SEA role in energy planning, towards matching of energy systems

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Abstract
Most countries are adopting renewables in their energy strategy to reduce CO_2 emissions and as a way to mitigate global climate change. Despite being natural and renewable, they must be assessed since the same resources have other important uses for local development. Strategic considerations must be accounted in the planning process to ensure that the use intensity and way of exploitation of natural resources for energy purposes respect the overall goal of sustainability. This work addresses the link between Energy Planning and Strategic Environmental Assessment, showing the importance of introducing SEA from the beginning of the EP process so that real strategic decisions can take place for sustainable energy systems.

Introduction
The global trend towards sustainable development calls for a transition in the energy paradigm, moving away from the combustion of fossil fuels and considering renewables as the solution for the reduction of CO_2 emissions. Countries have defined their energy policy based on three pillars: energy security, economic competitiveness and environmental protection [1]. In practice that is translated into a reduction of the dependence from external energy resources, by using endogenous resources and increased energy efficiency, without compromising the human development and assuring the protection of the environment.
Starting from a new energy paradigm, based on the use of natural renewable energy resources as the main energy sources, on decentralized generation, proximity of user to energy source, efficient energy use and environmental friendliness, two aspects are highlighted in this research. The first, related to the introduction of the principles of the new paradigm in the energy planning process. This calls for a different approach in the structure of energy demand and supply, referring to “matching” and “shift” as the concepts for the change on the modelling of energy systems. The second aspect highlights environmental assessment as a cornerstone in the development of these energy systems for sustainability. It helps to keep a long-term, strategic vision in the planning process, and the necessary integration among sustainability issues that ensures the enhancement of the energy options. Guaranteeing a holistic and integrated approach it will be possible to provide a prioritization for the exploitation of sun, water, wind, biomass or other renewable resources.
These two aspects establish the context for the research on the design of sustainable energy systems (SES) and the integration of Strategic Environmental Assessment (SEA) in the energy planning (EP) process. The main goal is to contribute for a more coherent treatment of the energy, considering an energy planning methodology aimed at the matching of the available energy resources with the energy demand, in qualitative and quantitative terms.

Energy planning processes
The concept of EP is widely used, which makes a single and clear definition difficult [2, 3]. Beyond scientific authors, much work has been developed in practice, where a broad scope of the concept is used [4-7]. Most of the time EP is linked with a technical planning [8], focused on the use of

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tools (analytical models), without considering the engagement of agents that can provide larger insights about the whole energy system. This is due to energy be considered, most of the time, in a fragmented way in relation to other areas and generally viewed as a technical subject [9]. The instrumental vision in the concept of EP is applied in areas such as local energy and climate action plans, renewable energy planning, energy resource allocation, transportation energy management or electric utility planning [10].

Planning is all about setting a direction for something and assuring that that direction is followed or adapted to changing circumstances. Therefore, two points are important to distinguish: First, that planning includes always a decision about the direction and the ways (solutions) that allow that direction. Second, that in any planning situation many aspects interfere and interact with the planning direction.

EP needs to be brought at a higher level, moving from a focus on tools to a focus on the decision process with a new way of thinking, towards a more comprehensive analysis and allowing the development of better options for energy systems. Approaches from other fields, applied to the energy issue can also contribute with useful principles for the planning of SES [11]. This way, rather than develop a tool to help deciding about options and measures to implement (there are plenty of them already available), the effort is on an EP process that truly helps raise new options that effectively can help the new energy paradigm to achieve SES.

Despite being challenging, as Foell states "… the energy planning process can be effective only as an integral part of development planning" [12]. Moreover, EP must have the capability to integrate those changes without losing its core: the energy vision and objectives.

Energy systems – the proposed vision

Several interpretations of energy system can be found. For this approach, which is intended to be a holistic vision about the energy systems, a tripartite vision about the energy system is defined, split between energy resources, energy supply and energy demand. Although shaped by its own intricate interactions among each part proprieties, a simplified representation of these tripartite systems could be characterized as shown in Figure 1.

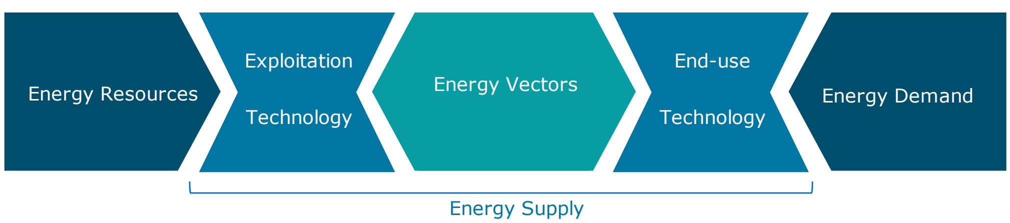

Figure 1 – Simplified diagram of the tripartite energy system

There are different energy pathways from 'primary' to 'useful' energy to fulfil a same need (Figure 2 illustrates that for heating), but different energy vectors or final forms of energy have different levels of 'available energy', which thermodynamically is translated by the level of exergy. Exergy is "a measurement of how far a certain system deviates from a state of equilibrium with its environment" [13] translating "its usefulness or quality or potential to cause change"[14]. In other words, exergy is the parameter that qualifies energy, allowing us to say, for instance, that 1 kWh at 400ºC is energetically more valuable than 1 kWh at 20ºC.

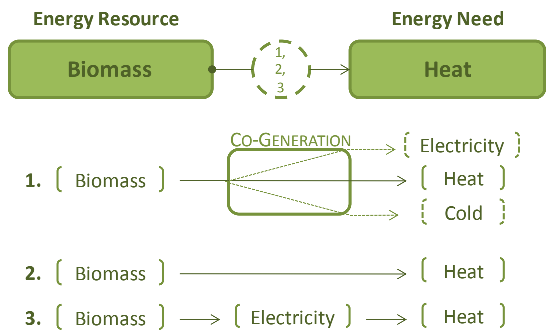

Figure 2 – Representation of different paths to provide the same energy need, from the same energy resource

The current way of thinking about the use of energy, in terms of the energy chain, from supply to demand-side, does not consider the quality of energy delivered to the end-users, provided their needs are satisfied.

Introducing the quality of energy on the planning process will allow a reorganisation of the energy demand, shifting towards more adequate energy vectors and end-use technologies for the required energy service. At same time, from the supply side, it has an environmental expression as it translates into an efficient use of the resources, promoting the matching between the available energy resources and the existing energy demand (Figure 3).

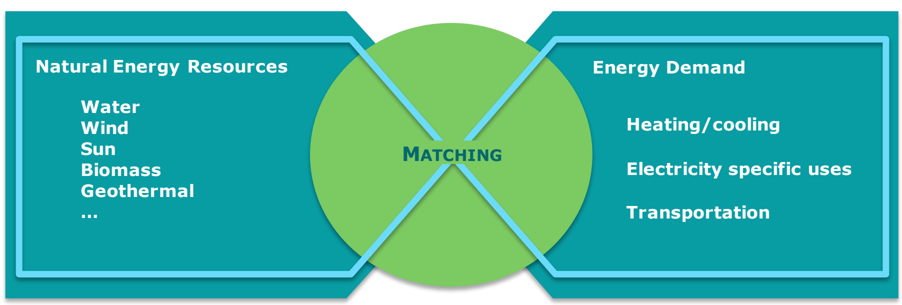

Figure 3 – Highlighting the matching exercise on the energy system

The role of SEA

SEA is a procedural instrument [15] that can be used as a "facilitator of strategic decisions, which aims to ensure the integration of environmental issues in a context of sustainability" [16]. For an EP process concerned with a strategic decision dealing with the direction of the energy systems (the "Where to" question) and the way to get there (the "How to" question) [17] as described above, SEA can provide relevant support.

The energy sector is perhaps one of the most transversal sectors, where a high number of political aspects, social and environmental considerations [18] must be taken into account to direct the systems towards a sustainable pathway. The strategies for sustainable development illustrate quite well this situation when they establish as key challenges for sustainability the use of clean energy to face the climate change (the global side of energy systems) and the conservation and management of natural resources (the local side of energy systems) [19]. Therefore, decisions about energy systems can benefit from the support of SEA, as discussed elsewhere [16].

While SEA aims at the integration of environment for sustainability, it is necessary to ensure the development of strategic options so that real strategic decisions can take place. "Real strategic change requires inventing new categories, not rearranging old ones", stated Mintzberg [20]. This allusion to the development of new options puts in evidence a dichotomy between the analytical and creative aspects to which EP process cannot be indifferent and that SEA can help.

At a first glance SEA could be used to simply introduce environmental concerns in the EP process, however it becomes clear that it can have a significant role in the development of solutions and improvement of decisions as "the role of SEA is dictated by how and where it fits into the decision making process" [21]. If promoted from the beginning of the planning process it can effectively contribute to the integration amongst planning dimensions, consistency in objectives and improvement of solutions for the decision.

In this work, the strategic options are related to the prioritization on the exploitation of the endogenous renewable energy resources that can better fit the energy demand (in a regional and isolated context), considering the matching between supply and demand based on the quality of the energy vectors and respecting the environmental balance. In practical terms this means establishing a preferred order of exploitation among the resources that can provide heat (e.g. sun and biomass) or the ones that can provide electricity (e.g. sun and wind).

Practical results

Introducing SEA in the EP process allowed setting a comprehensive vision for sustainable energy systems as well as grouping into three main integrated aspects the dimensions within which the EP process interferes. We call these integrated aspects the critical decision factors – CDF, after the strategic-based methodology for SEA developed by Partidário [22]. Both the vision and the CDF for the EP process were surveyed by an on-line questionnaire sent to different agents (professionals, agencies and researchers) on the energy and environment fields, which results are presented.

On the vision, SEA supported the clarification of hidden concerns related to the sustainability of energy systems and articulated the concepts presented from the energy side (energy quality, shift and matching), in a synthesized vision, largely supported, as follows:

> *Sustainable energy systems are based on the use of natural renewable energy resources as the main energy sources, having as major characteristics the decentralization of the supply, proximity of user to energy source, efficient energy use and environmental friendliness.*

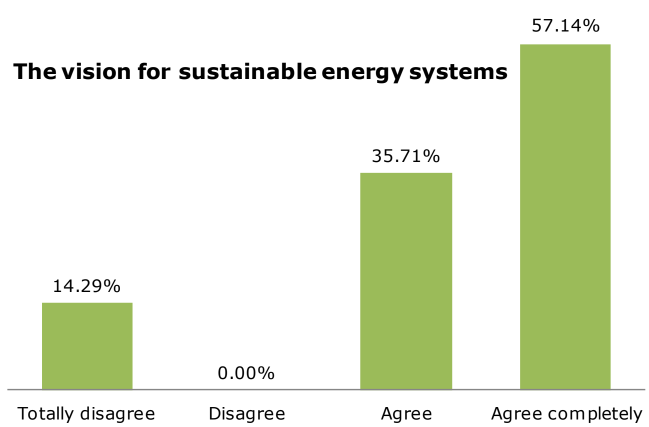

Figure 4 – Survey results regarding the level of agreement with the vision for sustainable energy systems

The strategic assessment framework in the SEA is expressed through the CDF (see Box 1) which are used in the assessment of strategic energy options. CDF express the energy issues but also introduce the sustainability concerns related to the dimensions that interact with energy, such as the territory, the natural resources or social and governance aspects. These CDF as defined are intended to be as generic as possible so they can be generally applied. Nevertheless, it will require adaptation and "fine-tuning" to each particular case.

Box 1 – Generic CDF for sustainable energy systems' planning process

Energy Shift
It translates the importance of the energy options on the shape of the energy system and as promoters of change. Those energy options that promote the shift can be grouped as: use of different energy vectors, promotion of energy efficiency along the entire energy chain (supply and demand sub-systems) and adequacy of the energy use to the required energy services. The main goal is to assess the way in which the shift occurs and if it promotes the matching between the energy needs and the energy that can be provided endogenously. As the changes at this level are related to behavioural changes from the stakeholders and citizens in general, the governance dimension is put in evidence, in what regards pointing out the direction to follow. This CDF is crosscutting to almost all the strategic reference framework, as it relates with the different energy goals, CO_2 emissions' reduction and, ultimately, combating climate change.
Natural Resources and Territorial Shape
It translates how different uses of natural renewable energy resources affect differently the evolution of the energy system and have different expressions in the territory. The use of a resource for energy purposes inhibits its use for other purpose (e.g. the biomass case) or it has a territorial expression of that use (e.g. wind power and landscape link). The main goal is to assess the way that the natural resources are used and the territorial organization of activities is shaped. This factor expresses the physical effects of the energy system's planning, linking the natural resources and the territorial dimensions by assessing how the territorial organization is shaped by the use of the resources. It is related with the environmental values present in the territory, which constitute the basic matrix that supports all the activities.
Energy and Development Nexus
The development within a delimited region is more than the physical expression of activities. This CDF translates how the energy system influences the access to energy and the availability of different energy types allow or inhibit the development of economic activities and the improvement of living conditions. The main goal is to assess the development path promoted by the different energy options and the improvement for populations along time from it. The nexus between energy and development allows introduction of the social and temporal dimensions in the planning process, particularly important to assure an integrated vision for sustainability.

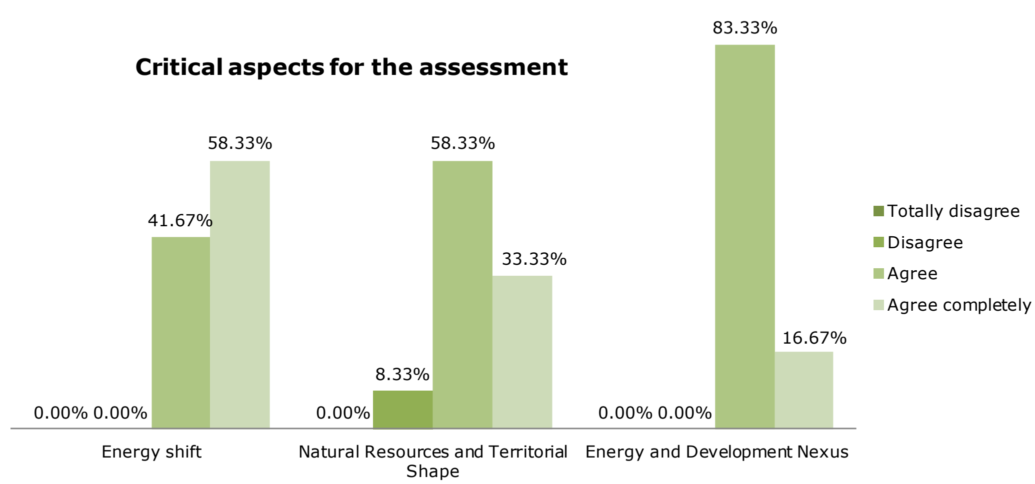

Figure 5 - Survey results regarding the level of agreement with the critical aspects for the assessment of options

Conclusion

This paper gives a perspective on energy systems for the matching of natural energy resources and energy demand, based on the concepts of energy quality and vectors shift. Moreover, it highlights the role that SEA can have if considered since the beginning of the planning process for a broader, holistic approach leading to the enhancement of energy solutions.

The final remarks for this approach emphasize some preliminary conclusions about a possible methodology for the planning of SES, namely:

- An EP process is characterized by high complexity given the transversal characteristics of the energy sector and the tripartite vision of the energy system;
- SEA, through the use of its strategic elements, can facilitate the EP process by merging different concerns in a short number of factors – the CDF;
- The exploitation of the natural energy resources can be optimized by introducing energy concepts with an environmental expression such 'energy quality', 'matching' or 'shift'.
- The steps to achieve SES are relatively simple to give:
    a) Considering the current way of modelling the energy systems, few extra data is required, being necessary to reformulate the structure regarding the demand by energy services;
    b) Stakeholders involvement is essential to cover all dimensions related to the core issue of energy.

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