Model Integration for Territorial Environmental & Social Assessment trough Life-Cycle Approach: The case study of the Province of Matera.

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Abstract—**Systemic view in Strategic Environmental Management is gaining even more attention. The paper proposes the case of a Territorial Environmental and Social Assessment (TESA), based on a Life-cycle approach, applied to set-up the Matera Provincial Plan for a strategic environmental management. Information for performing LCA is here integrated through an Energy-Social Planning model as a decisional support tool. The city-owned buildings are critical facilities for Territorial energy management: the focus here is mainly on energy efficiency. The results obtained of the study contribute to reach EU targets according to the new Directive of the European Parliament and of the Council on the energy performance of buildings.**

I. INTRODUCTION

A Strategic Environmental Assessment (SEA) is an approach to incorporate environmental issues in territorial plan and program development. It can also be regarded as a decision support process, especially when considering plan development. Details on SEA are defined in the Directive 2001/42/EC, which is mandatory for the EU Member States by July 2004.

Different analytical tools can be used to perform such assessments (e.g., Material Flow Analysis, the Ecological Footprint, Emergy analysis, etc.). Among all, Life Cycle Assessment (LCA) has been identified as one of the most promising tools, as it can be used to perform a comprehensive assessment of a territory as a whole (systemic view). Behind LCA, there is the assessment of the environmental impacts and resources used throughout a system's life cycle; for a product, for instance, from raw material acquisition, toward production and use phases, up to waste management. Its capability to avoid problem-shifting between life cycle stages, territories, and environmental impacts is a significant asset [1].

Few studies has been devoted so far performing LCA at a territorial scale, to assess the impacts of specific anthropic activities (economy, social, cultural, training, education,..). An approach based on LCA has been developed to provide macro-level life-cycle indicators to monitor the consumption of the EU-27 and Germany (European Commission 2012a). LCA study has been performed to evaluate different energy resource-management scenarios as in Sweden municipalities [2]; the same has been done for water systems in Sydney [3]. Another study investigate the environmental sustainability of the Province of Siena and of its communes, by means of different indicators and methods of analysis [5]. The standardized LCA framework has never been applied as such to study a territorial system [4].

In this paper, an integrated approach of a Life-Cycle Assessment methodology is proposed to perform a Territorial Environmental & Social Assessment (TESA) to provide a systemic analysis to the Matera strategic environmental management based on Life-cycle policy. A conceptual model is proposed to contextualize the data and assessment criteria and make the TESA congruent with the on-going Territorial energy strategy. This allowed to take into account the meaning of data in a dynamic scenario, thus allowing to set-up an effective analytical tool. A benchmark is also provided with a previous Social & Environmental Management applied to the municipal energy-plan of the Province of Matera.

When estimating environmental impacts of a territory, one can consider it as a "black box" that interacts with other black-box territories via a variety of inputs and outputs. In this case, impacts of human activities are independent of location within the territory. The territory should be considered as a system in which emissions occur at different places and impacts are influenced by the sensitivity of the receiving environment [6].

II. LCA AND TESA PROCESS

This section outlines the design and scope of the Territorial Environmental & Social Assessment (TESA) process performed according to the LCA approach made possible by the use of a conceptual Model as shown in figure 1.

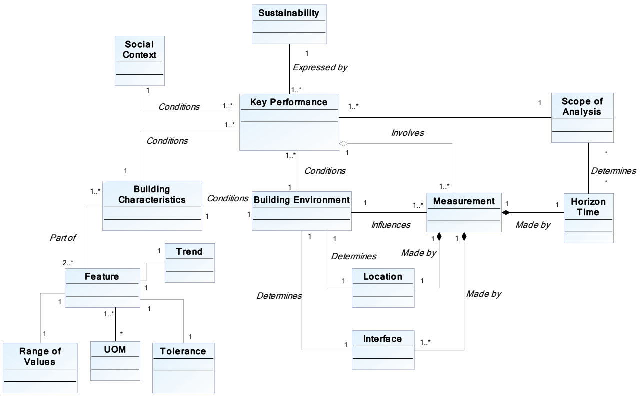

Figure 1. TESA Conceptual Model

It is clear that the core of the approach, the assessment of sustainability, is based on the appropriate selection of one or more key performance indicators. In the same way, it is evident that these are influenced by some factors (namely the scope of the analysis and the social context) which should be taken into account. Buildings features are critical to performance assessment; this fact should be also considered when organizing data or information for the assessment. To say it in a word, the conceptual model represents a sort of guide to organize the overall information gathering and organization at Territorial level. This process is still under testing and the present paper represents an initial method to go in the direction of organizing a systemic approach to the area.

Where sustainability is the core concept to the successful assessment. It is more than an index since it is expressed by a set of key performance indicators. Building environment and building feature as well as social context strongly influences the assessment approch. The same model specifies the critical knowledge assets either to perform a correct Territorial Environmental & Social Assessment as well as to design and manage an appropriate and interoperable database at territorial level. The model in fact ensures the internal congruence of information and knowledge of several Territorial real estate assets so as to build a de-facto interoperable management database.

The process consists of several steps; the focus will be on the city-owned buildings are an important asset for managing the Environmental plan of a Region, where it is necessary to strongly focus on energy efficiency.

In the following we give details of the case study presented to discuss model integration.

A. *First TESA- process step: Energy analysis of public buildings*

The first phase of the TESA process based on the Territorial LCA consists of a careful check-up (inventory) of the municipal construction, to provide a detailed picture of the public buildings features, their facilities as well as their energy performances. This phase is a key element for maintenance planning aimed at energy saving, both on the buildings as well as the energy plants. This Territorial inventory of public buildings is strongly influenced by the Territorial management strategies in terms of Social welfare as well as Energy management. Strategic choices in this terms strongly influence the data related to energy consumption of different buildings (say, efficiency improvement plans, energy policies in term of renewable sources, etc.). TESA may allow to identify the critical in territorial management and therefore may enable to support the development of a intervention strategy on the entire building stock and energy plant, selecting the priority actions to take.

Energy analysis of public buildings was performed to get the relevant data to the energy performance of the Territorial public buildings as well as the Territorial energy facilities (thermal characteristics of the housing, the energy conversion systems and distribution etc.). Consumption (bills), characteristics structural building, near buildings (away) as well as areas of shading were also evaluated. The Energy-Social Planning model was adopted to guide the data acquisition based on the information related to each asset: namely social destination of buildings (and therefore the consequent use) as well as the forecasted improvements on the buildings themselves. The social destination are: schools, municipalities, hospitals, theaters, stadiums,..

B. *Second TESA- process step: Data interoperability using the TESA Model*

The second phase of SEA process includes the performance of energy-audit of municipal buildings to assess the potential energy savings on municipal assets. The energy-audit survey (energy) involves an on-field inspection of the buildings and the collection of detailed information on the energy efficiency of the building envelope, as well as their facilities and equipments for energy production. Following the audit it is easy to assess savings and possible maintenances based on decision-support tools (say, e.g. cost-benefit analysis).

The basic variables that are behind the TESA Model and that are important to be cataloged for buildings and interact have been devised as follows:

- GPS coordinates;
- Consumption of methane gas;
- Consumption of thermal energy;
- Type of heating system;
- Heat fuel value
- heating system efficiency;
- Year of construction;
- Wall Building Materials (brick / concrete / stone / mixed)
- historical-artistic constraints (yes / no)
- Number of floors (including ground floor)
- Building height (m)
- Usable living areas (square meter)
- Heated volume (cubic meter)
- Type of roofs /coverages (plane / pitched)
- Windowed area (square meter)
- Matte surfaces (square meter)
- No. of lightings
- Renewable energy production
- Neighborhood shading

The consumption data are recorded on annual basis and were referred to residents of a given property, identified with the cadastral data according to the social planning information. These data have a format incongruence: it was necessary to link them graphically to the Geographic Information System with the aim of having a map view of the territory and recovering these using data of real estate as search keys. These interoperability problems were solved by merging three different databases (Land Registry property, civil status, energy consumption) according to the Energy-Social Model as reference. This allowed to create a common basis to have a wide systemic view of the territory to monitor the energy consumption.

C. Third TESA process step: Queries for LCA data

The third phase of the SEA process here performed focused on municipal assets involves the identification and assessment of possible maintenance or improvement interventions on the buildings. The interventions can be identified according to an integrated energy approach, which includes: measures of thermal insulation for buildings, the application of advanced technologies for shading, ventilation, heat recovery, heating and summer cooling high efficiency, possible use of renewable fuels such as wood or vegetable oil and the use of solar energy active and passive, and finally, the adoption of electrical equipments with low consumption. The various measures can be combined to assess the most promising cost-effective mix.

Starting from the common database created in step 2 several queries were possible to identify nearby buildings to endeavor their interaction with integrated operations to generate economic and social benefits in a systemic perspective.

The selection of appropriate technologies and solutions for energy savings can then be performed after the LCA study according to the environmental parameters devised. In this case the LCA integrated with energy, economic and social variables determines the optimal solution, to determine the possible operations of the system, avoiding wastage.

III. THE TERRITORIAL PLANNING

The Province of Matera (Italy) signed on 2010, the Partnership Agreement with the Directorate General of Energy Commission, assuming the role of "Territorial Coordinator" and “Supporting Structure” of the EC for the territory of the Matera Province, undertaking to:

- promote the adherence to the Covenant of Mayors of the municipalities of the territory and provide support and coordination to the municipalities who already have signed the Covenant of Mayors;
- provide technical and strategic assistance to the municipalities that wish to join the Covenant of Mayors but which do not have the resources to prepare an action plan for sustainable energy;
- provide financial support to municipalities and opportunities for the development and the implementation of the Sustainable Energy Action Plan.

The main outcomes of the present SEA process was to coordinate the Energy Efficiency and Renewable Energy switching interventions to reach an unique investment portfolio to provide important savings in Energy Territorial government. According to the assessment results derived from the SEA process, the investment portfolio can be composed in a near future of a sum of smaller interventions (building groups) each composed of two/three buildings. The test case has been Matera school complexes according to a widespread international paradigm of energy districts or settlements. Endeavoring a mix of technological solutions, it will be possible to optimize the interaction between local energy generations and consumptions, reducing energy consumption and using as much as possible and economically compatible renewable sources in the LCA view. The integrated view of public buildings descending from the SEA approach proposed will allow to optimize the design of the entire public real-estate system by acting simultaneously on the minimization of the consumption of individual households, on local and economical production of energy, the integration of renewable energy sources and the efficient management of the system. The proposed SEA process may suggest more typologies of interventions on different kind of building complexes: say, for instance, between school buildings with public offices or school buildings with hospitals.

These examples will represent case examples (or pilots) to define the guidelines of virtuous actions that can be performed for energy management in the Matera province. The aim is also to promote other interventions in a smart grids logic (in line with the guidelines laid down in this area by the “National strategy for the internal areas”) either among different public authorities or between public and private actors (taking into account the specific utilization of schools energy facilities that are used above all in the morning and from September to May).

Following to the SEA process performed, an archive with all the structural information of the buildings within the jurisdiction of the Province of Matera was drawn up. Data coming from a wide auditing project were also performed within the same province, taking diagnoses, testing and certificating the energy and environmental buildings. This corpus of knowledge was used for planning of the energy retrofit of the proposed buildings.

A. Geographical Area

The geographical zone in which the proposed action will be implemented concerns the City of Matera located in the convergence region of Basilicata, in southern Italy.

Matera is the capital of the province of Matera and has a territory of about 387,4 sqkm with a population of 60.023 inhabitants (the density is 150 inhabitants/sqkm).

Regarding the territory involved, the challenge of the prosed action is to actively involve all local and Territorial stakeholders and to achieve a significant impact in terms of contribution to the realization of the Cohesion Policy of the European Commission.

For the present study no attention will be devoted to the social aspect because they aren’t the focus of this paper.

In the context of the proposed action it is important to distinguish between two important intervention areas: “cities” and “internal areas”. This distinction particularly represents the Italian reality. The largest part of the Italian territory is in fact characterized by a spatial organization based on small centers, usually of reduced geographical dimensions and capable to ensure to its inhabitants only a limited accessibility to essential services. The action proposed aims to actively contribute directly at one of the five development factors – energy conservation and renewable energy – by representing a "pilot" action with high replication capacity which will contribute to increase the Territorial cohesion and access to internal market, maintaining at the same time the "specificity" of such areas.

B. Analysed buildings

The following description provides an overview of the interested buildings, grouped in complexes of three buildings.

The school complex, located in Matera, includes:

- the Liceo Scientifico "Dante Alighieri" (LS);
- the Liceo Classico "Emanuele Duni" (LC);
- the Istituto Tecnico Commerciale "Loperfido-Olivetti" (ITC2)

The LS is characterized by numerous classrooms for teaching activity with large windows. It has 10 laboratories, 1600 sqm large gym, a library and an assembly hall. In the school year 2013-2014 there was about 793 pupils divided into 32 classes.

The LC of Matera is the oldest school of the city (established in 1864). The current headquarters in the Nazioni Unite Street has 4 laboratories, 2 gyms and a library. In the school year 2013-2014 there was 524 pupils divided into 22 classes.

With regard to the ITC2, the building located in Aldo Moro Street will be involved in the energy intervention of the second school complex.

The figure 2 below shows the closed geographical location of the three school complexes.

FIGURE 2. Geographical location of the second school complex

The LS was built in 1971 in reinforced concrete, four-floors with a flat roof; the building height is of 12 m, with a surface area of 7.830 m2 and a heated volume of 27.400 cubic meters (m3).

The LC was built in 1966 in reinforced concrete, six-floors with a pitched roof, the building height is of 20 m, with a surface area of 6.085 m2 and a heated volume of 21.800 m3.

The ITC2 in Aldo Moro Street was built in 1961 in reinforced concrete, five-floors with a flat roof, the building height is of 18 m, with a surface area of 5.814 m2 and a heated volume of 18.600 m3.

The LS is equipped with a heating system fueled with natural gas boiler, whose annual consumption in 2012 amounted to 57.680 m3. The school has not insulated walls and ceilings; the glazed surfaces, of approximately 956 m2, are single-glazed windows, with iron frame without thermal break. In 2012 the electricity consumption were equal to 79.242 kWh, whose main component is given by lighting with about 439 neon lighting.

The LC is equipped with a heating system fueled with natural gas boiler, whose annual consumption in 2012 amounted to 23.546 m3. The institute has insulated walls and ceilings according to the Territorial energy plan but the glazed surfaces of approximately 155 m2 are represented by single-glazed windows, with iron frame without thermal break. In 2012 the electricity consumption totaled 39.532 kWh, whose main component is given by lighting with about 366 neon lighting.

The ITC2 is equipped with a heating system fueled with natural gas boiler, whose annual consumption in 2012 amounted to 33.193 m3. The institute does not have insulated walls and ceilings; the glazed surfaces of approximately 777 m2 are represented by single-glazed windows, with iron frame without thermal break. In 2012 the electricity consumption totaled 75.579 kWh, whose main component is given by lighting with about 384 neon lighting.

Energy-Social Planning serves to optimize investments in the territory increasing social activity and energy.

For these three important school complexes several LCA-optimal energy improvements have been devised according to the Energy-Social Planning following the SEA process:

- thermal coating of the opaque part of the building envelope in order to reduce the loss of heat with the external environment and increase the thermal insulation, only for the ITC2 and LC;
- replacement of windows with low-emissivity double-glazed windows;
- installation of photovoltaic solar shading on the south facades of the buildings allowing to make the best use of free solar gains and try to eliminate or minimize them when they can be harmful, avoiding overheating in summer and ensuring the efficient use of natural lighting during the winter. It is estimated a production of 12 kW for 100 m2 of solar shading.
- replacement of obsolete lighting equipment with LED type with built-in sensors for monitoring the presence and adjustment in function of the natural light, ensuring this way at least a 60% of savings, with the aim of reducing energy consumption and costs;
- replacement of the existing boiler with a new next-generation condensing boiler, with efficiency ratios exceeding 107% suitable for

operation with gas burners and installation of thermostatic valves where necessary.

The investment required for these projects amount to approximately €1.131.000,00. The interventions generates an annual saving of 100% of electricity and save 56% of natural gas. It is also reasonable to fed into the grid part of RES energy produced.

TABLE1.
DETAILED DESCRIPTION OF THE PROPOSED INVESTMENTS

Location and name of buildings	**Province of Matera LS, LC, ITC2**
Number of buildings	3
Total surface (m2)	19.729
Current primary electricity energy consumption (MWh/year)	431
Current natural gas consumption(MWh/year)	1.211
Primary electricity energy savings (MWh/year)	872
Natural gas savings (MWh/year)	676
Energy savings %	100%
Natural gas savings %	56%
Average GHG emissions (tCO2e/m2/year)	321,27
Estimated CO2 reduction %	90%

IV. CONCLUSIONS

The proposed approach of TESA process based on LCA applied to a real case of school complexes, led to an interesting paradigm of energy districts in which, through a mix of technological solutions, Energy Efficiency and RES interventions can be rejoined into an unique investment. This allows to optimize the interaction between local energy generation and consumption.

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