The notion of sociotechnical system in the planning process of a Smart Region

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Abstract: Energy transition is a long-term change process of the energy system of regions and cities towards smart and low carbon features. From a technological point of view, energy system is an integrated system including several sources, technologies, and products for energy production, distribution, and consumption. From a social point of view, local population's choices and actions determine the time and the features of energy transition at regional and local scales. Energy system is not only technology matter. Sociotechnical and territorial approaches underline the importance of interactions between energy, society, and space.

Based on these interactions, this research delineates an analytical framework and an applied definition of sociotechnical system for place-based contexts, with the aim to promote recommendations towards Smart Regions.

Starting from the definition of the important concept in the social sciences of sociotechnical system, this research proposes an applied definition of sociotechnical concept in space-based contexts. This applied definition can shape and change the socio-energy system that is another important concept in social sciences, meaning the world that 'one wants to create for the future' (Miller et al. 2015).

Keywords: social science; sociotechnical system; territory; South Tyrol

Introduction

Energy transition is a long-term change process of the energy systems of regions and cities towards smart and low carbon features. From a technological point of view, energy system is an integrated system including several sources, technologies, and products for energy production, distribution, and consumption (Balest 2018). However, energy system is not only technology matter (Miller et al. 2015). From a social point of view, local population's choices and actions determine the time and the features of energy transition at regional and local scales. Sociotechnical and territorial approaches underline the importance of interactions between energy, society, and space (e.g. Sovacool and Hess 2017, Osti 2010, Geels 2007). Based on these interactions, this research delineates an analytical framework and an applied definition of sociotechnical system for place-based contexts.

The sociotechnical approaches are more and more important in explaining the energy transition and its elements (i.e., from Geels and Schot 2007). Sociotechnical system is a complex system that includes society, technologies and the relationships among them. An energy system is a sociotechnical

system which shapes and gets shaped by different dynamics of natural, technological, economic, legislative, social and cultural dimensions of the territory (Balest et al. 2019b).The sociotechnical system exists in different territorial contexts (e.g. municipalities, regions, etc.) including their spatial, technological, and social aspects. Indeed, sociotechnical systems provides societal functions and are the result of co-evolving of mix of technologies, infrastructures, supply chains, regulations, cultural meanings, user practices, markets, and other elements. Geels et al. 2017 (p. 471) recognize that energy transition is a "multi-dimensional process, with complex interactions between techno-economic, business, social, political, and cultural dimensions".

In the interaction among technical-technological elements and social groups, this research underlines how local populations are embedded in territories at several local scales and how local population's choices are influenced by the territorial context that is not only made by technological and social systems, but it also includes natural, cultural, economic, and legislative systems (Figure 1). *Viceversa*, the choices of local populations shape the territorial systems. This framework is the basis of the analysis included in this research and it is an interpretation of the sociotechnical regime presented by Geels and Schot (2007).

The regime can be destabilized by both sociotechnical landscape (the context at a higher scale, such as national ones) and niche-innovations (innovations that are not spread yet), and different regimes will differently answer to them. For this reason and for analysing the long process of transition to a new regime that includes innovations and new landscapes (Geels et al. 2017), it is important to have a clear picture on the actual features of the territory. It is also important to spread knowledge for citizens and public administrations on how local features and civil society can contribute to energy transition.

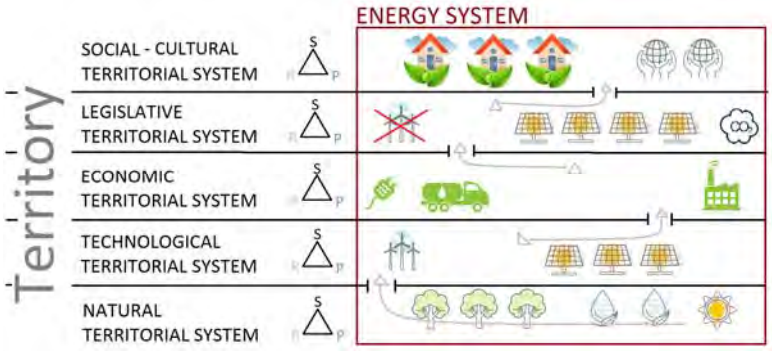

Figure 1 – Framework for analysing territory. Source: (Balest et al. 2018)

How can the sociotechnical system concept be applied into research? Which are the characteristics of a territory that have an influence on the local populations' choices in terms of renewable energy and energy transition? How do these characteristics vary along the local territories within a region? Does the actual energy governance consider the characteristics of the territories?

A Smart Region is a geographical and administrative area that is able to change towards low carbon emission features, using the local resources and promoting effective relationships

among the actors of civil society. The findings of this research support the increase of competences and know-how of public administrations for achieving the energy transition goals in their regional and local territories. The analysis of the territory based on the interaction among society, energy, and space creates knowledge for developing Smart Regions.

In an ideal Smart Region, public administrations collaborate one another when their territories share features, resources and needs. Collaborative actions mean to save and share resources (i.e., funding, human capital and knowledge). In the scarcity of resources for municipalities (at least in Italy), common plans or, at least, strategies can help for a more effective transition.

Common plans and strategies are realistic if the territories share resources, needs, and features (European Commission 2008). For this reason, the identification of the sociotechnical systems, their features and the existing collaborations in the energy governance is relevant for promoting effective energy actions and Smart Regions.

The sociotechnical system description, analysis and recommendations can address the socio-energy system (Miller et al. 2015) that is another important concept in social sciences. Trying to include social and political dimensions of the energy systems beyond the technological ones, this research works in the direction of socio-energy system concept. This research proposes some “practices and techniques through which potential energy futures are envisioned, modeled, analyzed and evaluated” (Miller et al. 2015, p. 36). The socio-energy system is a matter of design and coherence with the preferences of local populations and administrations.

Methodology

In order to answer the questions in the previous section, this research uses a methodology based on several methods and steps.

First, this research identifies the most relevant aspects of territory that can have an influence on the acceleration of the energy transition, using systematic literature review method (Balest et al. 2018). Based on the analysis of these aspects, the findings propose a definition of energy system as a sociotechnical system within a territorial context (Balest et al. 2019b).

Second, the definition is operatized and applied to a case study: the municipalities of Autonomous Province of South Tyrol. South Tyrol is a region placed on Northern-East Italy. The choice of variables (Table 1) and a cluster analysis defined homogenous groups of municipalities, defined as sociotechnical systems (Balest et al. 2019b).

Third, a social network analysis is applied to define and analyze the structure of the energy governance that includes public administrations and public utilities in the energy sector (Balest et al. 2019a). In this case, a Bayesian Exponential Random Graph Model (BERGM) is applied (Caimo & Friel 2011) in order to model the energy governance network and to understand the network configurations that promote the existence of the actual governance. For having more detail on the methodology, please refer to Balest et al. (2019a).

Dimension	Specific dimensions
Socio-demographic	Population size, household size, population age, strangers, variation of inhabitants, density
Quality of life and household wealth	Services access, quality of life
Socio-economic	Income, economic development, energy focus, tourism
Cultural	Environmental attitudes
Governance and political	Political participation, civic participation, political address
Geographical and infrastructural	Dimensions of territory, elevation, natural parks, land cover, transport infrastructures
Renewable energy	Hot water production from RE, heating produced by RE sources, electricity produced by RE sources, people activity in increase RE share
Climate	Avalanche and flooding phenomena

Table 1 – The table includes the dimensions that describe sociotechnical system in the place-based context of South Tyrol. Source: Balest et al. 2019).

The crossing of the analysis and findings of the three steps of the research define new and important results in terms of sociotechnical system research. This crossing activity capitalizes the findings of three researches creating a basic scientific knowledge of the territory. This scientific knowledge can be integrated with the local ones promoted by people and public administrations that live and manage the territory. The findings are the basis for the creation of socio-energy system, addressing the futures of energy transition.

Results and discussion

The futures of energy transitions are several for the South Tyrol region and they are given by eight different sociotechnical systems. The provincial administration and planner can use the findings of this research for being aware of the differences and specificities of its local territories. This way to look at the territory promotes effective actions for the territories and their contribution to the energy transition, deepening the list of resources available in the territory for the energy transition.

This research defines eight patterns of territories defined as sociotechnical systems in South Tyrol (Figure 2). Each sociotechnical system could have its own path and speed of energy transition. In particular, energy planners and decision-makers should differently act in the patterns of territory for promoting quicker achievements of energy transition targets.

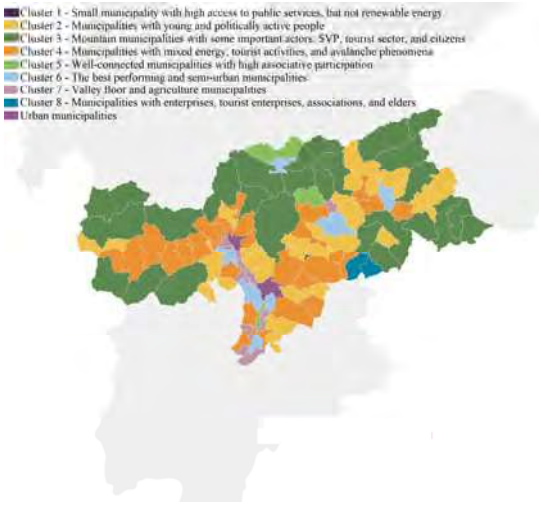

Figure 2 – The map shows the eight patterns of territory in South Tyrol, defined as sociotechnical systems. Source: elaboration of Amy Segata.

For example, cluster 2 (Figure 2 and Figure 3) includes 34 little inhabited municipalities, with high percentage of youths and related higher average of household components. Political participation is high in these municipalities, considering the number of voters in the last local elections and Südtiroler Volkspartei political party is prevalent. These municipalities have, in average, experience in biogas sector for the energy production and high number of people is producing renewable energy or is linked to local thermal energy distribution plants. In this clusters, several resources can be addressed to promote the energy transition. For example, two resources of the sociotechnical system are youths and politically active people (Paravantis et al. 2018). Other two resources or actors, in this case useful for increase and spread awareness on energy topics, are the local associations (Rogers et al. 2012).

The recommendations for the municipalities of cluster 2 are to organize *ad hoc* education activities starting from the primary school and promote a discussion with SVP to increase its public and political commitment to achieve energy transition. SVP can be included in energy planning process emphasizing its role in public commitment, while youths and families could be involved through *ad hoc* activities starting from the primary schools and the actual high people involvement in producing and consuming local energy. This people involvement can be strengthen, for example, promoting and sharing a community RE project based on a collective decision.

These recommendations are considerations not based on the knowledge between cause-effect relationships, but they are fundamental to permit research and findings to be used by public administrations. Based on the findings, public authorities can also be aware on the other municipalities that share the recommendations, resources, and needs, with the aim to promote new and useful collaborations. These collaborations can permit the achievement of resource savings and transition targets.

The listed social and territorial resources can support the effectiveness of energy actions, plans and, consequently, the energy transition. These findings represent a structured knowledge on the territory that goes beyond the local knowledge and that could be integrated with the local knowledge. When more municipalities, sharing resources and having some pioneers in renewable energy production, already collaborate, the use of the recognized resources is easier. A Smart Region exists when public administrations and the main civil society actors recognize the local resources, also in terms of relationships for the energy system planning and management.

Crossing the results of the three steps analysis, this research shows that the potential collaborations among municipalities belonging to the same cluster (i.e., cluster No. 2 of Figure 3) are much more than the actual ones. If municipalities within the same sociotechnical system share resources and features that can support a common planning of the energy system, more relationships among municipalities should exist. However, analysing the actual energy governance, made by relationships among municipalities in the energy sector, the collaborations among municipalities do not consider the specificities of the different territorial patterns in South Tyrol and the collaborations are fewer than the potential ones.

Today, even in the case that municipalities collaborate, they collaborate if spatially closed and not based on similar needs and resources and the findings of this analysis can address new effective collaborations among territories towards the energy transition[1].

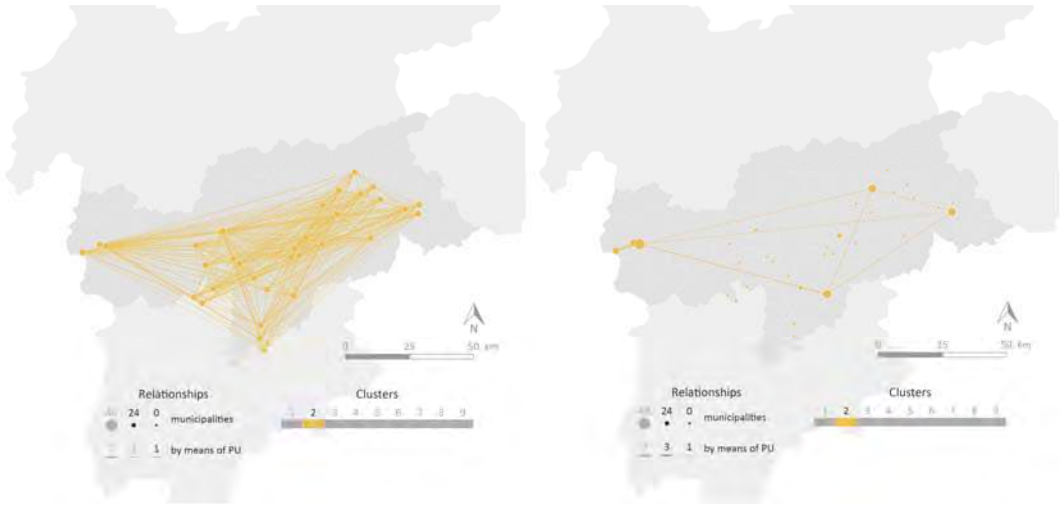

Figure 3 – The map on the left shows the potential collaborations among municipalities of the same cluster, while the map on the right shows the actual collaborations among municipalities belonging to cluster 2, by means of public utilities. Source: elaboration of Amy Segata.

The model for the analysis of energy governance, the BERGM, explains that, according to the considered variables and network configurations, no new relationships should exist (Balest et al. 2019a). For this reason, it seems unlikely that today or in short future the relationships among

[1] For further results of the governance analysis, please refer to Balest et al. (2019a).

municipalities that belong to the same sociotechnical system can be created. Qualitative studies could define important aspects and variables for addressing energy transitions and new collaborations among municipalities that this research has not considered yet.

The relationships among municipalities in the energy sector in South Tyrol are few today and they do not consider the resources available in the territory. With the definition of sociotechnical patterns, public administrations can strengthen the contribution of their territories to the energy transition and they can promote new relationships in the energy sector, based on similar needs, preferences, and available resources.

Conclusions

This research defines an analytical and applied framework for the definition of sociotechnical systems within a region. The framework is applied to a case study: South Tyrol (IT). The application defines eight sociotechnical system within the case study and in which the municipalities are included. Municipalities included in the same sociotechnical system have high potential to collaborate for the energy system planning and management. Indeed, they share resources and specificities.

However, many potential collaborations do not actually exist today in South Tyrol among municipalities that have common resources. Further studies should in-depth and qualitatively investigate the reasons of the existence or absence of these collaborations, promoting a support information for public administrations. Furthermore, the knowledge on the specificities of the eight sociotechnical system is a tool for the promotion of new relationships in the same sociotechnical system for energy transition.

The findings of this research support the creation and development of Smart Regions that are able to decrease the carbon emissions, based on interventions of public administrations. The used framework and the related results are not exhaustive, while further analysis on the social, political, and cultural processes (Geels 2017) and on the social practices (Shove 2018) must be done for having a wider picture on the potential energy transitions of territories. The energy transitions vary along space and they need decades to be happen. This research is an attempt to define analytical and applied framework that is important for supporting public administrations in energy planning for transition. Further research should promote other concepts for the development of Smart Regions such as energy citizenship. The developed methodology and the created knowledge can be replicated in other case studies.

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