Re-vitalising Energy Transition in Touristic Islands

GENERA ET Monitoring tools description

Deliverable 3.1 - Public

Lead beneficiary: UPV

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History of Changes

Version	Date	Authors
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List of Acronyms

Acronym	Meaning
AHP	Analytical Hierarchical Process
AP	Action Plan
BAU	Business As Usual
CA	Consortium Agreement
CoM	Covenant of Mayors
DHW	Domestic Hot Water
D2.1	GENERA Deliverable on Comprehensive report on Island Dynamics
D4.1	GENERA Deliverable on Road-mapping needs, typology, Island-specific recipes
EP	Energy Planning
ET	Energy Transition
EU	European Union
EV	Electrical Vehicle
GA	Grant Agreement
SCOP	Seasonal Coefficient Of Performance
SE	Sustainable Scenario
SECAP	Sustainable Energy and Climate Action Plan
SEER	Seasonal Energy Efficiency Ratio
SMEs	Small and medium-sized enterprises
WP	Work Package

Executive Summary

This document has been developed as part of **LIFE21-CET-LOCAL-GENERA** project, funded by European Climate, Infrastructure and Environment Executive Agency - LIFE Project Grants, under **Grant Agreement No. 101077073**.

It corresponds to Work Package 3 (WP3) – *Energy Transition Monitoring Tools* and to Deliverable D3.1 – *GENERA ET Monitoring tools description*. This deliverable includes the information gathered through the activities: *T3.1 Identifying Energy Context, T3.2 Knowledge Database Module, T3.3 Inference Module* and *T3.4 Multi-criteria Decision-Making Module,* which is still under development.

This document focuses on the definition of the technical specifications of the tools that GENERA will provide to facilitate the decision-making process of the municipalities towards the Energy Transition (ET), as well as the requirements of the users. It is a first user manual of the different tools that should be easily understandable and allow to obtain the general energy casuistry of the municipality and the future projection through the actions in agreement with the municipal council to create an Action Plan (AP).

GENERA provides four tools corresponding to the four modules: *1 - Definition of the National Energy Context, 2 - Knowledge Database, 3 - Inference Module and 4 - Multicriteria Decision-making Module.* These tools together constitute the Energy Transition Package that will be described in this document and will be applied in different municipalities until the end of the project.

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1. Overview

1.1 Purpose and Scope

The main objective of this deliverable is to provide energy planning and monitoring tools to municipal ET actors tailored to islands to drive and lead ET.

In GENERA key objectives include providing tools to identify the energy context of the islands at national level and to create a municipal roadmap appropriate to the municipal casuistry of the islands. This deliverable is based on the information collected in WP2 and WP4 that has been processed together with a desk study for the creation of the database module.

The aim is that this document provides a manual for users to understand and use the tools. However, since at the point of delivery of this document the final version of the tool has not been implemented, it is possible that some changes will be made during the course of the project while the tool is being implemented at the municipal level.

1.2 Structure of the Deliverable

The document is structured in four chapters in addition to this first one, which is the general overview:

Chapter 2 – Introduction

Contextualize the role of European islands in the ET together with current policies. In addition, the need for roadmaps at the municipal level is highlighted and a short review is made on the main actions included in the action plans of the consortium countries: Italy, Spain and Greece.

Chapter 3 - GENERA's tool for the creation of roadmaps.

This chapter is focused on showing the main characteristics and specifications of the modules proposed by the GENERA project:

1 - Definition of the National Energy Context

2 - Knowledge Database

3 –Inference Module

4 - Multicriteria Decision-making Module.

Chapter 4 – Conclusions

This chapter highlights the main conclusions of this deliverable.

2. Introduction

2.1 Energy context and objectives

The European Union (EU) faces a context of change and transition towards a more sustainable and cleaner energy Europe. This is evidenced by the package of policy initiatives launched to achieve the ecological transition through the European Green Deal [1]. One of these measures is the 2030 - 2050 agenda, in which EU Member States have committed to a reduction of at least 55% of greenhouse gas emissions by 2030 compared to 1990 levels and a reduction of net greenhouse gas emissions to zero by 2050.

The Green Deal also created the European Climate Deal initiative to engage individuals, communities and organisations in the fight against climate change, in the ecological transition and in building a greener Europe. Among the measures is the "Target 55" package which aims to review and update EU legislation and launch new initiatives to bring new EU policies in line with agreed climate objectives.

Some of its measures involve making transport more sustainable, greening buildings, boosting renewable energy, supporting citizens and businesses and increasing energy efficiency among others. Studying ET at different levels forces to pay attention to island territories, as they vary enormously in terms of electricity grids, geographical specificities, local population, tourism and other aspects, all of which affect the stability of the energy grid and create energy planning challenges. Thus, an Energy Transition (ET) to reduce CO_2 emissions is taking place at all levels within the EU: national, regional and, ultimately, local.

At the regional level, cities play a key role in the transition to a sustainable economy and in achieving the EU targets. They are therefore important actors in climate change adaptation and mitigation, as well as in the move towards clean energy and low-emission mobility. Initiatives such as the Covenant of Mayors for Climate and Energy seeks to create an alliance of cities and local governments voluntarily committed to fighting climate change, reducing its unavoidable impacts and facilitating access to sustainable and affordable energy for all.

2.2 Need for roadmaps at the municipal level

Local governance is important to encourage behavioural change among individual residents and industries, as well as to increase the visibility of initiatives and provide guidance and support to communities. This is how the EU has promoted and supported the creation of the Covenant of Mayors for Climate and Energy [2] to develop transversal roadmaps and highlight the power of local and regional authorities to support the energy transition.

The Covenant of Mayors (CoM) promotes the creation of a Sustainable Energy and Climate Action Plan (SECAP) that defines a set of actions to achieve climate change mitigation and adaptation goals. This is how this initiative facilitates the achievement of the objectives set by the EU, as it requires the creation of an Action Plan whose actions must be monitored in consecutive years. However, defining a SECAP is not a simple task and requires the creation of an ecosystem involving all citizens, businesses, political authorities and other existing funding bodies at both municipal and national level. This requires the creation of urban governance, in which all stakeholders must be involved in public decision-making [3]. Another important fact is that the initiative also involves follow-up and monitoring to achieve the objectives defined in the Action Plan itself. This is done through reports in which all stakeholders must participate, although in recent years there has been a notable lack of commitment to this monitoring task [4].

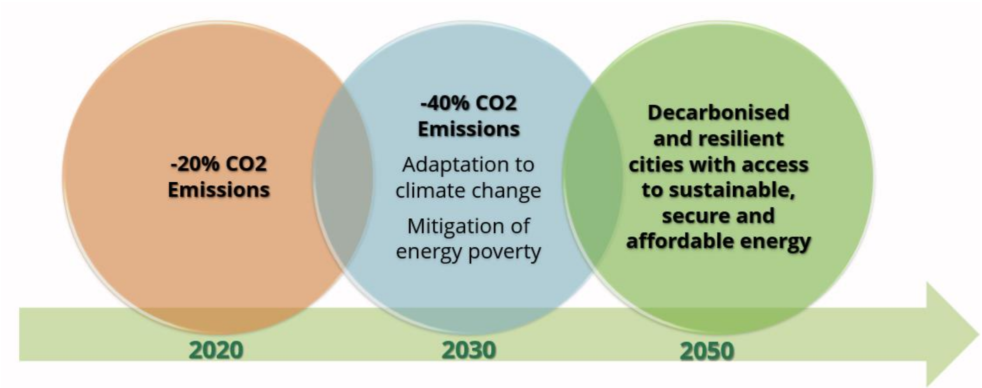

Figure 1: Temporal evolution of the Covenant of Mayors' objectives

This initiative requires a great effort from all municipal actors to initiate the municipality and to plan what actions can be implemented within the specified framework and what results will be achieved. Therefore, the planning stage is the most tedious part that requires the most technical knowledge when drawing up the Action Plan, as well as estimating the emissions associated with each action.

Within the CoM platform there are certain parameters that must be compulsorily reported when creating the Action Plan, most notably the emissions inventory that must be updated every 4 years. In this inventory, data such as CO_2 emission factors, final energy consumption, certified green electricity, local (renewable) generation/distribution, local heating/cooling generation as well as other non-energy related sectors are entered.

Ultimately, the SECAP should clearly specify the mitigation target to be achieved with the CoM (i.e. a reduction of at least 40% of CO_2 emissions by 2030) and the adaptation target. In addition, Covenant of Mayors signatories are invited to renew their commitments with higher targets once the SECAP has been submitted or to submit the SECAP in the following years in order to achieve these renewed targets.

To achieve a successful plan, it is necessary to strengthen horizontal cooperation between different policy areas and to integrate climate action into existing sectoral strategies. In addition, providing municipal support for the creation of SECAPs according to their municipal casuistry would facilitate the inclusion of more municipalities in the CoM initiative. This is the role of GENERA through the tools described in this document.

Module	Description	Objective
National energy context	It consists of the definition of a Business As Usual (BAU) scenario and a Renewable scenario applying Energy Sustainability measures.	Understanding the national energy status and future trends
Knowledge Database	Overview of the most popular measures in current SECAPs and their impact in terms of energy, emissions and economic savings.	Be aware of ET measures that are applied in other municipalities with similar characteristics.
Inference	Seeks to adapt the measures to the municipality that applies the tool, making calculations according to the information provided by the user. The more information, the more it is adapted to the municipality of analysis.	Provide the municipality with information in terms of energy and emissions on the measures they can include in their SECAP.
Multi-criteria Decision-Making	Adapts the measures to the sectoral strategy of the municipality, according to the considerations of the user (municipality). It weights the proposed measures according to the user's criteria in terms of sectors such as environment, social, economic, etc.	Provide the municipality with a list of measures with their corresponding emissions and energy savings, ordered according to municipal criteria.

Table 1: Overview of GENERA tool modules

2.3 Relation of this WP to other WPs

Different plans of municipalities located on tourist islands in Spain, Italy and Greece, mainly from the Covenant of Mayors initiative, have been reviewed in order to identify the main actions proposed at the municipal level. Most of the plans analysed are from Spain and specifically from the island of Tenerife, a total of 22 plans. Furthermore, on the island of Sardinia, 9 plans from different municipalities were analysed. As for the Greek islands, the Cyclades and some of the Dodecanese islands were analysed.

Following the review of plans, the actions were mainly divided into the following categories: municipal buildings and equipment, industry, lighting, buildings, local electricity production, resource management, transport and awareness raising.

A summary of the number of plans per country that include such actions is shown in the figures below, indicating which categories each of the countries are focusing on. In addition, the information provided in WP2 (characterisation of islands and surveys of technicians and citizens on ET) as well as in WP4 on the typology of the island and its characteristics (e.g. whether it is land-based, fossil fuel dependent etc.) should be considered.

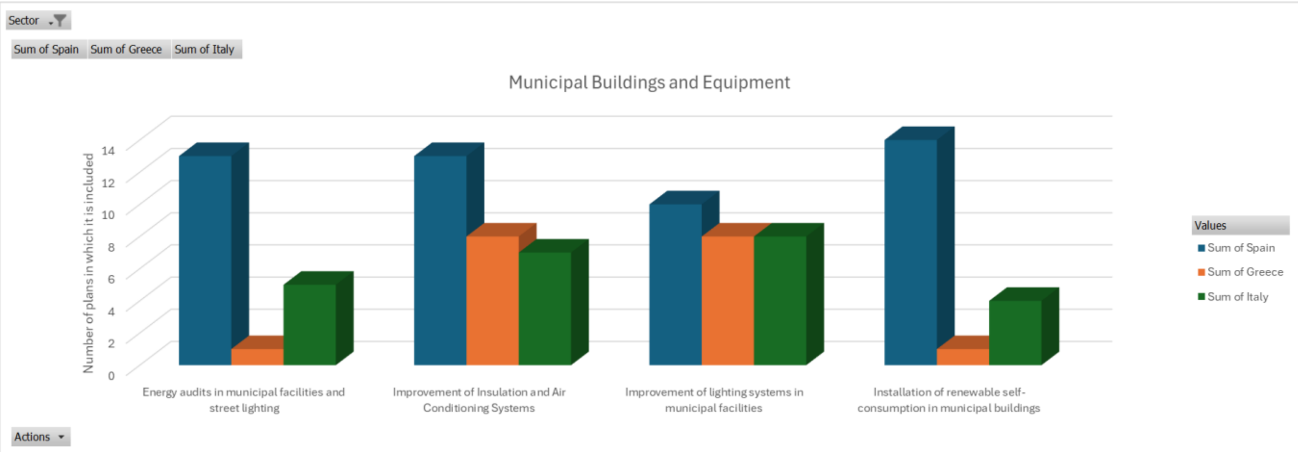

Figure 2: Island ET Plans including Municipal Buildings and Equipment Actions

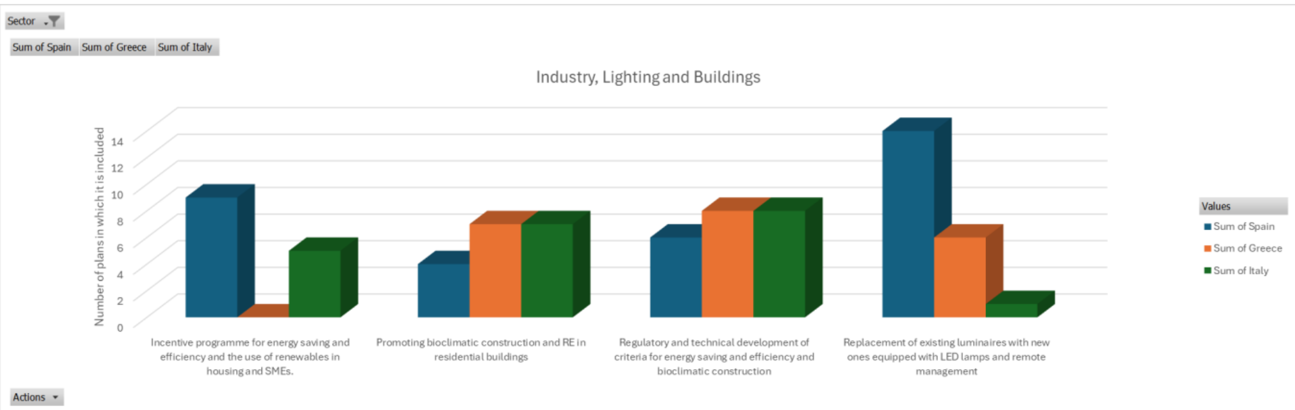

Figure 3: Island ET Plans including Industry, Lighting and Building Actions

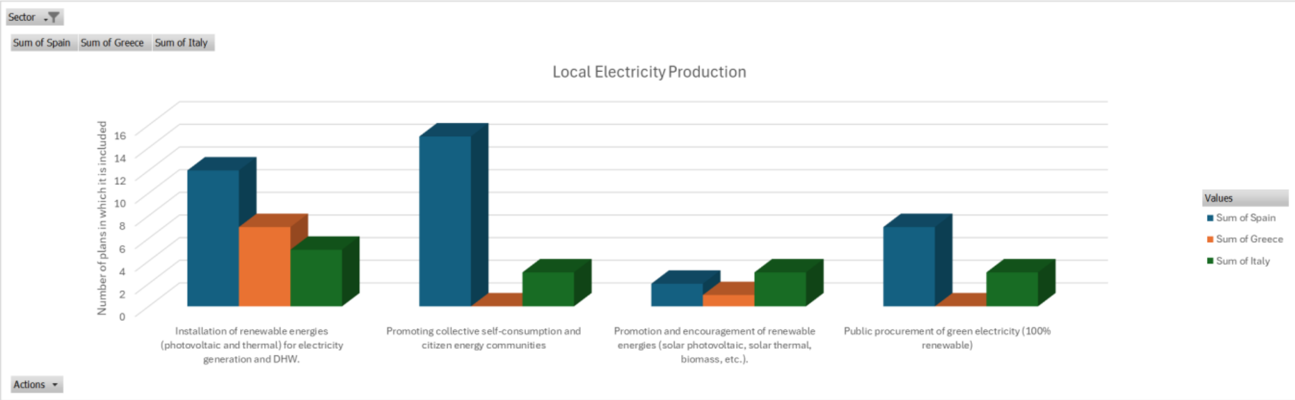

Figure 4: Island ET Plans including Local Electricity Production Actions

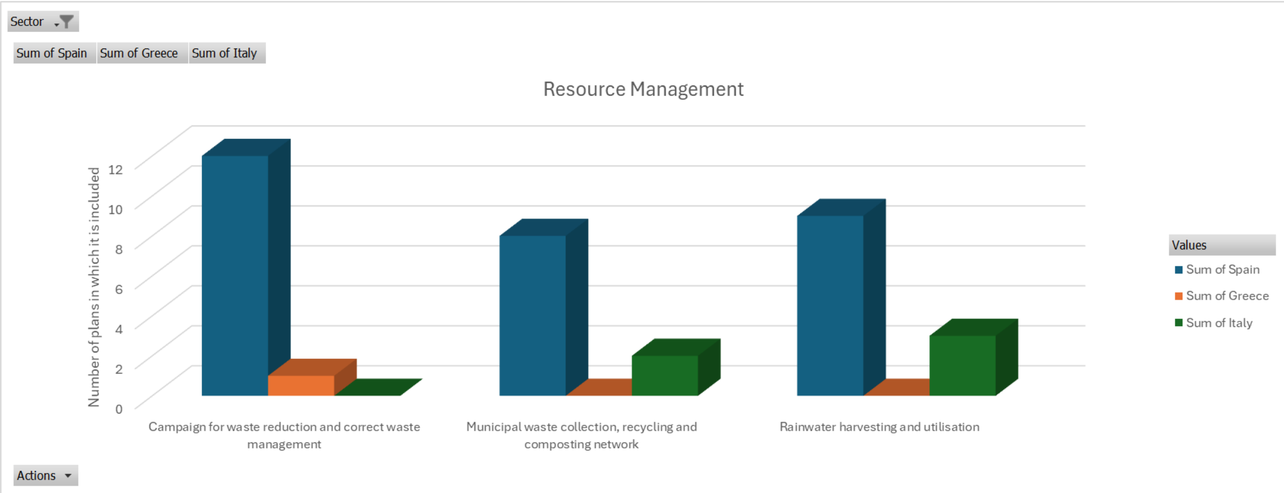

Figure 5: Island ET Plans including Resource Management Actions

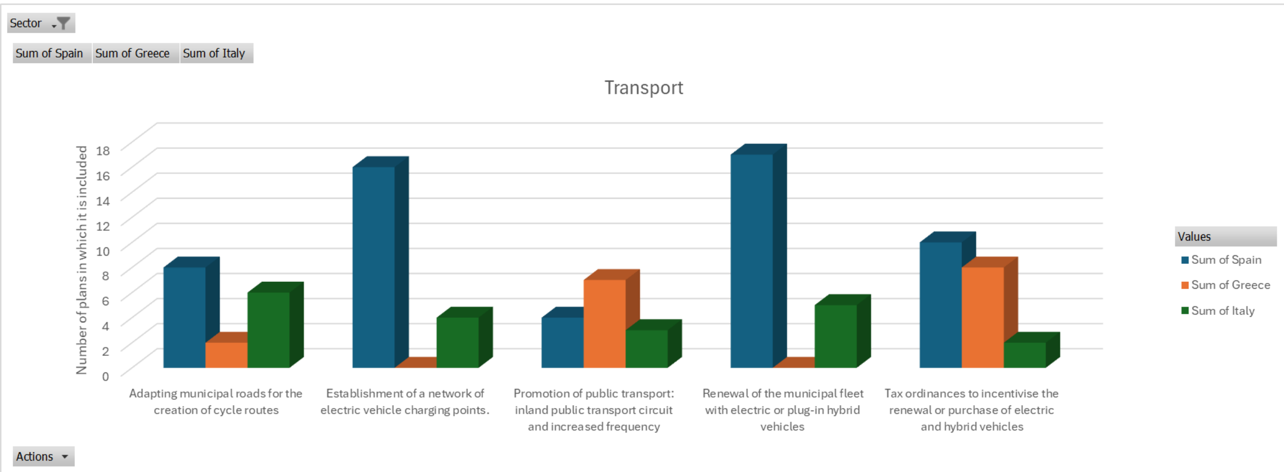

Figure 6: Island ET Plans including Transport Actions

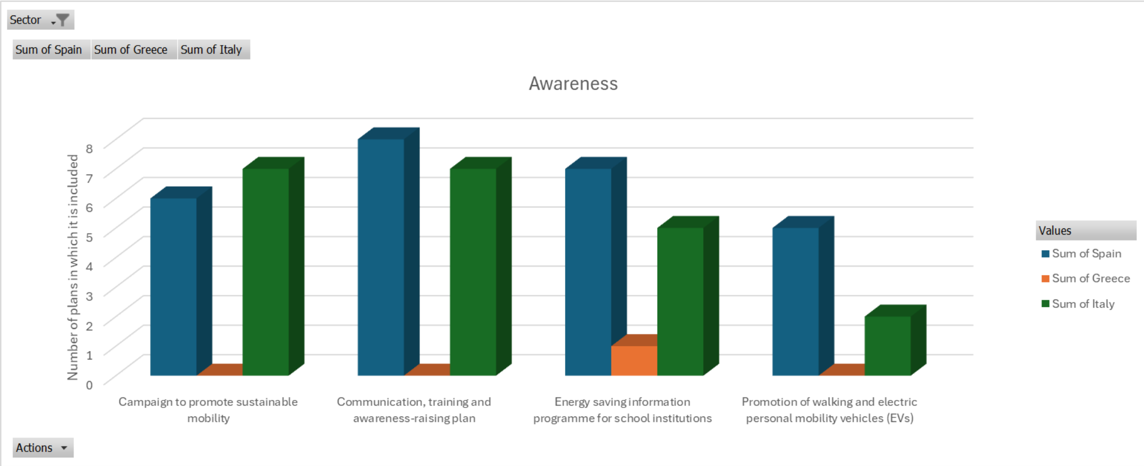

Figure 7: Island ET Plans including Awareness Actions

Most of the plans are from Spain and specifically from the Canary Islands. Therefore, according to the island typology (D4.1) it is a fossil fuel dependent island type E, so most of the actions are focused on improving energy efficiency, introducing renewable energies, promoting electric vehicles (EV) and energy communities as well as raising awareness in society, which coincides with the data provided in the surveys of municipal technicians (D2.1).

As for the Greek islands studied, the main typologies studied are type B1-connected to the mainland and with high peak energy demand and type D1-interconnected to other islands, but not to the mainland. In these cases, involvement in the improvement of energy efficiency in municipal buildings and lighting, as well as in the promotion of public transport and the purchase of EVs can be noted. However, in the plans analysed, there is less interest in the introduction of renewable energies and the creation of energy communities, as well as in raising citizens' awareness, as indicated by the surveys of municipal technicians. This indicates that there is a current tendency to introduce these new actions for ET.

Finally, in relation to the Italian islands, Stintino stands out with a typology A - energy stability as it is connected to the mainland and has sufficient energy to cover demand. In the revised plans, there is a greater interest in energy efficiency actions in municipal buildings and equipment, as well as in the promotion of sustainable transport and citizen awareness. This is all in line with the surveys obtained by municipal technicians, although they also highlighted the incentive of energy communities, which may be a future trend.

This was considered in the development of the GENERA tool modules described in the following chapter.

3. GENERA's tool for the creation of roadmaps

3.1 Aim of the GENERA tools

The main objective of the GENERA tool is to assist municipalities with special needs, specifically those located on tourist islands, in the development of a municipal roadmap or AP. The idea is to facilitate the creation of the municipal SECAP and to provide information of interest such as energy savings, avoided emissions, energy generation, etc. that will also allow their incorporation into initiatives such as the Covenant of Mayors.

The tool will yield the Energy Transition Package, composed of four modules (Table 1), the main functions of which are:

- Analyse the current energy context of touristic islands in terms of sustainable objectives and energy transition indicators.
- Develop a knowledge database based on the information of current SECAPs.
- Develop the Energy Transition Package building upon existing calculation methodologies and tools.
- Develop a relational model capable of converting gathered information and collected data into added value for decision/ policy makers in touristic islands, and more specifically local public authorities.

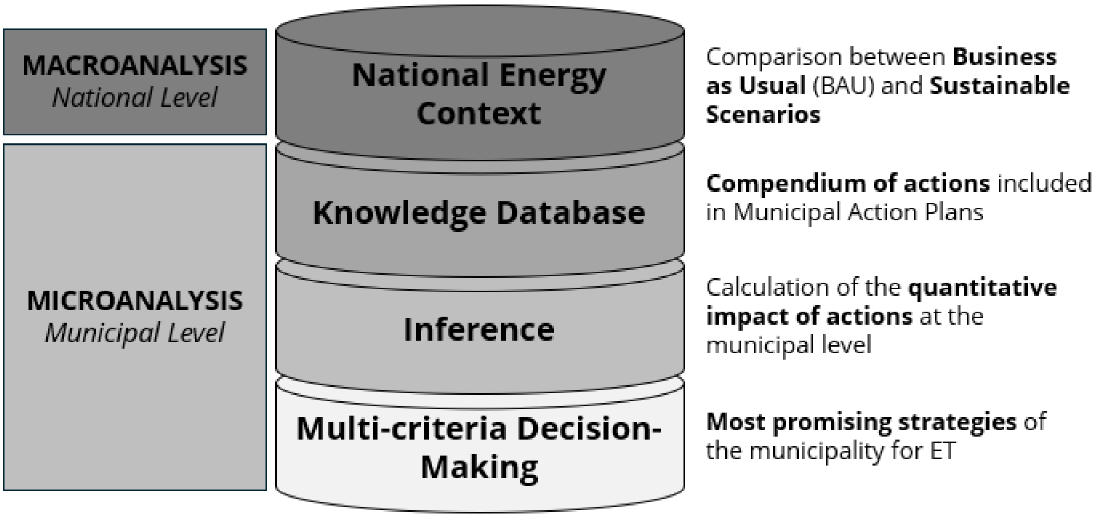

Figure 8: GENERA tool and the connection of its different modules

3.2 Module 1: Energy Context Analysis

The main objective of this module is Energy Planning (EP), which aims to analyze the alternative energy evolution paths of a region by studying different energy scenarios. First of all, the current scenario, called "Business As Usual (BAU)", and its evolution for the time interval under consideration are referenced. It is then compared with alternative scenarios with the same time horizon and the same demand constraints. Each energy scenario involves evaluating and optimally matching energy sources and their conversion to the energy needs of the different demand sectors (commercial, industrial, residential, etc.). At this point, several decisions and criteria come together, along with the existence of complex relationships between the different actors involved in the simulation process: generation, demand, emissions, economics and technologies.

The SIMESEN tool (Simulation of Energy Scenarios) was developed at the *Energy Engineering Institute of the Universitat Politècnica de València* in 2010 on the basis of the evolution of independent variables that can be defined by means of a predetermined mathematical law [5]. This is a tool that makes it possible to determine the evolution of a given energy scenario using energy demand and primary energy availability as a starting point; it then deduces the role that renewable energies could play in making a sustainable scenario possible within a predetermined timeframe.

Therefore, the model to be used in the project is based on the SIMESEN tool, which in turn is based on a linear model that relates demand with the possible contributions of each primary energy source and electricity. In this way, the evolution of each of these primary energy sources and their associated CO_2 eq. emissions is obtained to analyse a series of energy variables.

In this type of analysis, annual rates of variation are used to define the energy demand of each sector. The tool compares two macro-level energy scenarios: Business As Usual (BAU) and Energy Transition (ET), an exploratory energy scenario based on renewable energy and policy-driven sustainability targets. It compares the evolution of the energy context with the actual energy mix of the region with a scenario based on the integration of renewable energy to reach a set sustainable target.

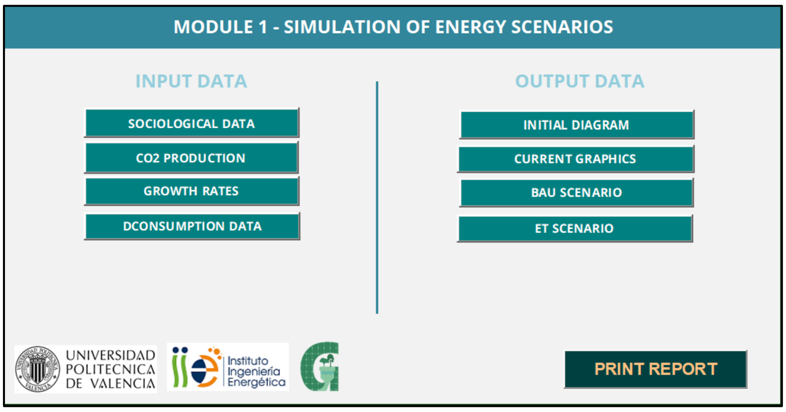

Figure 9: Overview of module 1 Simulation of ET scenarios

The main indicators that are assessed are:

- Percentage of external dependence in the supply of primary energy.
- Share of renewable energy in total energy consumption.
- Energy intensity, defined as the ratio of energy consumption to gross domestic product. The evolution of this parameter is considered as an indicator for the improvement of energy savings and efficiency.
- Total amount of CO_2 emissions of each energy sector.

3.2.1 Energy Planning Module Sections

The tool consists of 3 independent sections:

- **The first section corresponds to data input**, which includes a first screen with data on population, GDP, energy demand and CO_2 production rates of the community analysed. Input data also requires primary and final energies by each demand sector from each resource and data from CO_2 emissions associated with the use of each type of energy is collected as well.

  It mainly calculates the temporal variation rates of each variable indicated. To do this, by means of **a linear regression**, future data are extrapolated from the initial data for which information is available. In this way, the scenario to be simulated is defined and the percentages in which each primary source and electricity contribute to covering the demand of each economic sector are calculated.

- The **second section calculates the evolution of energy consumption and CO_2 emissions** for the energy scenario defined in the input module through established mathematical relationships. Through certain sustainability indicators, the improvement achieved in the ET over the BAU is evaluated, assuming that no qualitative changes are introduced in the evolution of the energy system, keeping constant the initial values defined in the input data and the percentage contribution of each energy source to the demand segments. Finally, the SE scenario provides the renewable contribution needed to achieve a sustainable ET.

- The **third section is dedicated to the presentation of the results**, both graphically and numerically. It shows a diagram with the initial energy context of the region in year zero (the starting point used for the calculation) and another screen with the evolution of energy consumption, both primary and final energy, for each of the sources. In addition, it also shows the evolution of CO_2 emissions. Finally, it also shows the comparison between both scenarios defined (BAU and ET). `

Figures 10 show some of the sections discussed above:

Spain REPORT

PRIMARY ENERGY (ktep)							
Total Primary Energy	0	1,532	0		27,089	0	28,713
Import-Export	92						

FINAL ENERGY (ktep)							
Total Final Energy	3,370	1,490	69	16,580	0		21,509

CONTRIBUTION (ktep)							
Industry	373	0	39	0	2,958	0	3,370
Transport	0	0	1,490	0	0	0	1,490
Commercial/Services	69	0	0	0	0	0	69
Residential	237	0	3	0	16,340	0	16,580
Agriculture/Fishing	0	0	0	0	0	0	0
Electricity Gen.	119	0	0	0	759	0	878
				77.34%	SOURCE: IEA 2014		

Figure 10: SIMESEN tool input data for a case applied to Spain

An example of the numerical results obtained following the time evolution is presented below:

SCENARIO DESCARBONISATION Spain

Indicators	Units	2022	2015	2020	2025	2030	2035
Population	Millions	74.9	60.5	70.5	82.0	95.5	111.2
GDP	Billion€$_{2010}$	52,200,000	50,735,761	51,777,386	52,840,397	53,925,232	55,032,338
Consumption of Electricity	TWh	7.9	7.1	10.0	15.9	27.7	54.6
CO_2 Emissions	Mt	4.53	2.59	3.48	5.00	7.26	10.79
Primary Energy (EP)	ktep	28,713	23,736	27,813	32,789	39,902	51,223
EP Generated	ktep	20,057	16,986	19,782	23,133	27,974	35,883
Import-Export	ktep	92	83	117	185	323	636
Generated Electricity	ktep	587	528	744	1,178	2,060	4,060
Exterior Dependency	%	30.15	28.44	28.87	29.45	29.89	29.95

Figure 11: Results obtained for some indicators and their evolution over time

3.3 Module 2: Knowledge Database

This module consists of a repository of existing actions in Municipal Action Plans located on tourist islands in Greece, Italy and Spain. The main actions taken have been compiled together with the annual energy savings, annual CO_2 emissions savings and implementation cost per 1000 inhabitants.

The actions have been clustered in the following sections: awareness raising, industry, municipal buildings and equipment and transport.

SECTIONS	ACTIONS	AP in SPAIN	AP in GREECE	AP in ITALY	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO2e)	COST (€)
Awareness-raising	Communication, training and awareness-raising plan	8	0	7	22	8.3	666.67
Awareness-raising	Energy-saving information programme for school institutions	7	1	5	7	3.3	666.67
Awareness-raising	Campaign to promote sustainable mobility	6	0	7	500	80.0	833.33
Awareness-raising	Promotion of walking and electric personal mobility vehicles (EVs)	5	0	2	500	300.0	10000.00
Awareness-raising	Municipal waste collection, recycling and composting network	8	0	2	1	0.3	375.00
Awareness-raising	Rainwater harvesting and utilisation	9	0	3	13	4.5	65000.00
Awareness-raising	Campaign for waste reduction and correct waste management	12	1	0	17	50.0	4000.00
Awareness-raising	Promoting collective self-consumption and citizen energy communities	15	0	3	9	10.0	3333.33
Awareness-raising	Promotion and encouragement of renewable energies (solar photovoltaic, solar thermal, biomass, etc.).	2	1	3	625	1000.0	27500.00
Awareness-raising	Promoting bioclimatic construction and RE in residential buildings	4	7	7	450	300.0	100000.00

SECTIONS	ACTIONS	AP in SPAIN	AP in GREECE	AP in ITALY	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO2e)	COST (€)
Industry	Incentive programme for energy saving and efficiency and the use of renewables in housing and SMEs	9	0	5	57	42.9	1714.29
Municipal Buildings and Equipment	Improvement of Insulation and Air Conditioning Systems	13	8	7	15	9.8	32500.00
Municipal Buildings and Equipment	Energy audits in municipal facilities and street lighting	13	1	5	2	6.3	1666.67
Municipal Buildings and Equipment	Improvement of lighting systems in municipal facilities	10	8	8	1000	46.7	33333.33
Municipal Buildings and Equipment	Installation of renewable self-consumption in municipal buildings	14	1	4	10	45.0	40000.00
Municipal Buildings and Equipment	Replacement of existing luminaires with new ones equipped with LED lamps and remote management	14	6	1	17	8.0	20000.00
Municipal Buildings and Equipment	Renewal of the municipal fleet with electric or plug-in hybrid vehicles.	17	0	5	57	42.9	1714.29
Municipal Buildings and Equipment	Public procurement of green electricity (100% renewable)	7	0	3	17	9.0	2500.00
Municipal Buildings and Equipment	Installation of renewable energies (photovoltaic and thermal) for electricity generation and DHW.	12	7	5	500	500.0	6666.67
Municipal Buildings and Equipment	Regulatory and technical development of criteria for energy saving and efficiency and bioclimatic construction.	6	8	8	533	333.3	2500.00

SECTIONS	ACTIONS	AP in SPAIN	AP in GREECE	AP in ITALY	ENERGY SAVINGS (MWh/year)	CO_2 SAVINGS (tCO2e)	COST (€)
Transport	Establishment of a network of electric vehicle charging points	16	0	4	1050	65.0	7500.00
Transport	Adapting municipal roads for the creation of cycle routes	8	2	6	153	49.4	43529.41
Transport	Promotion of public transport: inland public transport circuit and increased frequency	4	7	3	550	275.0	17500.00
Transport	Tax ordinances to incentivise the renewal or purchase of electric and hybrid vehicles	10	8	2	375	825.0	23125.00

Table 2: Example of the information included in the knowledge base module

3.4 Module 3: Inference

This module provides the user with a calculation method to obtain the impact of implementing actions similar to those offered in the database in terms of energy and emissions, appropriate to the municipality. To this end, a method for calculating energy savings and emissions has been developed for each of the proposed actions. The actions have been organized according to the sections listed in the database module. The following table shows a summary of the sections and the actions included in each one:

Sector 1	**Awareness-raising**
1.1	Installation of Municipal Ecomobile
1.2	Municipal Information Stands
Sector 2	**Industry**
2.1	Incentive program for energy savings and efficiency and use of renewables in SMEs
Sector 3	**Municipal Buildings and Equipment**
3.1	Improvement of building insulation
3.2	Improvement of municipal lighting
3.3	Climate control measures
3.4	Introduction of renewable energy and self-consumption
3.5	Renewal of municipal vehicle fleet
Sector 4	**Transport**
4.1	Creation of cycling routes
4.2	Installation of a network of EV recharging points
4.3	Promotion of public transport

Table 3: Sections and actions included in the Inference Module

Each of the sections and the actions included are described in detail hereafter.

3.4.1 Section 1: Awareness-Raising

This section includes actions related to public awareness, i.e. those directly aimed at having an impact on society. In order to know the emissions saved, it will be sufficient to make the conversion using the electricity mix according to the country in which the municipality is located.

- **Action 1.1 - Installation of Municipal Ecomobile**

Ease of waste disposal (option closest to homes) and informing neighbors on how to dispose of waste (brochures and visual information).

Of particular interest will be the **hours of operation of the ecomobiles** per municipality. Ecomobiles are present in the municipalities according to the number of inhabitants:

Inhabitants	Days of ecomobile services/year
> 50000	52
25000 - 50000	43
15000 - 25000	35
8000 - 15000	26
4000 - 8000	13
2000 - 4000	9
1000 - 2000	7
< 1000	4

Table 4: Number of Ecomobile services/week according to the inhabitants

In terms of **recycling per person**, the EU recorded an average of 249 kg per person by 2024 [6] which amounts to a **person rate (PR) of 0.68kg** per inhabitant per day. Moreover, out of all the waste generated, 46.5% is considered to be part of **the renewable fraction (RF)** [7].

The presence of the ecomobile is considered to increase the collection of Urban Solid Waste (USW) rate by 10% per inhabitant.

The recycled renewable portion is calculated as:

$$Recycled\ waste\ (kg) = Days\ of\ Ecomobile \cdot PR \cdot inhabitants \cdot RF \cdot (1 + 10\%) \qquad (1)$$

To know the thermal energy generated and valorized, it is sufficient to multiply the residue by the Lower Calorific Value (747.7kcal/kg) and convert it to MWh.

- **Action 1.2 - Municipal Information Stands**

This action involves creating campaigns and information stands that have a direct impact on the amount of waste generated per inhabitant or on energy consumption. It is considered that 1.37kg of waste is generated per inhabitant per day [8]. and according to the country there is an energy consumption per capita, being that of Europe of 5,924 MWh / capita [9].

The different campaigns and their impact on waste generation are shown below:

Actions	Impact
Communication, training and awareness plan	Reducing the amount of waste generated by **5%** per person reached
Environmental school for school groups	Reducing the amount of waste generated by **3%** per person reached
Collection of special waste at recycling centres	Reducing the amount of waste generated by **10%** per person reached
Responsible energy consumption strategies	Reduction in energy consumption by **11.5%** [10] per person achieved

Table 5: Actions included in the dissemination campaigns and their impact on the population

3.4.2 Section 2: Industry

This section includes actions that can be promoted for industries and SMEs to reduce energy consumption and emissions.

- **Action 2.1 - Incentive program for energy savings and efficiency and use of renewables in SMEs**

Within the different ways to promote SMEs to achieve energy savings and efficiency, this action proposes different paths and actions to encourage enterprises, and the corresponding energy savings that this entails. The values have been obtained from a technical guide for energy efficiency in industrial practice [11].

The proposed **incentive lines** are *Change of energy vector, Improvement of Industrial Buildings, Improvement of processes and Renewal of equipment*.

Actions	Energy savings (%)	Electric energy savings (kWh/year)	Ratio (investment/savings)	Emissions tCo2/year
Hot water preparation by heat pump	60%	3605300.00	161.57	1879.11
High efficiency, variable flow LPG burner	20%	17445.00	449.96	9.09
Substitution of fuel oil for high efficiency LPG burners for steam generation	40%	232600.00	139.81	121.47

LPG burner in direct air vein	20%	23260.00	612.81	13.33
Replacement of boiler with heat pump for DHW and process hot water production	60%	372160.00	208.10	192.84

Table 6: Actions for SMEs on energy vector change and impact

Actions	Energy savings (%)	Electric energy savings (kWh/year)	Ratio (investment/savings)	Emissions tCo2/year
Improvement of thermal insulation in freezing chambers	60%	186080.00	898.62	99.16
Reduction of heat gains in air-conditioned process halls	20%	1093220.00	116.68	571.54

Table 7: Actions for SMEs on change and impact of industrial building improvement

Actions	Energy savings (%)	Electric energy savings (kWh/year)	Ratio (investment/savings)	Emissions tCo2/year
Replacement of a refrigeration plant for a more efficient one with a cold storage tank	40%	360530.00	774.89	183.18
Evaporative cooling for industrial air conditioning processes	70%	1697980.00	161.74	885.7
Replacement of the refrigeration plant for another with natural refrigerant and subcritical Co2 cascade plant	60%	116300.00	1170.77	58.51
Replacement of the refrigeration plant with a more efficient mini-plant, designed under eco-design criteria	40%	73269.00	1164.92	38.23
Replacement of existing chiller plant for one with natural refrigerant R717 (ammonia) in primary circuit with glycol distribution in secondary circuit	40%	3756490.00	1087.96	140.76
Air conditioning in food industry with Water/Water inverter system (geothermal)	70%	46520.00	1096.04	26.05

Table 8: Actions for SMEs on change and the impact of industrial process improvement

Actions	Energy savings (%)	Electric energy savings (kWh/year)	Ratio (investment/savings)	Emissions tCo2/year
Replacement of existing chiller plant for one with natural refrigerant R717 (ammonia)	40%	348900.00	1133.28	184.78
Replacement of existing refrigeration plant with partial heat recovery refrigeration plant	60%	104670.00	327.34	53.32
Replacement of existing chiller plant for one with natural refrigerant R290 (propane)	60%	3605300.00	0.34	22.81
Industrial air conditioning with EC fans (electronic switching)	40%	46520.00	44193.55	24.75

Table 9: Actions for SMEs on change and the impact of industrial equipment refurbishment

3.4.3 Section 3: Municipal Buildings and Equipment

This section includes all actions related to municipal buildings and equipment under the responsibility of the city council. A table with the actions and the measures to be selected within each action is provided below.

Actions	Description
Improvement of insulation of Municipal Buildings	Improvements in windows (replacement of glass) and facade insulation.
Municipal Lighting Improvement	Replacement of lighting fixtures with more efficient ones
More efficient HVAC systems	Improved heating, cooling and DHW systems.
Introduction of renewable energy and self-consumption	Possibility of integrating renewable energies such as: solar thermal, photovoltaic and biogas, as well as introducing self-consumption at the municipal level.
Renewal of the Municipal vehicle fleet	Current municipal vehicles: retired vs. purchased with new technologies (hybrid and electric).

Table 10: Summary of actions at the municipal level

- **Action 3.1 - Improvement of building insulation**

This action proposes to improve the insulation of municipal buildings mainly through the replacement of windows with others with better performance or the introduction of new insulation in the facade. To calculate the insulation improvement, the heat transfer equation is used, for which the thermal conductivity of the material (W/mC), the thickness of the insulation (m) and the difference between outside and inside temperature will be necessary.

➢ Improvement of enclosures: windows

Replacement of glass with glass with better thermal transmittance value or replacement of glass with solar control or improvement of solar control.

The objective is to calculate energy savings as well as avoided emissions. To do so, the user must enter the data of the current windows and select the ones he/she wants to implement to improve insulation. The system offers a type of glazing with its corresponding thermal transmittance (can also be entered manually by the user):

Glazing type	Transmittance (W//m2K)
Double glazing b	1.8
Solar control glass	3.3
Double window	5.7
Frame enhancement	3.2

Table 11: Improvement values of municipal windows

Considering the glazing area to be replaced $W_{surface}$, the difference between the outdoor/indoor temperatures and the difference between the old and new windows (new t_n and old t_o transmittance), the average daily savings in kWh/day are calculated. For this it is assumed that in summer the sun heats for 12 hours and in winter about 10 hours.

$$Daily\ savings\ \left(\frac{kWh}{day}\right) = W_{surface} \cdot \Delta_T \cdot (t_n - t_o) \cdot \frac{H_{sun}}{1000} \quad (2)$$

To obtain the avoided emissions, it will be enough to multiply the saved energy by the electricity mix gCO2eq/kWh.

➢ Improvement of thermal insulation in façade

Improvement of thermal insulation in facade or change of insulation to one with better properties. To calculate the insulation improvement, the heat transfer equation is used, for which the thermal conductivity of the material (W/mC), the thickness of the insulation (m) and the difference between outside and inside temperature will be necessary.

$$q\ \left(\frac{W}{m^2}\right) = \left(\frac{k}{l}\right) \cdot (T_s - T_{ext}) \quad (3)$$

Below are the values offered by the tool for the insulation change:

Insulation type	Conductivity (W/mC)
Glass wool	0.04
Stone wool	0.05
Expanded polystyrene	0.03
Gypsum panel	0.17
Insulating brick	0.15
Ordinary Brick	0.8

Table 12: Conductivity values for new insulating materials

To obtain the avoided emissions, it will be enough to multiply the saved energy by the electricity mix gCO2eq/kWh.

- **Action 3.2 – Improvement of municipal lighting**

This action involves the replacement of luminaires with more efficient ones, according to the existing ones in the following table:

Luminaire Type	Minimum power (W)	Maximum Power (W)	Lifetime (h)	Efficiency (lm/W)
Incandescent	25	2000	1000	8
Halogen	40	100	2000	15
Fluorescent tubes	16	65	6000	48
Mercury	50	2000	24000	32
Metallic halogen	70	3500	10000	75
Induction	70	150	60000	80
BP Sodium	18	180	8000	100
AP Sodium	35	1000	8000	60
Sodium White	35	150	15000	40
LEDs	1.5	50	50000	60

Table 13: Types of luminaires and features

To calculate the energy saved it will be necessary to know the power of the initial and final luminaires with the most efficient change for the annual electricity consumption.

$$E_{saved}(MWh) = (P_{in} - P_{fin}) \cdot 7.5\ h/day \cdot 260\ day/year \quad (4)$$

To obtain the avoided emissions, it will be enough to multiply the saved energy by the electricity mix gCO2eq/kWh.

- **Action 3.3 – Climate control measures**

This action aims to study the current system and propose more efficient measures in air conditioning services for cooling/heating/DHW in municipal buildings.

First, the energy demand of the municipal building is characterized taking into account values such as:

- **Demand of the municipal building**. *Annual heating demand* in kWh (months from May to October) and *annual cooling demand* in kWh (months from December to March) are requested. *Annual DHW consumption* in liters is also requested.
- **Current installation, differentiating heating and DHW if applicable**: standard boiler, condensing boiler, electric radiator.
- **Fuel used**: oil, natural gas, pellets, electricity, etc.
- **Type of emitter**: radiators, underfloor heating, fan coil, etc.

If it is not possible to provide specific data, a selection of current systems will be made to estimate electricity demand.

Heating system

Different heat generating systems are provided to determine both the current system and the heating system to be implemented. The following table shows some types of systems and the factors that characterize the determination of their demand:

Heating equipment/emitter system	Factors for calculating electricity consumption (kWh)
Boiler/Fuel	Performance
Air conditioning equipment	Seasonal Coefficient Of Performance (SCOP)
Aerothermal	Seasonal Coefficient Of Performance SCOP| Weighting Factor (WF)| Correction Factor (CF)
Geothermal	Seasonal Coefficient Of Performance | Weighting Factor (WF)| Correction Factor (CF)

Table 14: Characterization of heating systems

The following formulas are used to calculate the electrical consumption of the system:

$$SCOP = COP_{nominal} \cdot WF \cdot CF \qquad (5)$$

Where:

- **PF**: weighting factor that considers the different climatic zones, based on the Spanish Technical Building Code (CTE), which has been calculated with an exclusively technical methodology using objective values and existing Recognized Documents [12].

- **CF:** correction factor that considers the difference between the distribution or use temperature and the temperature for which the COP has been obtained in the test.

Finally, electricity consumption is calculated as follows:

$$Annual\ electricity\ consumption = \frac{Annual\ heating\ demand}{SCOP} \tag{6}$$

The new heating system will have to be taken into account:

Heating equipment/emitter system	Improvement parameters
Boiler/Fuel	Choose a boiler with the best performance according to the table and with the selected fuel.
Air conditioning equipment	Choosing equipment with better COP
Aerothermal	Considering formulas 5 and 6, choosing the system with the lowest power consumption
Geothermal	Considering formulas 5 and 6, choosing the system with the lowest power consumption

Table 15: Heating systems and the parameters to be considered for system improvement

In relation to boilers, a table has been created with the different types of boilers, the fuel used, their energy rating and energy consumption in order to offer more efficient systems:

Heating equipment	Fuel	Energy Qualification	Boiler Performance	kWh total primary E./kWh final E.	Primary energy for 1 kWh demand	CO_2 Emission Factors	Associated emissions
Standard boiler	Natural Gas	A	90%	1.195	1.3278	0.252	0.3346
Standard boiler	Gasoil	B	90%	1.182	1.3133	0.311	0.4084
Standard boiler	GLP	A	90%	1.204	1.3378	0.254	0.3398
Standard boiler	Biomass	A+	90%	1.037	1.1522	0.018	0.0207
Standard boiler	Pellets	A+	90%	1.113	1.2367	0.018	0.0223

Low temperature boiler	Natural Gas	A+	95%	1.195	1.2579	0.252	0.317
Low temperature boiler	Gasoil	A+	95%	1.182	1.2442	0.311	0.3869
Low temperature boiler	GLP	A+	95%	1.204	1.2674	0.254	0.3219
Condensing boiler	Natural Gas	A+	105%	1.195	1.1381	0.252	0.2868
Condensing boiler	Gasoil	A+	105%	1.182	1.1257	0.311	0.3501
Condensing boiler	LPG	A+	105%	1.195	1.1467	0.254	0.2913
Electric water heater	Electricity (within the mainland)	D	100%	2.403	2.368	0.331	0.7838
Electric water heater	Electricity	D	100%	2.368	3.011	0.833	2.5082
Electric radiator	Electricity	D	100%	2.403	2.368	0.331	0.7838

Table 16: Types of boilers and their characteristics

- ### *Heating and DHW system*

In case heating and domestic hot water are considered as a single system, the DHW demand should also be considered in the calculations of energy consumed. The following shall be taken into account for the improvement of the system:

Heating and ACS equipment/emitter system	Improvement parameters
Boiler	Choose a boiler with the best performance according to the table and with the selected fuel.
Aerothermal	Considering formulas 5 and 6, choosing the system with the lowest power consumption
Geothermal	Considering formulas 5 and 6, choosing the system with the lowest power consumption
Solar Thermal Energy	Introduce renewable system whenever there is available surface on the roof of the building.

Table 17: Heating and DHW systems, as well as the parameters to be taken into account to improve them

In relation to solar thermal energy, the calculations are somewhat more complex as more parameters must be considered:

- The DHW demand must be calculated considering the water flow rate used depending on the type of building (ANNEX I).
- The climatic zone in which the building is located provides the minimum solar contribution in %.
- The volume of the solar storage tank is calculated according to the average daily DHW demand.

Therefore, the power provided by the solar thermal collectors is calculated with the following formula [13]:

$$Power_{solar} = \eta \cdot S_{panel} \cdot G_t \qquad (7)$$

Where:

- $\boldsymbol{\eta}$: Performance according to collector type.
- $\boldsymbol{S_{panel}}$: Useful surface or area of the collector (m^2).
- $\boldsymbol{G_t}$: Total irradiance on collector surface (W/m^2).

○ *Cooling system*

In relation to cooling systems, the methodology is similar to the case of heating. First, the current systems present in the building are studied, and the electricity consumption is calculated according to the Seasonal Energy Efficiency Ratio (SEER).

Cooling equipment/emitter system	Factors for calculating electricity consumption (kWh)
Fan	Performance
Air conditioning equipment	Seasonal Energy Efficiency Ratio (SEER)
Aerothermal	Seasonal Energy Efficiency Ratio (SEER)| Weighting Factor (WF)| Correction Factor (CF)
Geothermal	Seasonal Energy Efficiency Ratio (SEER)| Weighting Factor (WF)| Correction Factor (CF)

Table 18: Characterization of cooling systems

To calculate the electrical consumption of the system, the following formulas are used, similar to the case of heating but in this case the parameters related to cooling are used:

$$SEER = SEE_{nominal} \cdot WF \cdot CF \qquad (8)$$

$$Annual\ electricity\ consumption = \frac{Annual\ cooling\ demand}{SEER} \qquad (9)$$

When installing a new refrigeration system, the following should be considered:

Cooling equipment/emitter system	Improvement parameters
Fan	According to the consumption of the fan (W) at average speed and the hours of use, obtain the kWh of use of that fan and propose one with lower consumption.
Air conditioning equipment	Choosing equipment with better EER
Aerothermal	Considering formulas 8 and 9, choosing the system with the lowest power consumption
Geothermal	Considering formulas 8 and 9, choosing the system with the lowest power consumption

Table 19: Cooling systems and the parameters to be considered for system improvement

- **Action 3.4 - Introduction of renewable energy and self-consumption**

This action is aimed at introducing renewable energies in municipal facilities and even encouraging the municipality to participate in self-consumption modalities.

Initially, buildings where renewable energies can be installed, such as schools, public service buildings, sports centers, indoor pavilions, heated swimming pools, emergency services, public events buildings, waste collection centers, etc., should be identified.

Afterwards, the hours of use of the buildings will be analyzed. If the hours of use coincide with production, the self-consumption mode without surplus will be proposed, and if the hours of use do not coincide with production, self-consumption with surplus will be proposed.

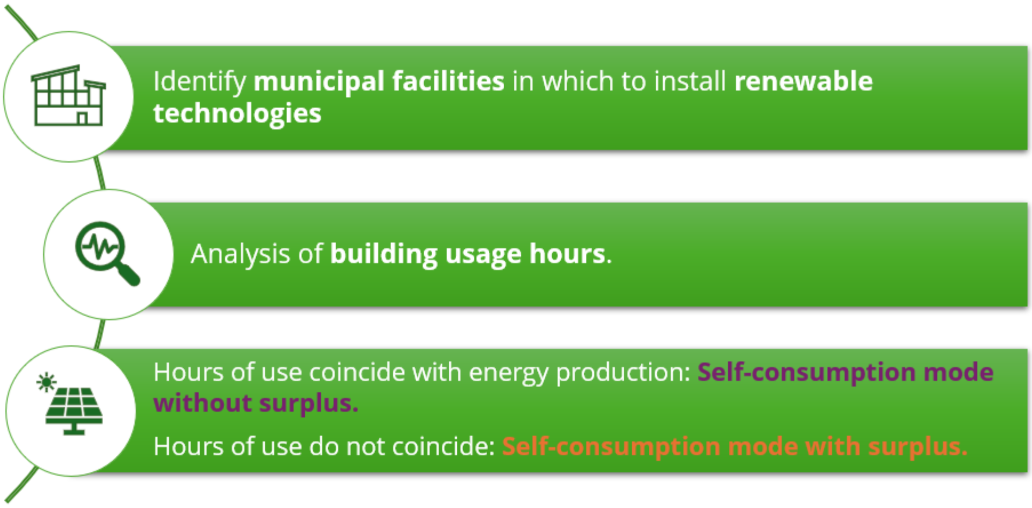

Figure 12: Methodology for the introduction of renewable technologies in municipal buildings

Once the needs of the municipality have been identified, the following renewable sources are proposed:

Proposed renewable system	Municipal energy use
Solar thermal energy	Covering the DHW demand of municipal buildings
Photovoltaic Energy	Partially or totally cover the electricity demand of municipal buildings.
Photovoltaic energy and batteries	Complete coverage of the electricity demand of municipal buildings
Biogas	Use of organic wastes for biogas
Energy community with self-consumption	Creation of an energy community to share the energy generated with other buildings/municipalities.

Table 20: Renewable systems and modalities proposed at the municipal level

For each of the renewable systems, the following will be required:

- **Solar thermal energy.** *Please, review the information included in the previous action in the section of "Heating and DHW system".*

- **Photovoltaic Energy**

In the case of introducing photovoltaic energy, the following data will be requested:

- Location irradiance G_t (Wh/m^2)
- Panel surface S_t (m^2)
- Panel type efficiency η (%)

Based on the above, the photovoltaic production would be calculated as follows:

$$Ph_{prod}(Wh) = G_t \cdot S_t \cdot \eta \qquad (10)$$

- **Photovoltaic energy and batteries**

This case is complementary to the installation of photovoltaic panels but including batteries to store energy. This would apply to the case of self-consumption without surplus to consume the energy generated by the panels in a non-instantaneous way.

To calculate the battery capacity, it would be necessary to know the **days of autonomy** established according to the use of the building, and the value of the **depth of discharge** depending on the type of battery used.

➢ Biogas

This renewable system will be proposed for those municipalities that generate organic waste that can be processed and from which gas can be obtained either for use or electricity production. Information will be provided on the different organic wastes to be used:

Type of waste	Examples
Animal origin	Manure, urine, guano, bedding, slaughterhouse wastes, fish wastes
Vegetal origin	Weeds, crop residues, straws, fodder, forage, etc.
Human origin	Feces, garbage, urine etc.
Agro-industrial	Seed residues, pomace, molasses, rice bran, rice bran
Forestry	Leaves, stems, twigs, branches and bark
Aquatic crops	Seaweeds, hyacinths and aquatic weeds

Table 21: Types of waste for biogas generation

The data that will be required will be mainly:

- Kg of urban waste per day
- Percentage of organic waste (%)
- Type of reactor (mainly anaerobic to generate biogas)

➢ Energy community with self-consumption

The municipality will be offered the possibility of becoming part of an energy community. To this end, questions such as the following will be raised:

- Current cost of energy
- If there are photovoltaic panels, is all the energy consumed?
- Would there be a possibility of sharing energy with other municipal buildings?

Finally, the final cost of energy would be provided in the case of shared self-consumption.

• Action 3.5 - Renewal of municipal vehicle fleet

This action proposes to calculate emission reductions based on the number of vehicles retired at the municipal level and those purchased new. The reference emissions per vehicle vary from country to country, for GENERA the project it has been established:

Country	Type of fuel	Emissions (gCO2/km)
Spain	Diesel	143
	Gasoline	125
	LPG	115
	Diesel/Electric	40
	Gasoline/Electric	35
	Electric	82
Italy	Diesel	140
	Gasoline	125
	LPG	118
	Diesel/Electric	40
	Gasoline/Electric	30
Greece	Diesel	128
	Gasoline	125
	LPG	115
	Diesel/Electric	43
	Gasoline/Electric	38

Table 22: Emissions by vehicle type and country

3.4.4 Section 4: Transport

The transport section involves all those activities that imply and promote the reduction of emissions due to transport at the municipal level.

- **Action 4.1 - Creation of cycling routes**

  It focuses on emissions savings per km of cycling compared to conventional vehicle use. After reviewing the bibliography [14], the report of a tool to assess the impact of cycling has been obtained that the average travel distance for cycling routes is 4.1km while for public car routes it is 15.6 km. Therefore, by creating a new cycling route it is intended to reduce the distance to be traveled within the municipality and the emissions saved by the use of bicycles instead of cars would be calculated:

$$Car\ emissions_{saved} = Cycling_{distance} \cdot bike_{em} - Car_{distance} \cdot Car_{em} \qquad (11)$$

- **Action 4.2 - Installation of a network of EV recharging points**

  Calculations of emissions savings per installed recharging point are made taking into account the values in relation to the installed charger.

  Required data will include:

- Daily hours of use of the recharge point (RP)
- Charger power (kW)

Considering the electric energy supplied (kWh) and the consumption of a standard electric vehicle, the km traveled are obtained. This value can be used to calculate the emissions savings compared to a conventional vehicle.

- **Action 4.3 - Promotion of public transport**

Finally, an action to promote public transportation is included. For this purpose, an analysis has been made of different actions taken in cities [15] and classified according to the size of the municipality. Each action implies a specific percentage of emissions reduction as shown below:

Measures	Description	CO_2 Savings (%)
Reduced speed zones	Establish reduced speed zones within the municipality	25
Ecozone (ZBE)	Zones in which vehicles with certain emissions labels may be entered. For large municipalities with more than 50,000 inhabitants	97
Tolls	Implementing peak hour tolls. For large municipalities with more than 50,000 inhabitants	30
Congestion charge	Reduce the number of cars entering the city centre. For large municipalities with more than 50,000 inhabitants	20
Increased throughput frequency	Increasing the frequency of public transportation in schedule or route.	10
Reduced fees	Reduced rates for Youth and Retirees	5

Table 23: Actions on transport to reduce emissions in municipalities

3.4.5 Example of the Inference Module

Some examples of the inference module are shown below:

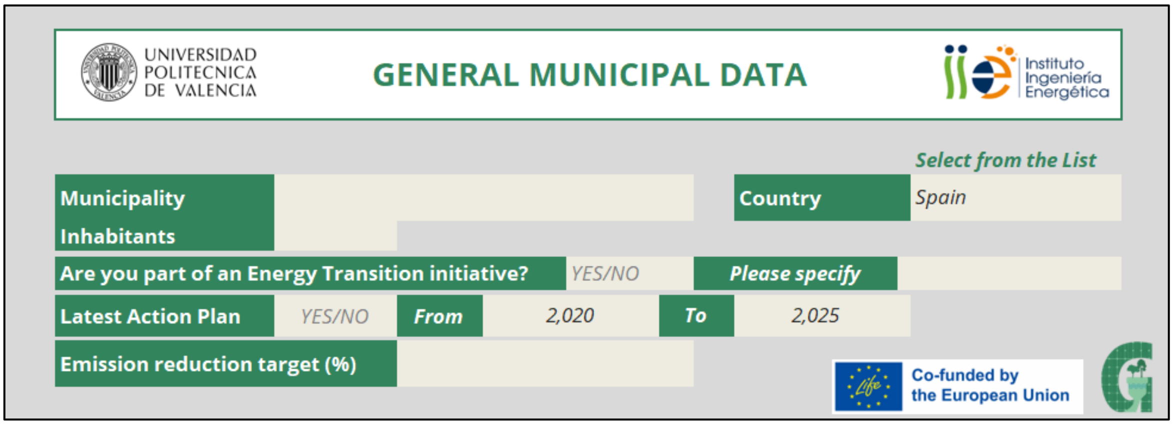

Figure 13: General data input interface

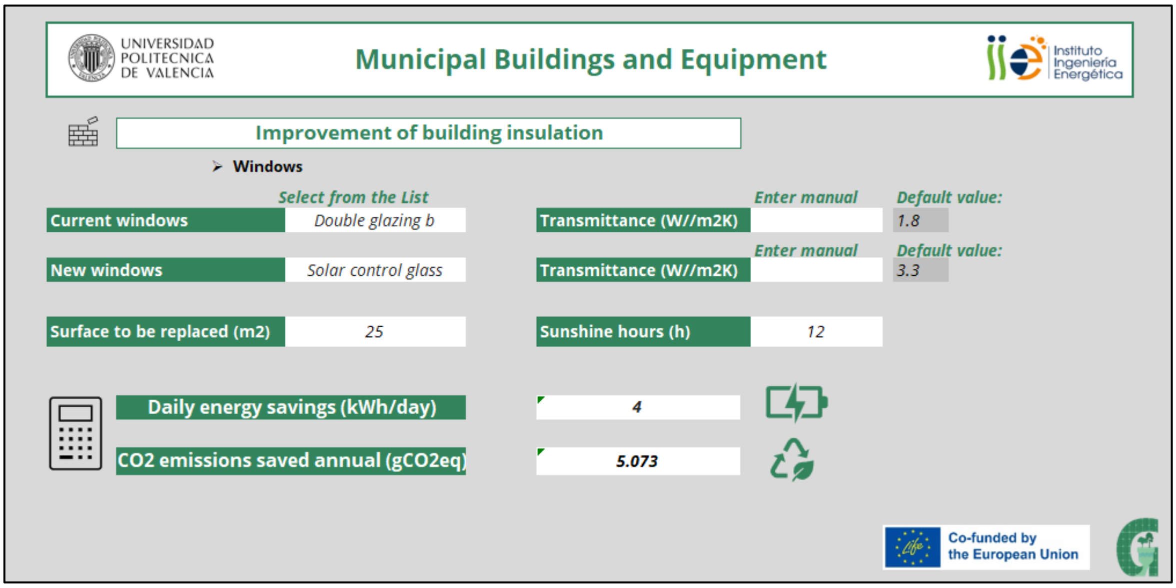

Figure 14: Interface for data input and calculation of savings measures

3.5 Module 4: Multi-criteria Decision-Making

The last GENERA module presents is strongly related to decision-making at the municipal level. It is a process of analysing several alternatives in order to select the best solutions for the particularities of the case, which is usually extremely complex due to the presence of conflicting and competing objectives among the available criteria or alternatives.

In the municipal case, the multi-criteria evaluation of alternatives is applied to analyse and evaluate feasible solutions to be applied in SECAPs from a broader approach. Not only are the technical or economic parameters of implementing sustainability-related measures such as solar photovoltaic energy in isolated communities considered, but also the environmental, social and political variables involved in the final decision. The multi-criteria approach allows quantitative and qualitative aspects of the solution to be integrated into the evaluation process.

3.5.1 Analytical Hierarchical Process (AHP)

This last module is approached using the Analytical Hierarchical Process (AHP), a well-known method proposed by Thomas Saaty and which has been used in different sustainability applications [16]. It is one of the most widely used multi-criteria analysis methods, which considers a hierarchical process with multiple levels. At the top level of the hierarchy is the objective, the next level includes the selected criteria, and the lower level consists of the possible alternatives. At each hierarchical level, paired comparisons are made with judgments using numerical values taken from the absolute AHP fundamental scale of 1 to 9 (see Figure xx). These comparisons are used to establish matrices in which eigenvectors are defined from ratio scales.

The AHP process is developed in four stages as shown in the following figure:

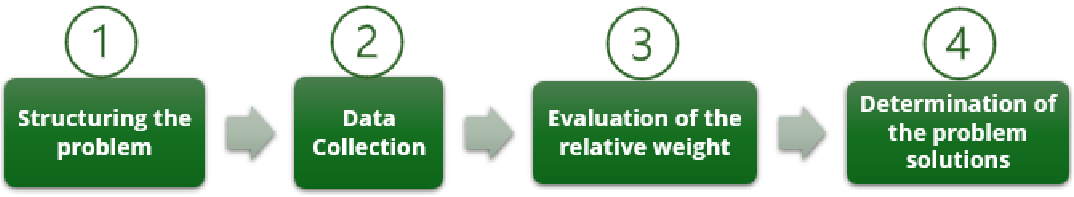

Figure 15: Phases of the AHP method

1. **Structuring the problem.** It attempts to define the problem to be addressed in hierarchical levels represented by attributes. The AHP method deals with the mutual comparison of the elements of a hierarchical level with the elements of a higher level, which generally includes three levels (objective-criteria-alternatives). Thus, the criteria are compared in relation to the objective, in order to determine their mutual importance, and the alternatives to each of the criteria established.

2. **Data Collection.** The second phase involves:
   o Collecting and/or measuring data.
   o Defining pairwise importance ratings with attributes of a hierarchical level relative to the top level.
   o Repeat the process for all hierarchical levels.

3. **Evaluation of the relative weight.** The relative weight is then estimated. That is, the priorities of the criteria, sub-criteria and alternatives are determined using a method of:
   o Arithmetic mean,
   o Geometric mean, and
   o Difference method.

4. **Determination of the problem solutions.** The last stage in the application of the AHP method is the determination of the composite normalized vector. The composite vector is used to determine the relative priority of the entities at the lowest (hierarchical) level, which allows to achieve the set objectives of the overall problem.

3.5.2 AHP applied to municipal decarbonization

The **main objective** is to select the best solution for the Municipal Action Plans to achieve sustainability and decarbonization of the municipality according to municipal priorities.

The **four criteria** identified as priorities for the elaboration of the Municipal Action Plans are *technical, economic, environmental, social and political*, with several sub-criteria each.

The **criteria** with the chosen **sub-criteria** are presented below:

o ***Technical Criteria.***

- **Maturity:** A mature technology is a technology that has been in use for long enough that most of its initial faults and inherent problems have been removed or reduced by further development.
- **Demand coverage:** share of total demand covered by renewable energy (RE).
- **Excess of electricity:** surplus electricity generated that must be fed into the grid because it cannot be used to serve demand instantaneously or charge batteries.
- **Efficiency:** energy efficiency measures that apply to the municipality.

o ***Economic Criteria***

- **Initial investment**: is the total installed cost of decarbonisation measures.
- **O&M:** cost associated with operating and maintaining the decarbonisation plan. The total O&M cost of the system is the sum of the O&M costs of each system component.

- **Cost of Electricity (COE):** average cost per kWh of useful electrical energy produced by the system.

- ***Social Criteria***
- **Public acceptance:** Public perception of the different measures taken to decarbonise the municipality. Based mainly on the type of technology used.
- **Job creation:** Potential of employment opportunities to be created by constructing and operating the decarbonisation plan.

- ***Environmental Criteria***
- **CO_2 emission:** Capacity of measures to alleviate CO_2 emissions.
- **Renewable fraction:** percentage of total energy production generated from renewable power sources.
- **Impact on environment:** Effect of decarbonisation measures on the environment, visual and biodiversity.
- **Land requirements:** Land requirement for physical installation renewable energy plant and its fuel supply.

- ***Political Criteria***
- **Political acceptance**: political priorities in terms of energy and the promotion of renewable power supply.
- **Alignment with national/regional energy policies:** degree of relation with the actual national and regional policies in energy, mainly in energy accessibility and promotion of renewable energies.

The alternatives correspond to the feasible solutions identified in the previous section, where different system architectures are suitable to meet the municipality's decarbonisation objectives.

The hierarchical AHP implementation scheme for the selection of decarbonisation solutions is presented below:

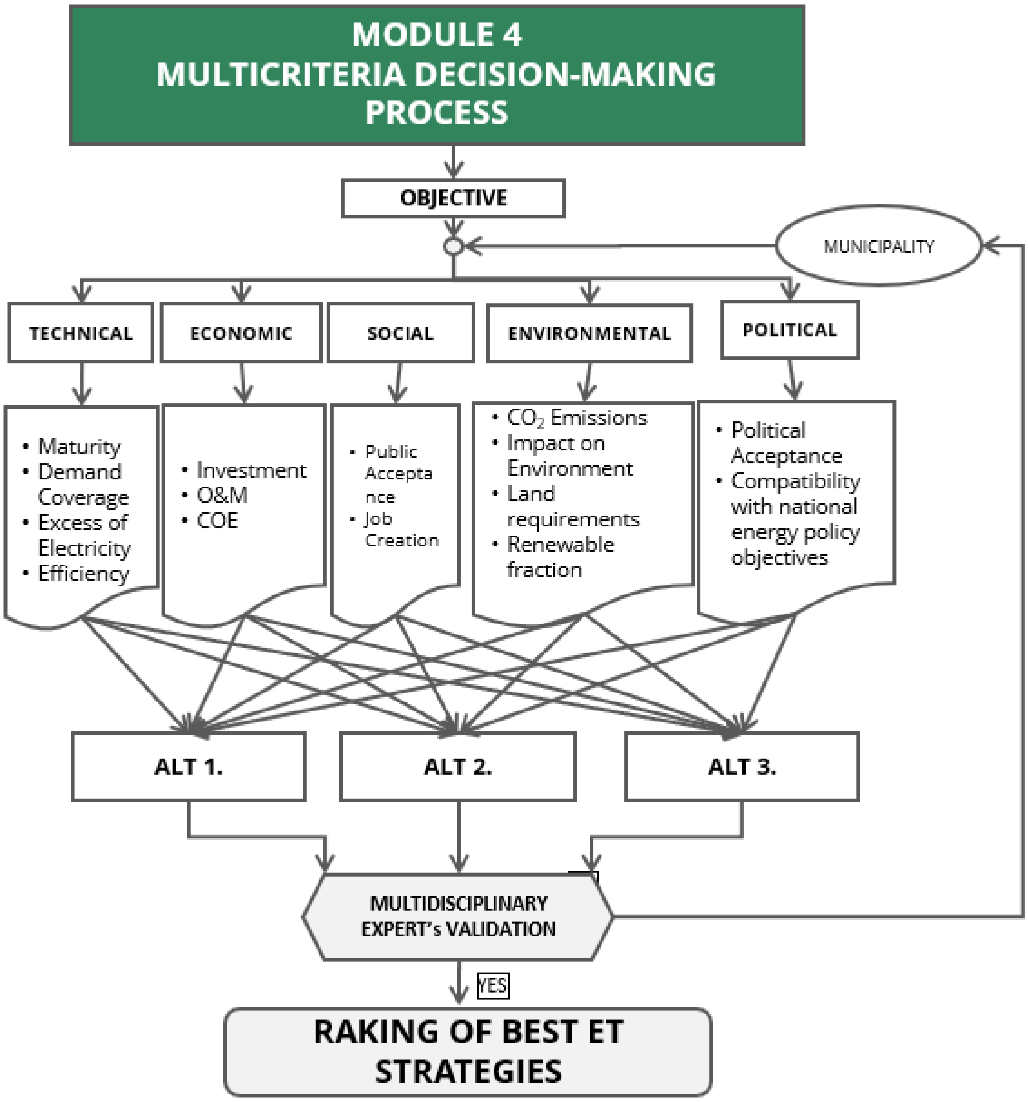

Figure 16: Outline of the AHP method with the defined criteria and sub-criteria

4. Conclusions

As a conclusion, it can be said that through this document, the GENERA project proposes the provision of harmonized and user-friendly ET monitoring tools for municipalities in order to:

- Monitor their progress towards set commitments (such as the Covenant of Mayors);
- Create a knowledge database integrating holistic ET-related information in municipalities of tourist islands (Sardinia - Italy, Balearic and Canary Islands - Spain and Greek islands), including best practices;
- Provide a package of energy solutions specific to tourist islands, transforming the information into added value for policy and decision makers;
- Introduce a co-creation approach in the decision-making process by using a multi-criteria methodology for the identification of the most promising solution.

All this is intended to achieve the goal of providing ET stakeholders with novel, valuable and common multi-criteria energy monitoring tools, adapted to the needs of the islands, to facilitate decision making and drive the sustainable energy transition by leveraging existing initiatives.

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ANNEX I

DHW demand criteria according to type of Municipal building:

ACS Demand Criteria	Unit consumption (liters/day)
Hospitals and clinics	55
Outpatient clinic and health center	41
Hotel *****	69
Hotel ****	55
Hotel ***	41
Hotel/Hostal **	34
Hotel/Pension *	28
Residence	41
Penitentiary Center	28
Locker Room/Collective Showers	21
School without showers	4
School with showers	21
Offices	2
Gymnasiums	21