liquefied Petroleum Gases (LPG)	34,178.92	2.8%
Gasoline	142,945.95	11.5%
Other fossil fuels	26,948.27	2.2%
Biomass	556.09	0.0%
Coal coke	7639.51	0.6%
Fuel oil	403.95	0.0%
Heating oil	8628.04	0.7%
Total	1,237,971.29	100.00

While from the analysis of the SEAP data the city of Messina shows the greatest impact on the consumption of the province, with a share of 41.55%, in terms of per capita consumption, the highest value concerns the municipality of Pace del Mela, with 9.36 tCO_2 per inhabitant (Figure 4). This value is very high if compared to the ones of other cities, generally between 2 and 4 tCO_2/inhabitant; it could be due to the inclusion in the BEI of data relating to emissions from the Emission Trading System (ETS) industries, located in this important production site.

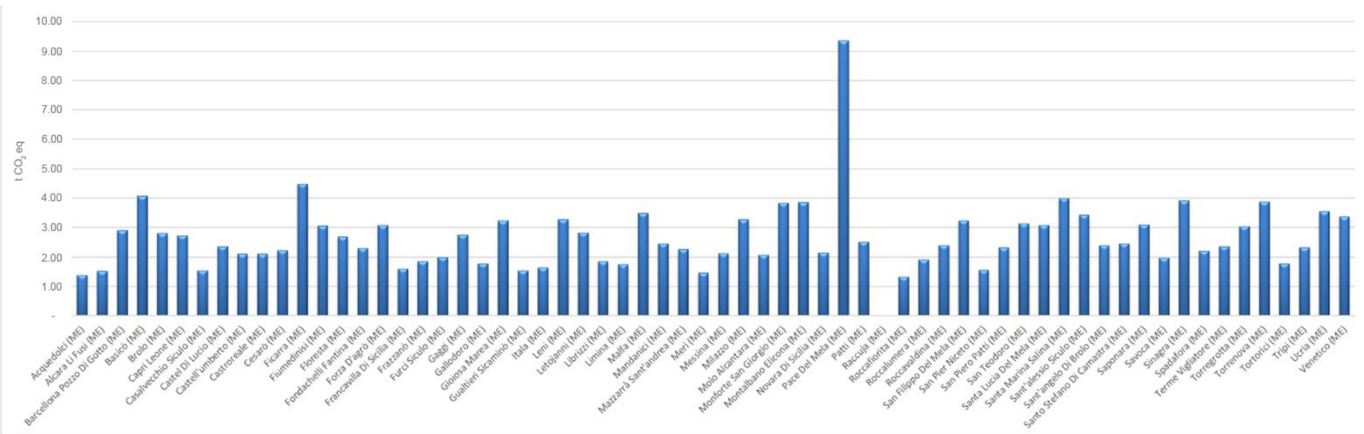

Figure 4. Per capita CO_2 emission (tCO_2/inh) in Messina's province.

As for the local production of electricity, the SEAP study reports an estimation of the amount of electricity generated by photovoltaic systems of 26.2 GWh/year, corresponding to 1.9% of the electricity needs of the municipalities of the analysed sample (1381.1 GWh/year). The production of electricity from photovoltaic sources reported in the SEAPs equals 26.2 GWh/year and represents 96.7% of the total provincial production, based on what is indicated in the statistical yearbook of the GSE for the benchmark year 2011 (i.e., 27.1 GWh/year).

Analysis of the Interventions Proposed in the SEAPs of the Province of Messina

The objective of reducing greenhouse gas emissions by 21.29% by 2020 [36], which was envisaged in the SEAPs of the municipalities of the Province of Messina under consideration, can be achieved through the implementation of 1851 actions whose cost amounts to approximately EUR 2 billion. It is worth noting that almost 89% of the costs are ascribed to actions of private individuals, while only 11% relate to public administration actions.

The private and commercial transport sector, with an amount of EUR 1146 billion, represents 55.9% of the total estimated costs. This datum explains why transport is perceived as one of the most important problems to be solved, even though its weight on the balance of emissions is equal to 16.54% of those referring to the entire provincial territory. The resources requested by local authorities amounted to EUR 224,045 million (10.93%); investments in the residential sector amounted to EUR 524,269 million (25.6%), while those necessary for local energy production amounted to EUR 132,850 million (6.5%).

Table 8 shows the breakdown of the costs of the various actions proposed by the SEAPs.

In Table 9, the costs of the CO_2 reduction actions proposed in the SEAPs divided by category of actions are shown.

The interventions proposed in the SEAPs, in terms of CO_2 reduction [37], are strongly concentrated on the efficiency of private and commercial transport, residential buildings, and local authorities. If we do not consider the investments envisaged by private individuals for the replacement of old means of transport with more efficient ones—equal to approximately EUR 1146 billion, mainly linked to government incentives for low-emission cars and improvements in the country's economic conditions—the greatest investments are foreseen in the residential sector (25.6%) and the production of electricity from photovoltaic sources (5.3%).

Concerning the efficiency and modernisation of buildings and implants of local authorities, the SEAPs focus mainly on the reduction of electricity consumption: in figures, 105,865.34 MWh/year for buildings and public lighting, for an overall total of 20,728.75 MWh/year. The Local Authorities, from the sample of the Province of Messina, have planned investments for the energy efficiency of public lighting systems and the production of electricity from renewable sources, for EUR 145,246,228.67, equal to 47.5% of the financial resources foreseen by the SEAPs for this sector (Figure 5, Table 10). A cost of EUR 21,405,790 is foreseen for the replacement of the most polluting municipal means of transport with others with low emissions; while for training activities, citizens' awareness, involvement of stakeholders, strategic planning and the other remaining actions, the sum of EUR 8,704,712 is foreseen. In this regard, the local authorities included in the sample of the Province of Messina have planned investments for the energy efficiency of public lighting systems and the production of electricity from renewable sources for EUR 145,246 million, equal to 47.5% of the financial resources foreseen by the SEAPs in this sector (Table 10). The amount of EUR 21,405 million is foreseen for the replacement of the most polluting municipal means of transport with more efficient ones; while for activities of training, citizens' awareness, involvement of stakeholders, strategic planning, and the remaining actions, the sum of EUR 8704 million was estimated.

Table 8. Resource allocation SEAP actions.

	Type	MWh	tCO_2	EUR	Cost%
A1. Municipal, residential, tertiary buildings, equipment/facilities					
A 1.1—Municipal buildings, equipment/facilities	PA	105,865.34	31,642.33	130,545,951.89	6.368%
A 1.2—Tertiary (non-municipal) buildings, equipment/facilities	P	21,382.35	9035.13	7,492,150.00	0.365%
A 1.3—Residential buildings	P	211,947.33	61,964.09	524,269,076.25	25.574%
A 1.4—Public lighting	PA	20,728.75	9013.94	37,249,003.67	1.817%
A 1.5—Industries non-ETS	P	15,007.29	5336.22	7,799,507.00	0.380%
A2. Transport					
A 2.1—Municipal fleet	PA	3042.00	869.89	21,405,790.00	1.044%
A 2.2—Public transport	PA	34,150.79	8853.54	25,184,900.00	1.229%
A 2.3—Private and commercial transport	P	161,279.63	43,592.21	1,146,133,700.00	55.908%
A3. Local electricity production					
A 3.1—Hydroelectric power	P	1066.01	482.12	1,670,725.71	0.081%
A 3.2—Wind power	P	1441.58	1833.59	14,473,000.00	0.706%
A 3.3—Photovoltaics	P	43,290.23	32,792.23	107,997,225.00	5.268%
A 3.4—Combined Heat and Power	P	1026.78	2112.34	2,960,000.00	0.144%
A 3.5—Other local electricity production	P	4560.00	1710.64	5,750,000.00	0.280%
A4. Local heat/cold production					
A 4.1—Combined Heat and Power	P	0.00	0.00	0.00	0.000%
A 4.2—District heating	P	0.00	0.00	0.00	0.000%
A 4.3—CHP Plants	P	1351.30	1161.20	7,452,550.00	0.364%
A5. Territorial planning					
A 5.1—Urban planning and regulations	PA	17,341.58	3820.24	3,838,500.00	0.187%
A 5.2—Transport and mobility planning	PA	1981.66	568.50	1,283,000.00	0.063%
A 5.3—Standards for refurbishment and new development	PA	67,636.05	14,494.04	366,500.00	0.018%
A6. Public procurement of products and services					
A 5.1—Energy efficiency requirements/standards	PA	1030.99	358.28	36,000.00	0.002%
A 5.2—Renewable energy requirements/standards	PA	144.22	83.37	32,912.00	0.002%
A 5.3—Other model of public procurement and services	PA	2934.02	2113.96	61,500.00	0.003%
A7. Working with the citizens and stakeholders					
A 7.1—Advisory services	PA	0	0	0	0.000%
A 7.2—Financial support and grants	PA	1475.94	427.22	44,000.00	0.002%
A 7.3—Awareness raising and local networking	PA	47,065.25	16,268.83	1,251,200.00	0.061%
A 7.4—Other stakeholder involvement	PA	26,575.35	14,284.74	103,500.00	0.005%
A 7.5—Training and education	PA	359.30	152.11	212,600.00	0.010%
A8. Other					
A 8.1—Waste management	PA	340.00	306.02	60,100.00	0.003%
A 8.1—Other	PA	633.20	286.63	630,000.00	0.031%
A 8.2—Agriculture	PA	59.18	20	1,740,000.00	0.085%
Total		793,716.12	263,583.41	2,050,043,391.52	100.000%

"PA" stands for public administration, and "P" for private.

Table 9. Funding is required for SEAP Actions.

	Category of Action A	EUR	%
A1	Municipal, Residential, Tertiary buildings, equipment/facilities	EUR 707,355,688.81	34.50%
A2	Transport	EUR 1,192,724,390.00	58.18%
A3	Local electricity production	EUR 132,850,950.71	6.48%
A4	Local heat/cold production	EUR 7,452,550.00	0.36%
A5	Territorial planning	EUR 5,488,000.00	0.27%
A6	Public procurement of products and services	EUR 130,412.00	0.01%
A7	Involvement of stakeholders and citizens	EUR 1,611,300.00	0.08%
A8	Other	EUR 2,430,100.00	0.12%
	Total	EUR 2,050,043,391.52	100.00%

Table 10. SEAP resources for Public Administration.

Public Sectors	EUR	%
Municipal buildings, equipment/facilities	130,545,951.89	42.68%
Public lighting	37,249,003.67	12.18%
Municipal fleet	21,405,790.00	7.00%
Training, awareness, and involvement of stakeholders	1,251,200.00	0.41%
Strategic target setting and planning, sustainable building regulations, green public procurement	5,023,412.00	1.64%
Other	2,430,100.00	0.79%
PV energy production plants	107,997,225.00	35.30%
Total	305,902,682.56	100.00%

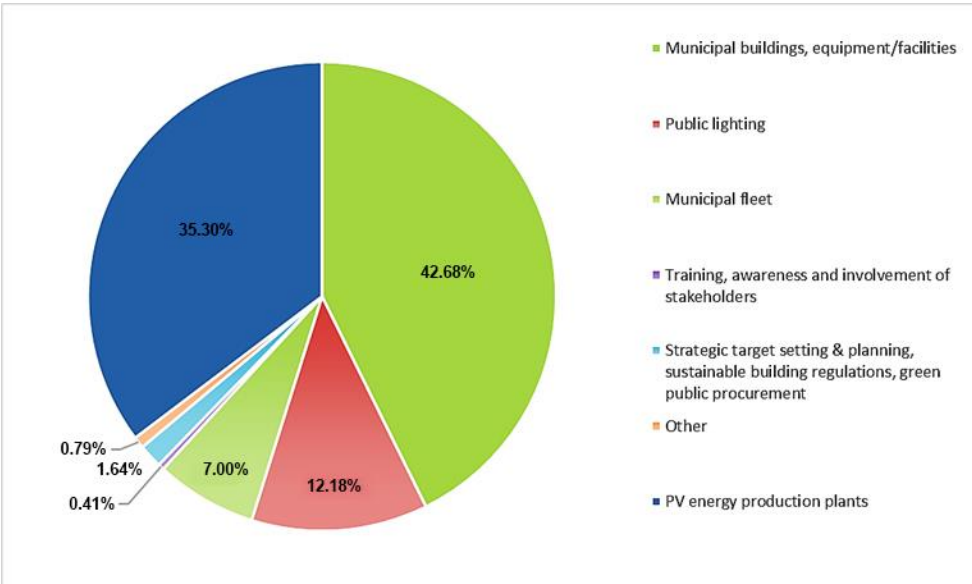

Figure 5. SEAP resources for Public Administration.

The production of electricity from photovoltaic systems was expected to produce 43,290.23 MWh/year by 2020, equal to 40.9% of the overall electricity requirement for municipal buildings and plants. The resources provided in the Action Plans for the construction of plants that use renewable energy sources, such as solar, wind, hydroelectric, and geothermal energy, amount to approximately EUR 132,850 million (Table 11); photovoltaic systems are the ones that attract the greatest interest, followed by geothermal heat pumps and micro-wind power.

Table 11. Economic budget for SEAPs RES plants.

Energy Source	EUR	%
A 3.1—Hydro energy	EUR 1,670,725.71	1.26%
A 3.2—Wind energy	EUR 14,473.000.00	10.89%
A 3.3—PV energy	EUR 107,997,225.00	81.29%
A 3.4—Combined Heat and Power	EUR 2,960,000.00	2.23%
A 3.5—Other energy plants	EUR 5,750,000.00	4.33%
Total	EUR 132,850,950.71	100.00%

However, by analysing the SEAPs, it emerges that most of the projects planned by Local Authorities do not have financial coverage; in fact, the intention to acquire financial resources from the State or the European Commission is often declared under the heading "Financing" of each Action sheet. Alternatively, the documents mention the possibility of financing through third parties or contracts with Energy Service Companies (ESCo). From this first analysis, we highlighted the complexity and the great variability of data to be considered in the decision-making process [38]. The choices made by public administrations derive from complex hierarchical comparisons between alternative options, which are often based on conflicting criteria and the need for a clear holistic vision by public decision makers.

5. Pilot Appraisal—Messina Province SEAPs

The proposed methodology has been applied to the SEAPs of Messina Province. The first step in the double-decision support system process is to assess the best possible categories of areas of intervention through an application of the AHP method.

5.1. Best Categories Evaluation for Areas of Intervention Based on the Analytic Hieratic Process

The guidelines on Sustainable Energy Action Plan and Monitoring report the categorisation of the actions: in particular, the following eight categories of intervention are identified in Table 12:

Table 12. Categorisation of the actions.

Categorisation	Area of Intervention
A1	Municipal, Residential, Tertiary buildings, equipment/facilities
A2	Transport
A3	Local electricity production
A4	Local heat/cold production
A5	Territorial planning
A6	Public procurement of products and services
A7	Involvement of stakeholders and citizens
A8	Other sectors

To determine the weights related to the eight categories of areas of intervention, the procedure contemplates a hierarchy which follows the AHP method. In particular, the hierarchy provides that every decision maker (or typology of decision makers) shall assess the importance of the criteria by comparing them in pairs. In general, it should not be difficult to estimate the decision-making power of the various parties involved according to the level of responsibility related to the subjects. Each decision maker can make quite simple judgments by comparing from time to time the importance of just two criteria as well as the final weights, which will be assigned to the criteria as an average of values given by the different decision makers.

A specific pairwise comparison (questionnaire) has been drawn up just to involve different types of decision makers regarding the assignment of weights to these eight categories of areas of intervention. The comparison is made by assigning numerical values to express the strength of the preference of one factor over the other, as shown in Table 13.

Table 13. Factors' preference possible choices for decision makers.

Value	Interpretation
1	Both compared elements contribute equally to achieving the goal.
3	Opinions and experiences gently prefer one element over another.
5	Opinions and experiences strongly prefer one element over another.
7	Opinions and experiences very strongly prefer one element over another.
9	Opinions and experiences completely prefer one element over another.
2, 4, 6, 8	It is used to express an intermediate level of preference.

The question asked to the expert panels concerning the different factors is: "What is the relative importance of each factor in selecting the most preferred alternative?". The questionnaire was sent to a work group formed by several experts (i.e., Directors and Heads of Units of regional and national authorities; university professors and researchers; stakeholders; energy managers).

According to the opinions collected, it was possible to apply the AHP method to calculate the weights of the criteria starting from the matrix of pairwise comparison of criteria related to each decision maker.

As shown in Table 14, we have calculated the weights of the criteria, which were used in the case study, applying a recombination matrix, specified by the methodology.

Table 14. Weighted scores matrix.

		Criterion	Weights	+/−
1	A1	Municipal, Residential, Tertiary buildings, equipment/facilities	16.7%	7.9%
2	A2	Transport	30.0%	11.9%
3	A3	Local electricity production	9.4%	5.2%
4	A4	Local heat/cold production	6.9%	2.9%
5	A5	Territorial planning	27.5%	11.2%
6	A6	Public procurement of products and services	3.4%	2.3%
7	A7	Involvement of stakeholders and citizens	1.9%	1.2%
8	A8	Other sectors	4.2%	2.3%

5.2. Evaluation of the Best Sustainable Criteria Based on the Analytic Hieratic Process

The second step in the double-decision support system process is to assign weights criteria to the nine decisional criteria considered through an analytic hieratic process (AHP).

The nine decisional criteria considered are:

(C1) Risk of failure; (C2) Average lifetime employment impact of SEAP actions; (C3) Third Party Equity Financing; (C4) Investment Cost Ratio/Energy Saving; (C5) Price Variance in standard Cost Accounting; (C6) Investment Cost for the Municipality; (C7) % Energy reduction; (C8) % CO_2 Emission Reduction; and (C9) CO_2 Emissions Reduction Cost.

Specific pairwise comparisons (through a structured questionnaire) were drawn up just to involve different types of decision makers in the assignment of weights to these criteria. The questionnaire was sent to experts and insiders (e.g., Public Administration managers, innovation managers, university professors, and environmental issues researchers). By the Data Protection Code, the questionnaire was anonymous. To determine the weights related to the nine decisional criteria of intervention, the procedure contemplates a hierarchy which follows the AHP proposed method. Particularly, the hierarchy allows each decision maker (or typology of decision makers) to assess the importance of the criteria by comparing them in pairs. Every decision maker can make quite simple judgments by comparing from time to time the importance of just two criteria. Thus, the final weights assigned to the criteria will be an average of values given by the different decision makers.

Thanks to the opinions collected, it was possible to apply the AHP method to calculate the weights of the criteria starting from the matrix of pairwise comparisons of criteria related to each decision maker.

As shown in Table 15, we have calculated the weights of the criteria which were used in the case study by applying a recombination matrix, as specified in the methodology.

Table 15. Weighted scores' matrix.

		Criterion	Weights	+/−
1	C1	Risk of failure	11.4%	4.5%
2	C2	Average lifetime employment impact of SEAP actions	19.8%	6.0%
3	C3	Third Party Equity Financing	1.7%	0.4%
4	C4	Ratio Cost Investment/Energy Saving	3.9%	1.7%
5	C5	Price Variance in standard Cost Accounting	1.6%	0.6%
6	C6	Investment Cost for the Municipality	3.9%	1.7%
7	C7	% Energy reduction	22.5%	7.3%
8	C8	% CO_2 Emission Reduction	22.5%	7.3%
9	C9	CO_2 Emissions Reduction Cost	12.7%	4.6%

5.3. Discussion on the Applied Methodology

The application of the methodology described above to a practical case study (i.e., a SEAP of the province of Messina) contributes to the advancement of two different research areas: on the one hand, the theoretical development of criteria interactions in MCDA; on the other hand, to practically obtain the most appropriate selection of RES/RUE actions to support the regional authorities in the implementation of their SEAPs.

Compared to the studies cited in the literature review [12,13,19], this methodology aims to develop and assess a multi-attribute decision-making method suitable for the in-depth analysis of mitigation actions of several SEAPs. This methodology does not provide a ranking of ideal scenarios of sustainable projects in the field of CO_2 reduction or energy efficiency but wants to give a suitable tool to the local authorities' managers to help them in their work to decide the best projects to be financed.

5.3.1. Target of Evaluation of Best Categories for the Area of Intervention

From the results obtained, the decision makers agree that it is a priority to finance projects on the expenditure lines relating to the following categories of actions, in the order proposed below: (1) Transport, (2) Territorial planning, (3) Municipal, Residential, Tertiary buildings, equipment/facilities. Only in 4th place is it considered important to allocate financial resources to local electricity production projects. Another important element from this study emerges, the marginal influence of the actions on the involvement of stakeholders and citizens, which is positioned at number (8).

5.3.2. Target of Evaluation of Sustainability Criteria

The resulting scenario from the expert panel choices shows an equal orientation towards the most energy-saving and CO_2 reduction actions. Furthermore, the panel assigned the highest importance to labour impact among the social and economic criteria, locating them in the middle-height priority rank (third place in the rank). The criteria assessing CO_2 Emissions Reduction Cost and technical reliability of actions (Risk of failure) are associated with a medium priority rank (4th place in the rank). The other economic criteria, such as Third-Party equity financing or Ratio Cost Investment/Energy Saving or Price Variance in standard Cost Accounting, are associated with a low priority rank.

The outcomes of the distillation procedure confer the final order for this decisional scenario. Each category of intervention area is defined as the area with the best design alternatives. These design alternatives represent the actions that fulfil the objectives that the decision maker has fixed.

A milestone will be the first monitoring phase in the next two years to realise if the promised targets will be achieved soon and in an expected way.

To sum up, the proposed methodology can help the regional authorities to identify the categories of intervention areas to allocate the financial resources, and then select the best design alternatives to improve integration in urban energy systems associated with GHG emission reduction.

6. Conclusions

This study presents a methodology based on a multi-criteria decision divided into two macro-phases. The first phase allows a ranking evaluation of the eight categories of criteria on provided SEAP actions based on the analytic hieratic process. The second phase assigns the weights to the nine decisional criteria, based on the three pillars of sustainability, considered through an analytic hierarchy process. The application of this methodology to the SEAPs targets of 64 municipalities of Messina province will lead to evaluating the ranking of CO_2 reduction of local eligible technological projects. This methodology will be applied to over 1800 strategic actions that have been identified for the reduction of greenhouse gases and energy efficiency.

This methodology also encourages debate and confrontation of criteria among expert group members and can result in a driving factor for the encouragement and addressing of sustainable development at the local level. Consequently, it is possible to assert that objectives derived from the CoM for the development and adoption of sustainable energy action plans (SEAP) can be achieved at the regional level.

As per the current limitations, there are still no objective data about the actual implementation of the analysed SEAPs. An interesting follow-up phase to this research would be the monitoring phase in the next years to assess if the promised targets will be achieved in the expected way and time.

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