Spatial Energy Planning

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Spatial Energy Planning seems to be an unexploited tool with the potential to provide significant insight into a planning process that could prevent conflicts when integrating renewable energy technologies into electric systems.

Keywords: Energy planning ; Renewable energy ; Energy transition ; Spatial energy planning

1. Background

Oudes and Stremke [1] have proposed a methodological framework for assessing the spatio-technological feasibility of energy transition targets at the local and regional scale. They based their methodology on the concept of Spatial Transition Analysis, which is spatially explicit and evidence-based, with regard to RE technologies, and inclusive of stakeholder preferences and values. In a similar way, the spatial energy planning (SEP) concept has recently emerged in the scientific literature; however, is this concept being used as a tool that could help to overcome challenges beyond the techno-economic ones when integrating RE technologies into electric systems?

2. SEP Framework

Historically, the integration processes between space and energy planning have mainly been related to the urban environment. During the 1970s, in parallel to the studies that started the integration of urban structures and energy planning, the integrated energy planning (IEP) concept was proposed by the International Energy Agency—along with several states—as a response to the oil crisis, in order to decrease the dependence on foreign oil and increase the energy diversity [2].

According to Cormio et al. [3], the global growing concern on environmental protection and sustainable development, along with the liberalization of the energy market in several countries, led to an increase in the interest in IEP at the sub-national level. In this regard, Mirakyan and De Guio [4] presented a generic IEP procedure for cities and territories in the early 2010s, in which the planning activities were divided into four main phases (I: preparation and orientation II: model design and detailed analysis, III: prioritization and decision, and IV: implementation and monitoring) and the implemented methods and software resources used until that time were allocated in the appropriate phase. Therefore, methods and models that quantitatively analyze the potential integration of RE technologies into energy systems are included in planning phase II, and the consideration of qualitative aspects and their eventual interaction with the spatial structures are involved in planning phase III. However, the spatial structures are not directly analyzed in the IEP procedure.

Considering the importance of re-thinking the role of spatial planning and energy planning as a strategic tool, due to its potential influence on urban design, infrastructures, mobility, land use, private property rights, the water supply, food security, environmental protection, public health, local development, resilience, and sustainability, among others, in the last decade, an Austrian research group has conceptualized the integrated spatial and energy planning (ISEP) concept [5]. The ISEP concept is defined as “the part of spatial planning that deals with the spatial dimensions of energy consumption and energy supply” [6]. Based on the interrelation between spatial structures, the energy demand, and the energy supply [7], a combination of models and methods used in both phase II and phase III of the IEP procedure can be implemented as strategy tools. Within this framework, the SEP concept has emerged during the last decade in the scientific literature.

3. Development of SEP Studies

Figure 1 shows the RE technologies involved in the articles that consider electric energy systems. As can be observed in Figure 1, solar photovoltaic (PV) has been the most frequently considered technology in the SEP concept, being present in almost half of the studies, followed by wind onshore (in 27% of the studies), wind offshore, biopower, and hydropower technologies (each of them in 9% of the studies). However, the SEP analysis on wind offshore technology [8] only involved technical aspects, and the SEP study on hydropower [9] discussed techno-economic aspects. Therefore, this evidence shows that solar PV, wind onshore, and biopower are the technologies that have been analyzed, considering aspects beyond the techno-economic ones, in terms of the SEP concept.

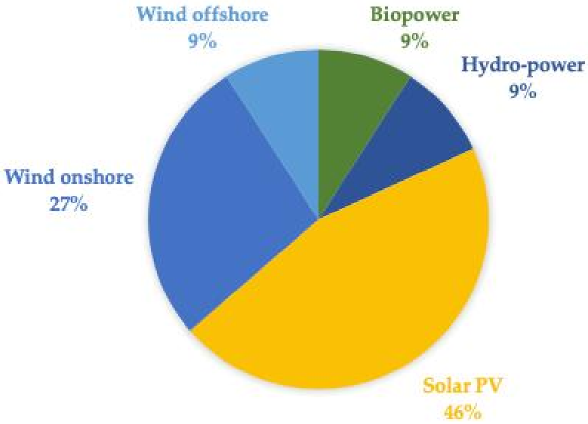

Figure 1. Share of renewable energy (RE) technologies involved in the SEP articles considering electric systems.

Thygesen and Agarwal [10] identified and discussed key criteria for promoting the environmentally acceptable wind planning. This was carried out through a comparison of the planning systems for wind power in Norway and Scotland. Based on a review of the impact assessment procedures in the literature, they found four key criteria for promoting sustainable wind energy planning: (i) clear and integrated political priorities; (ii) stakeholder involvement; (iii) strategic environmental assessment (SEA); and (iv) stringent permission and assessment requirements. They also found four political characteristics related to critical institutional conditions that effectively promote sustainable energy production: (a) coordinated energy policy institutions; (b) legitimate planning procedures; (c) that SEAs are followed in the decision-making process; and (d) statutory planning regulations. The authors argued that coordinated institutions, contributive stakeholder participation, and clear political priorities are crucial for addressing constraints of other environmental concerns that may not be included in SEAs related to wind power planning.

Scognamiglio [11] carried out a critical review of the design and assessment of photovoltaic landscapes for a new trans-disciplinary design vision. This author investigated the PV landscapes in terms of patterns, in order to evaluate them, basing their analysis on technological, economic, environmental, social, and political aspects. The quantitative evaluation was addressed in terms of the land use energy intensity and the qualitative one was addressed in terms of perception esthetics. The author of this work also proposed a quantitative approach focusing on land use to estimate the life cycle of the energy generation from PV landscapes. Scognamiglio [11] argued that new PV landscape patterns would allow for a better ecological performance of this technology, and also presented research questions related to the quantitative assessment of the beneficial ecological impacts that would be generated by PV patterns under a new design vision.

4. Conclusions

The main objective of this work was to reveal whether the spatial energy planning (SEP) concept, considering it as a tool to carry out energy planning processes, is helping or could help to overcome challenges and barriers that have emerged in the integration of renewable energy (RE) technologies worldwide at different levels. These issues are directly related to aspects beyond the techno-economic ones, such as environmental, social, and other aspects.

On one hand, how the SEP concept can be used as a strategic tool for carrying out energy planning processes is still an open question. On the other hand, the SEP concept seems to be an unexploited strategic tool with the potential to provide significant insight into energy planning processes that could prevent barriers to the integration of RE technologies at different scales and levels.

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