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Multicriteria decision support in local energy planning: An evaluation of alternative scenarios for the Sustainable Energy Action Plan ☆

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ABSTRACT

One of the major challenges for the implementation of local energy planning is the successful development of a Sustainable Energy Action Plan (SEAP) by the local authorities (especially within the framework of their participation to the Covenant of Mayors' initiative). This aspect constitutes a decision making problem, since the local authorities have to identify the best fields of actions and opportunities for reaching their long-term CO_2 reduction target. However, the already available methods and tools do not offer an integrated framework for the SEAPs' development and especially the selection of sustainable Renewable Energy Sources (RES) and Rational Use of Energy (RUE) technologies. In this context, the aim of this paper is to present a participatory supportive framework for the implementation of local energy planning. At the first level, the proposed approach incorporates the development of alternative Scenarios of Actions (using knowledge-based process, participatory approach and aspiration level). At the second level, a direct and transparent multicriteria decision support is introduced, in order to evaluate the feasible Scenarios. It includes the application of a multicriteria ordinal regression approach and an extreme ranking analysis method for the estimation of the best and worst possible ranking position of each Scenario. The results from the pilot appraisal of the methodological approach to a "real" problem are presented and discussed. The adopted approach contributes to the selection of the most appropriate combination of RES/RUE actions, supporting in this way the local authorities to the development of their SEAP.

1. Introduction

The Covenant of Mayors is the mainstream European movement, involving local and regional authorities, voluntarily committing to increase Renewable Energy Sources (RES) and Rational Use of Energy (RUE) actions on their territory. The Covenant counts more than 6460 signatories so far.[1] The Sustainable Energy Action Plan (SEAP) is the key document in which the Covenant signatory outlines how it intends to reach its long-term CO_2 reduction target (at least 20% by 2020). The target sectors are the buildings, equipment, facilities and transport. The sustainable energy policy may also include actions related to the local electricity production (development of photovoltaics, wind power, combined heat and power, improvement of local power generation) and local heating/cooling generation [22].

In rural environments, fulfilling the Covenant's commitment of submitting a SEAP within a one-year timeframe can come with very challenging constraints. Some rural communities, and in particular those which are most remote, depopulated or dependent on agriculture, already face particular challenges as regards growth, jobs and sustainability [19]. These challenges include lower income levels, an unfavourable demographic situation, higher unemployment rates, a slower development of the tertiary sector, weaknesses in skills and human capital, a lack of opportunities for young people and a lack of necessary skills in parts of the agricultural sector and food processing industry [21,26]. This situation has been aggravated by the financial and economic crisis in the current years.

To the best of our knowledge, these areas do not possess adequate capacity to implement SEAPs and promote RES and RUE actions towards the development of sustainable energy communities. Climate change policies and programmes in these communities are still

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in their infancy, in terms of putting real changes on the ground [19]. Therefore, particular emphasis has to be also laid on them for "greening" rural communities economies [58].

The main objective of this paper is to present a participatory supportive framework for the implementation of local energy planning. At the first level, the proposed approach incorporates the development of alternative Scenarios of Actions, namely a set of RES and RUE actions for the local authorities, as well as interventions for the local population. This means that Scenario is a synonym of alternative. Following an initial design of alternatives through a knowledge-based process (modelling RES/RUE actions based on the selected criteria and using different ranges of application) and their finalisation through participatory approach, the filtering of feasible Scenarios for the local community is carried out using an aspiration level.

At the second level, a direct and transparent multicriteria decision support is introduced, in order to evaluate the feasible Scenarios. It includes the application of a multicriteria ordinal regression approach and an extreme ranking analysis method for the estimation of the best and worst possible ranking position of each Scenario. The results from the pilot appraisal of the methodological approach to a "real" problem (namely the development of a Greek municipality's SEAP) are presented and discussed.

Apart from the introduction, the paper is structured along five sections. Section 2 provides a description of the actual decision making problem and Section 3 is devoted on the relevant literature review. Section 4 is devoted to the decision process, including the relevant approach for the development of alternative Scenarios of Actions and the multicriteria decision support framework. Section 5 presents the results from the application of the adopted approach to the SEAP's elaboration and development of a Greek municipality. Finally, the last section just summarizes the key issues that have arisen in this paper.

2. Decision making problem

According to Marinakis et al. [61], the elaboration and development of a SEAP constitute a decision making problem. The local authorities have to identify the best fields of actions and opportunities for reaching their long-term CO_2 reduction target [22]. The selected measures and actions concern not only buildings and facilities that are managed by the municipality, but also other key areas of private sector, such as the residential and tertiary sector, public and private transportations, etc.

The key stakeholders of this decision making problem and their relationships are described below:

- *Decision Maker*: The local authority, namely the Mayor and Municipal Council, are responsible for the elaboration of the Action Plan, defining the overall goal of CO_2 emissions reduction by 2020 and the main priorities, in line with the vision defined.
- *Analyst*: The technical manager, in close collaboration with the local authority, contributes to the development of the baseline energy and CO_2 emissions inventory, as well as the identification of the appropriate mix of actions and measures that will be integrated in the Action Plan.
- *Third Parties:* The local stakeholders, who possess/control information, resources and expertise needed for strategy formulation and implementation, have active role in the planning process. The energy centers, investors, companies, representatives of the local market and citizens are potentially important stakeholders.

Building appropriate scenarios for the elaboration of SEAP, within the framework of the Covenant of Mayors initiative, is a complex task. In this respect, the methodological approach developed to address this decision making problem integrates standard techniques and methods, for the development of alternative Scenarios of Actions (participatory approach, aspiration level) and their evaluation (multicriteria analysis and robustness analysis).

3. Materials and methods

The materials and methods, which were used to address the decision making problem, are described below through an extensive literature review.

3.1. Participatory approach

- *Specifications:* All members of the society have a key role in establishing a common vision for the future and defining the paths that will make this vision come true [22]. According to Renn et al. [70], stakeholders, experts and citizens should contribute to the planning effort, through their particular expertise and experience. Indeed, their views should be integrated in the alternative Scenarios for the region. In this respect, the participatory approach can stimulate the behavioural changes that are needed to complement the SEAP's actions and measures.
- *Background Information:* The benefits of combining participatory methods with analytical tools are widely acknowledged [34,55,64,69,84]. Different ways to consider participatory approach have been identified, such as "Information", "Consultation", "Deciding together", "Acting together" and "Supporting independent community initiatives" [11]. In any case, the participation in planning could improve the quality, acceptance and effectiveness of the alternative action plans for the region [22].

3.2. Aspiration level

- *Specifications:* The local authorities set the minimum longer-term target in percentage of CO_2 emissions reduction. According to the Covenant's guidelines, the target should be a minimum of 20% reduction by 2020. However, the local authorities can define a different longer-term target. This means that the examined Scenarios for the region should achieve this longer-term target. To this end, an aspiration level regarding CO_2 emissions reduction of each alternative is used, working as a filtering for the identification of feasible scenarios.
- *Background Information:* A number of studies exist on the aspiration level approach [65]. More specifically, Wang and Zionts [91] examined the relationship between aspiration levels and their mapped-to solutions in the MCDA context. Yun et al. [93] presented an aspiration level approach using generalized data envelopment analysis and genetic algorithms in multiple criteria decision making such as engineering design problems. In the study of Granat and Makowski [36], the specified aspiration levels are used for the generation of component achievement functions for corresponding criteria, which reflect the degree of satisfaction of results.

3.3. Multicriteria decision support

- *Specifications:* Multiple Criteria Decision Aid (MCDA) methods can be an important supportive tool in policy making, providing the potential to evaluate the alternatives' implications to the

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