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Arbitrariness in Multidimensional Energy Security Indicators

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ABSTRACT

Energy security (ES) has emerged as an issue of great importance in recent years. Nevertheless, the applied concepts of ES are rather vague and many methodologies have been proposed to construct ES indicators. Among these, composite indicators are very popular despite being affected by several methodological choices that often result in lack of robustness of the rankings involved. From a critical analysis of the methodological characteristic of ES composite indicators this study contributes to the debate on the construction of ES composite indicators by providing a better understanding of the various methods that are available. The analysis frames the ES definitions employed on multidimensional indicators and deals with the methodological implications of including the concept of sustainability.

1. Introduction

Due to the importance of supplying economies with more sustainable energy sources in quantity and competitive price, there is a strong consensus on the need for energy policies to be coherent with economic and environmental goals and a greater number of countries are committed to transforming their energy systems. Nevertheless, energy policies priorities have shift during recent years. Due to an increased global energy competition on both supply and demand side and the development of new technologies, energy security (ES) strategies are playing a more dominating role, making energy policy strategies harder to predict. This has resulted in what has been called a re-securitization process in which the focus shifted from sustainability to energy security issues. This increasing security concerns are not only related to classical security issues as reducing the risk of energy disruption, but they extend to a wide range of issues related to sustainability as the impact of biofuel development on agriculture, the unsustainable use of water sources on energy related activities and access to modern fuels. Consequently, the securitization process is characterized by the use of the notion of ES as a rationale for justifying a variety of policies ranging from military action to massive intervention into energy markets in order to increase or reduce the pace of renewable energy deployment or CO_2 emissions reduction (Bridge, 2015).

For these reasons, ES has attracted strong interest from the research community as well as from the policy community, to the extent that ES is currently consider as a major reference point, and tool, on the design of energy policy in national governments and international organizations. One of the current debates on the field deal with the definition of the notion of ES and the reductionism of considering ES and the security of supply as synonymous. Through this **fruitful discussion**, the concept of ES has undergone a major change, and a variety of ES notions and indicators for ES quantification coexist (Chester, 2010; Winzer, 2012; Ang et al., 2015; Narula and Reddy, 2015). The relevance of this debate on energy policy design has often been underestimated. Strategic decisions rely not only on market uncertainty, personal beliefs or on political interests, but most importantly: on the theoretically objective judgements that determine the notion of ES instrumentalized by policy makers and the decision-making processes in which risks and challenges in energy systems are quantified and evaluated.

In general, decision-making processes involve several (potentially) conflicting points of view (criteria) that should be taken into account conjointly, in order to evaluate the situation and arrive at a reasonable decision. These decisions have large effects on the development and implementation of energy policy, determining among other: energy subsidies/taxes, renewable energy deployment trajectories or carbon dioxide emissions over time, altering the social, technological, political and economic system structure. This is the case of the European Union (EU) energy policy, crystalized on the 2014 *Energy Union Package* in order to supply more secure and sustainable energy to their member states with the aim "to give EU consumers – households and businesses – secure, sustainable, competitive and affordable energy" (European Commission, 2014 and European Commission, 2015).

In the same manner a multitude of states and international organization have recognized that the transition to sustainable energy systems depends on the balance among economic, environmental and security targets. The World Energy Council (WEC) defined this situation as the "Energy Trilemma" and identified unclear and unstable policies as one of the biggest risks to developing more sustainable energy

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systems (WEC, 2013). Therefore, understanding how these decisions are taken as well as their consequences requires paying attention to the criteria involved in policy design and decision-making processes. Due to the existence of trade-offs among policy objectives a considerable amount of literature have been published on methods to quantify ES and their applications to national and regional energy systems (see Ang et al., 2015 for a recent review of indicators). The main task of all these indicators is to provide quantitative knowledge about ES in a way that can make heterogeneous threats commensurable and inform policy makers and stakeholders about the relative performances of energy systems highlighting its challenges.

However, the way in which indicators are selected and constructed affects the evaluation in a significant way. For instance, a fundamental division in the ES indicators literature exists between those who choose to aggregate a number of individual indicators and those who do not. The other decision that in effect divides the research community into two camps determines the number of dimensions or aspects that an ES indicator should cover: the ones focused on one of the core "dimensions" or "aspects" of ES as the economic and security of supply dimension and the ones extending the concept to a multidimensional perspective. Some authors criticized the reductionist and simplistic way in which security, economic, environmental and social dimension have been measured and aggregated, while some authors concentrated their efforts in demonstrating that individual indicators as the level of energy independence do not tell us very much about ES levels of national economies. Contrary to the more geopolitical or economical approaches proposing a concept of ES rooted on the threats to national energy supply/demand, multidimensional analysis modifies the object of security: it contextualizes the circulation of energy in relation to the welfare of the national population, the impact on environment or the regulatory framework. These divisions reflect the theoretical path drawn by the discipline of its author and the lack of consensus about what should be identified as an ES issue.

This study is motivated by the abundance of methodologies proposed to construct ES composite indicators from a sustainable perspective, also known as multidimensional ES indicators. The concept of ES that is adopted in the multidimensional studies included in next sections is what has been identified as a broadened definition of the concept of ES rooted on the concept of sustainability. As in the case of "Sustainable Indicators", the importance of the development of multidimensional ES indicators is that they are perceived as a first step towards the operationalization of a broadened security concept based on sustainability. For that reason, altogether with the risk associated to energy supply, new dimensions are included in order to embrace the impact of energy systems to factors essentials to the reproduction of social and economic life.

In a recent survey of the literature Ang et al. (2015) identifies 53 ES indicators on a survey of 104 studies. Their conclusions signal that their development is still in the stage of infancy from a methodological perspective. The aim of this article is to contribute to the debate on the construction of ES indicators by providing a better understanding of the various methodologies that are available. Our ambition is the identification of the main methodological challenges for the production of a composite indicator able to provide meaningful quantitative knowledge about ES. From a critical analysis of the methodological characteristic of composite indicators, the level of consistence and arbitrariness of the different methodologies are evaluated, with a special attention to the requirements of formal consistence as the interrelations between the ES notion and the aggregation techniques applied.

Due to the characteristics of the data, the presence of multiple dimensions and objectives pursued, while composite indicators appear to be simple to use, there are a number of difficulties. Among these, the methodology should incorporate specific methods to integrate the different dimensions while keeping the complexity low in order to make the results accessible to the public and non-scientists. What this means in practical terms is that according to the concept of sustainable development, a part of the security of supply dimension the composite indicator should incorporate environmental, social and economic conditions in a simple way. The reason to focus on this specific branch of the literature is that multidimensional indicator construction also implies the inclusion of very different data, usually expressed in different scales and therefore requiring the use of specific methodological tools. For this reason, we use the Ecological economics literature concerned with sustainable indicators as a basis for our analysis. In the Ecological economics literature, due to the rising concerns on the anthropogenic impact on the environment, a well number of studies have developed composite indicators designed to measure such impacts from a multidimensional perspective. The development of these indicators generated a debate around the methodological challenges of their construction and the arbitrariness and coherence among methodological choices. In fact, our conception of arbitrariness is based on the study of Ebert and Welsch (2004) in which the authors point out the presence of arbitrariness in the normalization rules. More precisely, in their discussion of the environmental indices and the aggregation and normalization procedure they highlight that "The popular procedure of normalizing data before aggregating them does not provide a solution to the noncomparability of the data and the ensuing ambiguity of orderings. Rather, the arbitrariness of the normalization rules introduces additional ambiguities" (Ebert and Welsch, 2004).

As in the case of the environmental indices, the conclusions of this study prove the high level of arbitrariness in the methodological choices. Moreover, we extend our critical review of the literature to analyze other characteristic of the construction procedure and found a lack of consistency between such choices and the argued energy policy targets. Furthermore, the conclusions notes the necessity to develop a more consistent approach in order to make available indicators useful to design, implement and assess energy policies, signaling the main drawbacks of the indicators review.

To do that, the article reviews the main methodological steps for the construction of ES composite Indicators in 16 studies. The first section describes the methodology applied in this study. It frames the ES concept used on multidimensional indicators and describes the main steps of composite indicators construction, starting with data normalization to allow comparisons, the weighting of simple indicators, their aggregation and the sensitive analysis. In that regard, as in Böhringer and Jochem (2007) this article will focus on the characteristics of the data and the meaningfulness of the final indicators in the sense of Ebert and Welsch (2004). Section three presents a resume of the main characteristics of the indicators reviewed. Fourth section present a discussion of the different methodologies signaling their consistence with respect to the formal requirements. Finally, the last section presents the main conclusions.

2. Methodology

Although in the last 10 years has been a period of intense proliferation of ES indicators or indexes, it has not been systematically followed by a discussion on the methodology behind the construction of such indices. In the literature, the criteria for the constructing appropriate ES indicators have been poorly discussed and only some contribution exist on this topic. This contrast with the development of the quantitative analysis on other scientific areas, especially ecological indicators, that during the 90 was object of intense research (Böhringer and Jochem, 2007; Singh et al., 2009).

The first discussion on the methodological challenges of creating comprehensive ES indicators is rather recent, and appear in Sovacool and Mukherjee (2011), Cherp (2012), and Sovacool (2012). This public discussion raised various sources of disagreement among energy experts: i) selection of indicators; ii) priorization of areas; iii) weighting procedure; iv) scoring; v) the use of quantitative versus qualitative methods; vi) scale; vii) comprehensiveness; viii) temporality and context; ix) data quality and availability.