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Review

Local reflections on low-carbon energy systems: A systematic review of actors, processes, and networks of local societies

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ABSTRACT

Local population actions determine the level of renewability of local energy systems in the context of **energy transition goals**. Local population makes energy choices based on the availability of different territorial resources and limits, i.e. natural or environmental, technological, and social ones. The aim of this research is to identify the main dimensions and aspects of territory that can address its change towards energy transition. Indeed, energy system is not only technology matter. Socio-energy and territorial approaches (Osti, 2010; Jessop et al., 2008 [2]) underline the importance of features and relationships between the territorial systems: natural, technological, economic, legislative, social, and cultural ones. This research identifies substantial, procedural, and relational dimensions or characteristics of territorial energy systems based on the Conflict Management Triangle (European Forest Institute, 1996).

1084 journal papers have been selected based on specific criteria, allowing 168 papers to be analyzed using NVIVO11plus®. Following the qualitative and quantitative method applied for the systematized literature review, 15 dimensions and 41 sub-dimensions related to local population choices about energy transition have been selected. This is a scientific attempt to use a content analysis software (NVIVO11plus) in this scientific domain.

1. Introduction

Climate change effects are apparent in everyday life: alteration in precipitations, higher temperatures, increased drought events, and rise in sea level [4,5]. Climate change is caused by anthropogenic greenhouse gas emissions (e.g. CO_2) into the atmosphere [5]. Greenhouse gas emissions can be decreased by reducing the use of fossil fuels towards the long-term process of energy transition [6]. For example, the European context is based on Directive 2009/28/EC and the Energy Security Strategy [7] which specify three directions to follow: (i) increase of renewable resources rate in energy production, (ii) rise of energy saving and efficiency, and (iii) decrease of CO_2 emission. These address energy systems towards energy transition goals in the wider world.

An energy system can be described according to technological and social viewpoints. From the technological viewpoint, an **energy system** is an integrated system including several energy sources, technologies, and products for energy production, distribution and consumption [8,9]. An energy system can be described through its characteristics of **renewability** [10], **efficiency** [11] **and saving** [10]. From the technological viewpoint, "energy systems are socio-technological systems that involve not only machines, pipes, mines, refineries, and devices but also the humans who design and make technologies, develop and manage routines, and use and consume energy" ([12]: p 136). As Sovacool [13] has pointed out the production, distribution and consumption of energy is determined by the interactions between the technical and human components of an energy system. The energy system is the result of the actions of individuals, stakeholders, and public actors in a territory. These actions can be a ***reaction*** to interventions of other actors or an autonomous ***action*** such as individual initiative, in a territory in which global and over local contexts impose their limits.

Social and individual reactions to energy interventions, plants, or technologies in a territorial context are often investigated in the scientific literature through the acceptance concept. [14] consider social acceptance as a "multi-actor phenomenon" (p. 104) or response to energy interventions such as new renewable energy plants. However, acceptance "risks oversimplifying the interactions between societies, communities, collective actors and individuals and energy technologies and further risks perpetuating a normative top-down perspective of these relationships" ([14]: p. 107). We must consider acceptance in wider way. Indeed, other literature does not investigate reactions, but **actions** for low carbon energy systems [15] such as energy innovations and initiatives.

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Selected literature considering reactions and actions of people (from here, we use actions for both concepts of actions and reactions) emphasizes the context in which the energy system is inserted and shaped. Sometimes, by observing two or more territories that have a similar availability of natural, technological, economic and legislative resources, different local population actions can be discerned [16,17] distinctively shaping the local energy systems. For example, some energy systems focus on the importance for direct links of local resources to the possible actions of the local population. Further, some energy systems consider real social, environmental and economic resources of the territory by looking for an effective use of local resources [18] and, consequently, they emphasise the energy system concept as both socio-ecological and socio-technological [19]. These systems, known as **distributed energy systems,** include small-scale technologies, renewable energies and storage units providing closed energy to end-users [18] based on a community or other type of ownership and management. The features of this kind of energy system are of specific interest for investigating the possible connections between energy and society within a site-specific context. For this reason, the dimensions and sub-dimensions that influence population choices linked to local energy systems are investigated in the current literature. However, it is important to mention that theoretical analyses of the linkages between energy and society from a sociological perspective are still in a black box waiting to be opened [13]. This research aims to define if and which dimensions and aspects of territory address local population choices and related socio-energy system changes towards energy transition, and how the actors, processes, and networks of local population are approached for their analysis in scientific literature. The value of the paper is to improve the research and the theorization on the relationship between energy and local societies, through the consideration of actors, processes, and networks that act for changes towards low carbon and distributed energy systems.

The paper is organized in five sections. After the presentation of the main scope of the research in the introduction, Section two presents the theoretical background and analytical framework proposed for the literature analysis. Section three describes the materials and explains the methods used for the content analysis of the selected literature with the NVIVO11plus® software. Section four presents the results and discusses the relevant dimensions of energy transition in local territories. Some concluding remarks are then proposed.

2. Conceptual background

From the sociological perspective, the action is a set of deliberated acts made by collective or individual actors. The actors choose between several alternatives for achieving a goal (trade-offs). Moreover the choices are based on and influenced by the context in which actors operate [20]. These hypotheses also apply in relation to human choices made on energy issues. The **territory** is one of those contexts. Territory is a delimited surface with an active system in which actors act on space and time and in relation to its material environment [1,2]. However, territory usually interacts with actors and resources within wider contexts. Territory is a simply term which implies a great complexity. It involves different scales of interaction and levels of governance. Indeed, a territory can have different geographical extensions, from global to local ones, and they all influence one another.

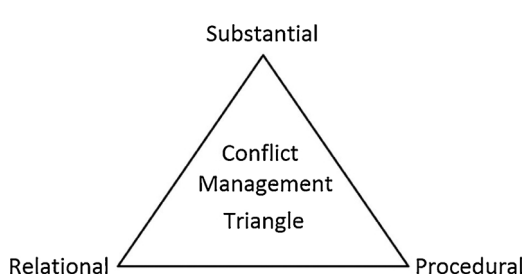

Fig. 1. Conflict Management Triangle.
Source: [3] – modified.

Within a given territorial extension, five interactive systems make up the territory [21]: natural, technological, economic, legislative and social ones. The **natural system** describes the natural environment of a specific territory including important resources for producing energy. Plants and technologies constitute the so-called **technological system** that can give space or not to further technological development or plants diffusion. Producers, distributers, consumers, their roles and interactions make up the **economic system** [22]. The **legislative system** is composed of rules, programmes, norms and legislations [23]. The entire system addresses or limits the choices. Lastly, the **social-cultural system** constitutes the sum of people and institutions, social rules, *habitus*,[1] cognitive values and relationships.

Through the interactions and thanks to the available resources of the five systems, local territories shape their energy systems through local population choices made in and influenced by territorial context. Territorial context addresses change opportunities through its characteristics and limits and, in this context, local population has the opportunity to make choices about low carbon energy systems. Low carbon energy systems are achieved by improving the production, distribution and consumption of energy based on a sustainable use of local resources and decreasing negative social, environmental and economic impacts by implementing, for example, distributional energy systems.

The actors' knowledge about the five territorial systems can increase the opportunities for low carbon energy systems. Each system in the territory is composed of three types of dimensions (Fig. 1) that can be summarised using the Conflict Management Triangle [3]: substantial, procedural and relational. Conflict management triangle is an useful tool to support the literature review identifying different levels of analysis of each territorial system. We must distinguish between a substantial level of territorial characteristics made by individual and collective dimensions that describe the current features of a system; a procedural level that describes processes driving change; and a relational level that describe interrelationships between components of each system. First, the **substantial** dimensions include the characteristics that belong to the system in a precise time and space, i.e. socio-demographic characteristics of the population, or the presence of renewable energy plants. Furthermore, the system functions according to some processes, procedures and rules. Indeed, the **procedure** is a series of actions that are taken in a certain way or order: an established or accepted way of doing something. For example, the energy system is driven by technological innovation that has a certain speed of diffusion, and the social system according to decision-making processes. Finally, actors or components have **relationships** with one another in the five systems. In this case, the characteristics of relationships (i.e. trust, information sharing, collaboration, integration in networks) between components (actors, plants, etc.) are important. **Low carbon energy system** is the result of actors who make choices in territory composed by natural, technological, economic, legislative, social, and cultural systems and their substantial, procedural, and relational characteristics (Figs. 1 and 2).

Actors make energy choices that are low carbon or not choosing between several alternatives, which are limited in the existing territorial context at different scales. When **local actors choose low carbon goals**, local actions shape low carbon energy systems or other local changes (e.g. in supporting policies) towards low carbon energy systems [24–27]. Socio-technical change theories explain that context is made by landscape, regime, and niche levels [28] and people choose

[1] Habitus is a set of schemes of thought, perceptions and actions that people have in the long period. The habitus are founded on objective conditions, but persist when conditions change [80].

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