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Towards a comprehensive policy for electricity from renewable energy: An approach for policy design

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ABSTRACT

Energy policy design in Europe is a complex issue involving multiple levels of governance, and heavily influenced by institutional contexts. However policy design in Europe, and model-based analysis even more so, is arguably shaped by the neo-classical school of thought. There is a need to provide a structured approach that would facilitate the incorporating of institutional contexts into Renewable Energy Sources for Electricity (RES-E) policy design and analysis. This paper presents a formal approach to RES-E policy design based on Design Theory, the Institutional Analysis and Development (IAD) Framework, and Agent Based Modelling and Simulation. Given a certain frame of analysis, we propose that it is theoretically possible to identify the complete policy design space, a set of design elements. Crucially, this aspect potentially opens up to the policy analyst new avenues for intervention, and allows her systematically explore, given a range of uncertainties, which element(s) of intervention is(are) the most vital to achieve the goals of the community. Its empirical applicability is demonstrated by representing and differentiating between six RES-E schemes from Western Europe in terms of the design elements; a model-based illustration demonstrates the value of this approach to quantitatively analyse the impact of design elements.

1. Introduction

1.1. Background: RES-E policy analyses so far and problem definition

Energy policy design and analysis, especially in relation to the incentivising of renewable energy, is arguably dominated by the neo-classical school of thought, at least in Europe. This is evident in the guidelines for incentivising Renewable Energy Source from Electricity (RES-E) by the European Commission, called the State Aid Guidelines, which primarily urge that all renewable support take the form of competitive bidding, see for instance European Commission (2014). In literature, general equilibrium models and optimization models are the preferred tools. Capros et al. (2014) for instance, offer detailed descriptions of seven EU energy economy models of decarbonisation pathways. Some of the most cited models of RES-E schemes specifically, have been given by Huber et al. (2004), Voogt et al. (2001), Most and Fichtner (2010), and Fais et al. (2014). The outcomes of these models however, depend heavily on underlying assumptions about reality; assumptions of perfect market conditions and perfect information being some of them. A recent controversy regarding the use of equilibrium models for informing policy decisions like EU energy efficiency targets questions their applicability to policy-making; see Riley (2015). The important question to be addressed here, is whether these perspectives and tools are sufficient to help achieve the goals the EU has set for its energy sector – competition, affordability, and sustainability.

The outcomes of a certain policy depend on far more than variables such as price and quantity. They depend on the explicit or implicit institutions, which may be part of the policy, or part of the environment surrounding the policy, that shape the socio-technical system. As Polski and Ostrom (1999) point out, “Institutions delimit the capacity for social change. They are important because they are intentional constructions that structure information and create incentives…thereby imposing constraints on the range of possible behaviour and feasible reforms”. This makes institutional analysis paramount in the study of policy design. In addition, such analyses lend to the policy maker, in a structured fashion, a set of policy design characteristics, with which to operate on the socio-technical system. The challenge then lies in identifying the most essential design characteristics of a policy or set of policies, which are sufficiently informed by their institutional setting, and evaluating their impacts on the socio-technical system.

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Some studies have tried to incorporate a more comprehensive approach to RES-E policy design, see for instance work by Bergmann et al. (2008), and Batlle at al (2012a). Most literature uses a "policy analysis approach" where comparisons, and categorizations are made between and across different *existing policies*; for examples refer to Batlle et al. (2012b), Kitzing et al. (2012), Kitzing (2014), and Fagiani et al. (2013). It is proposed here however, that the basic unit of analysis is not the policy itself, but a set of "design elements". Design elements refer to the detailed components that make up a certain policy, for instance, technology specificity, location specificity, duration of support etc. Two seemingly different RES-E support policies can be designed such that they have an equivalent effect on the market. This idea has been upheld by several authors such as Batlle at al (2012a), del Rio and Linares (2014), del Rio and Mir-Artigues (2014), and Haas et al. (2011). However, they have been empirical observations, rather than a formal approach to policy design.

1.2. Research objective

The primary objective of this research is to introduce a formal, structured approach to the design of policies for the stimulation of RES-E in Europe. To achieve this we decompose the objective into the following sub-objectives: (1) to identify a set of necessary and sufficient policy design elements to incentivise RES-E in Europe, and (2) to introduce a modelling framework to analyse the impact of the policy design elements on the socio-technical system.

In order to accomplish the above sub-objectives we introduce a formal method based on design theory and institutional analysis to identify a policy design space, i.e., a set of necessary and sufficient design variables that we term, 'design elements'. These design elements are identified for a certain level of analysis,[1] and for a selected set of participants in the socio-technical system. Following this, a modelling framework to facilitate the analysis of the design elements, and identify the impact of each individual design variable on the socio-technical system. The modelling framework is implemented using agent-based modelling and simulation. Such a formal approach would not only help analyse existing policies and their impact on the socio-technical system, but also help explore the full policy design space in a structured fashion, by incorporating the institutional context into the analysis.

This work is part of a two-pronged approach, where the first part aims at identifying the design elements and introducing a structured approach to their modelling, and the second part is dedicated solely to modelling the impacts of design elements. The objective of the current paper is thus to present a delicate, balanced, theoretically-founded, and empirically-supported argument towards the identification of policy design elements and consequently a new approach to analysing and designing renewable policies. The computational model here is only meant as an illustrative example of the modelling framework introduced. In fact, a separate paper by Iychettira et al. (2017), recently published, has been dedicated to describing the computational model in a detailed manner: it comprises the modelling of the design elements, the detailed algorithm, the results, and their interpretation.

2. Theoretical foundations and methodology

The objective of this section is to introduce a methodology to achieve the objectives outlined in Section 1.2. The section consists of a brief description of the different schools of thought on which methodology rests. It comprises three main components: the application of design theory to policy design, the application of the Institutional Analysis and Development (IAD) framework for identification of design elements, and finally, the theoretical foundation to create a modelling framework to analyse policies in terms of their design elements.

2.1. Theoretical foundations

2.1.1. Design theory applied to policy

"Ubiquitous, necessary, and difficult" is how Bobrow (2006) qualifies the act of policy design. Governments, irrespective of issue type, are interested in effective realization of their goals, by applying knowledge and empirical data to assess appropriateness of alternatives to achieve those goals, and thus engage in 'design', Howlett (2011). The application of (generic) design theory to policy design and policy analysis is not new. Linder and Peters (1984) are among the earliest, while Howlett and del Rio (2013), Considine (2012), and Taeihagh et al. (2009) are among the more recent authors who have contributed to this topic. Read Howlett (2011) for a comprehensive review of policy design literature.

In Taeihagh et al. (2009), an analogy has been drawn between process design and policy design, to inform transport policy. Their work is based on the theoretical frameworks of Process System Engineering. The framework used in this work, the Generic Conceptual Design Framework (GCDF), also has its roots in Process System Engineering.

The Generic Conceptual Design Framework has been developed collaboratively at the Carnegie Mellon University and Delft University of Technology. It is illustrated in the Fig. 1. This work is based on the design framework (specifically the problem definition and conceptual design aspects) initially developed by Westerberg et al. (1997), which draws heavily from process system engineering, and is described in detail and applied by Herder and Stikkelman (2004) and Subrahmanian et al. (2003). The framework comprises of the following main concepts, which together, structure the content of any level in a design process: 1. Design goals; 2. Design objectives (selection of goals to be optimised); 3. Design constraints (goals that need not be optimised); 4. Tests for the goals; and 5. Design space.

One may contend, as Rittel and Webber (1973) did, that for most social planning problems or 'wicked problems', the concept of design is a technocratic activity and is not applicable to policy making, as policy-making is a value-laden activity, and therefore its appraisal is highly dependent on each participant's personal value-set. In response, Howlett (2011) writes that there must be a distinction drawn between 'design' as a verb, and that as a noun – instead of treating design as an outcome, he urges the reader to view it as a process of "channelling the energies of disparate actors towards agreement in working towards similar goals in specific contexts". And that is the viewpoint that we wish to subscribe to.

2.1.2. Institutional analysis to identify goals and policy design space

Institutional analysis is a commonly used approach to study socio-technical systems, and especially so in the field of institutional economics; see for instance North (1991), Williamson (1998), and Ostrom (2005). There are several frameworks for institutional studies to describe socio-technical systems. For a concise, informative overview of the different frameworks, refer to Chapter 2 of Ghorbani (2013).

As argued in Section 1, institutional analysis is paramount in the study of policy design. For the purpose of this research, we choose to employ the Institutional Analysis and Development (IAD) framework developed and applied across decades by Ostrom (2005). Conceptually this framework dissects the socio-technical system into composite *holons,* defined as 'a stable sub-whole in an organismic or social hierarchy which displays Gestalt constancy', Ostrom (2005). This conceptual foundation, of sub-wholes and hierarchies, also corroborates with that of process design theory. Ostrom describes the application of the IAD framework to policy design and analysis, and presents a step-wise process for it in Polski and Ostrom (1999). It also lends itself easily to analysis by computational social sciences such as ABMS,

[1] In Chapter 2 of Ostrom (2005) 'levels of analysis' are described thus: "All rules are nested in another set of rules that define how the first set of rules can be changed It is useful to distinguish levels of rules that cumulatively affect actions taken and outcomes obtained in any setting".