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Original Research Article

A combination of existing concepts and approaches to take on energy system transitions – The Republic of Panama as a case-study

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ABSTRACT

The impact of our energy systems on the climate mandates an energy system transition. In this paper a combination of existing concepts and approaches to take on such transitions is discussed. This combination starts with first defining the unit of analysis, after which actors in the socio-technical energy system are charted through literature research and interviews. Next, using social network analysis, regimes and niches are identified to depict the unit of analysis in a more useful manner for managing transitions. The step hereafter consists of creating internal and external scenarios based on critical uncertainties to insure transition management efforts against uncertainty in and outside the unit of analysis. Moving to transition management, robustness analysis is then used to evaluate strategies and policies in all combinations of these internal and external scenarios to get to an optimum set of strategies and policies which are used to form a normative scenario. This will be used to get stakeholders behind the transition effort. This combination of approaches and concepts is used in the case of the Republic of Panama. It results in a clear overview of the energy system, impediments and opportunities regarding transition, possible futures, and the validity of strategies and policies in different scenarios.

Introduction

The world is on an unsustainable path when it concerns the energy usage which forms the basis for almost all activity undertaken by mankind. There are three main reasons for this: demand for energy services is growing primarily due to population and economic growth in developing countries; the majority of the energy supply is provided by finite fossil fuels; transformation of these fossil fuels into readily usable energy for the consumer generates greenhouse that contribute in a significant way to global warming and subsequently to climate change.

Hence, the last decades a lot of effort has been put into place in academia, politics, business and other groups to create so-called "sustainable energy systems", meaning energy systems which have a negligible negative impact on the environment on short, middle and long term which would otherwise result in climate change [28,33]. However, transitioning towards such energy systems has proven to be difficult due to the fact that the existing unsustainable energy systems in use are firmly embedded in society in terms of sunk costs en vested interests; their socio-technical nature – a term that encompasses the technological, social, political, regulatory, and cultural aspects of electricity supply and use [43] – has influenced and formed engineering practices, academia, legislation, institutes, behavior, spatial planning, among other things, all of which need to change (some more than others) if a new energy system is taking center stage. Another reason is also found in the fact that such a transition on a global scale will cost enormous sums of money and consume years (if not decades) and thus prove to be difficult, in particular for developing countries. Therefore, a lot of research regarding "energy system transition" has emerged and intensified in the last decades, spawning several academic courses, journals and articles, and various approaches to understand and manage transitions.

This paper attempts to add to this research on energy system transitions by examining the borders that make up the realm of energy system transition management in a particular case, namely the country of Panama. To do this, a methodology consisting of existing approaches has been used which addresses important transition aspects such as regimes (dominant actors), niches (innovative actors), landscape (i.e., external to the energy system) factors, uncertainty, etc., all of which will be explained in this paper. The methodology has its roots in social network, futures and transition studies. The added value of this paper to existing studies in the field of energy transitions comes in the form of this unique combination of approaches, the fact that energy transitions and futures for Panama have not yet been explored, and the fact that macro-scale analyses regarding energy transitions in the context of developing countries are virtually non-existent in contemporary literature on energy system transitions, even

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though transition characteristics are dependent on their context [6,44].

This paper is structured as follows: in the next section, the methodology is explained in detail. The section thereafter reflects on and discusses the approach. The fourth section discusses a case study (Panama) where the methodology is applied upon. The last section concludes this paper and provides a number of recommendations.

Methodology

The methodology used is aimed at understanding the construction and dynamics of socio-technical systems in general, and how to manage these in such a way that leverage points are identified and utilized to ignite and accelerate the transition of these systems towards desirable alternatives. Since it is a self-developed methodology is discussed rather extensive in this paper. It consists of several approaches which are chosen with the aim that the overall methodology provides a sound snapshot of the socio-technical system, uncertainties within and outside the system, and possible future pathways. It starts with conducting interviews and performing a literature study in order to be able to perform a social network analysis (to obtain a clear picture of the unit of analysis), and its environment. The latter is broken down into predetermined elements (factors that have more or less predictable developments) and critical uncertainties (factors with unpredictable developments). The next step is re-arranging the charted social network in such a manner that sets of regimes and niches become apparent. Next, scenarios are constructed (including a normative scenario) using the earlier mentioned landscape factors (factors outside the energy system) and other indicators. The final step consists of using robustness analysis and the normative scenario to guide transition management. The steps are detailed in the following subsections.

These steps are intertwined: information obtained through interviews and desk research is used in social network analysis and to identify landscape factors. These results are used to depict the unit of analysis in a more useful manner (more on this in Identify the Multi-Level structure section) for managing transitions and the latter is used to create scenarios for this unit of analysis (detailed in Create scenarios section). These scenarios are used to insure transition management efforts against uncertainty both within the unit of analysis as well as in external (landscape) influencing factors. Validating strategies, policies and actions against each scenario and iteratively tracking towards which scenario the present is heading is embedded in transition management (see Formulate strategy and create management system section). Thus in this paper, the social network analysis and scenario creation form the foundation which transition management builds upon.

Define the unit of analysis

It is important to start with carefully defining the unit of analysis. Since this paper focuses on the transition from one energy system to another, the unit of analysis will be a socio-technical energy system by definition, but the questions remains as to how large the scope will be, in other words, whether the energy system of a region, country, group of countries, etc., will be placed under scrutiny. Properly defining the unit of analysis will prevent the omission of important actors in the socio-technical energy system, and make a proper distinction between internal and external (regarding the energy system) influencing aspects (which will be called "landscape factors" from Conduct interviews subsection on). Partly due to these reasons, a proper definition will also influence which questions need to be asked in the interview process (which is discussed in the next subsection). It should be noted as a cautionary warning that a larger unit of analysis will automatically result in a longer and more difficult process (because of more actors, variables, data, etc.).

Conduct interviews

After the unit of analysis is defined, interviews need to be conducted. To do this in a proper and efficient manner, the following actions need to be undertaken:

- actors that are part of the socio-technical energy system need to be identified, for instance by researching websites, newspapers, magazines, etc.;
- a questionnaire needs to be conceived which is flexible in structure (i.e., the interviewer is allowed to ask additional questions, alter the sequence of questions, apply small changes to the questions, etc.), but also grounded in the local context [3]. The questionnaire needs to address the following topics:
  - o the strength of ties between the different actors within the energy system;
  - o landscape factors (named "driving forces" in Scenario Planning literature), which refer to events and trends occurring outside the confines of the energy system but which do have an impact on the system [10,39]. Furthermore, questions need to unravel whether these landscape factors belong to the category of predetermined elements (forces of change whose development and impact over time can more or less be estimated), or critical uncertainties (unpredictable driving forces that will have an important and sudden impact on a particular area of interest). These driving forces can be divided into social, technological, economic, environmental and political factors that form the structure in the landscape (the contextual environment) from which trends and events emerge [48];
  - o driving forces within the energy system (also categorized in predetermined elements and critical uncertainties);
  - o leading indicators which are used to anticipate towards which scenario the present socio-technical energy system is heading [8].

The interview process will be characterized by non-probabilistic sampling since the interviewer is directly targeting actors in the socio-technical energy network, rather than using a sampling frame from which actors will be randomly picked. Furthermore, to enhance the search for relevant actors, sampling will also be characterized by the snowball effect, which refers to gaining access through the initial respondents to other relevant observational units [2].

It is possible that the interviewer is unable to identify all actors within the energy system. However, if the research to determine the actors has been done properly, it can be assumed that those unidentified actors play a marginal role within the energy system – and even in the niches of that system (which will be discussed in more detail in the next subsection) – and thus their impact can be neglected.

Social network analysis

Utilizing the information obtained through research and interviews, the strength of the ties between different actors in the socio-technical energy system is made visual. The definition of tie strength is of the utmost importance. It can be defined in a quantitative sense (e.g., by using the frequency of recent contact as the definition of tie strength) or in a qualitative manner, i.e., through