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Review

Interdisciplinary energy research and energy consumption: What, why, and how?☆

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ABSTRACT

Reducing energy demand and increasing energy efficiency are two major objectives that numerous national and international programs, such as the EU 20-20-20 targets, seek to achieve in the ongoing transformation of energy systems. Despite the predominately socio-economic nature of energy demand, such interdisciplinary viewpoints – albeit on the rise – are still the minority within energy-related research. In this paper, we develop an applied approach to support interdisciplinary research focusing on a common research objective which examines and clarifies the three questions: 'What', 'Why' and 'How'. We test the capability of the approach by performing an exemplary review of energy demand both from an economics and a social-science perspective.

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Contents

1. Introduction

The ongoing debate about climate change, the nuclear accident in Japan 2011, the shale gas revolution in the United States, the progress in renewable generation, and the ever-increasing energy demand in emerging countries have ensured that 'energy' has been a focal issue in political, economic and societal discourses over the last decade. Especially in some European countries, the political vision is to achieve a transformation towards a 'sustainable energy system'. Although there is no generally agreed definition of what a 'sustainable energy system' exactly comprises or which achieve-

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ments are presumed (e.g., see [40,27,32,128] Swiss Academy of Sciences, 2012), it is obvious that this transformation process includes technological, economic, social and ecological factors, and requires measures and instruments on an institutional as well as an individual level [97,50].

Taking the ongoing transformation processes in Europe as a benchmark, this includes promoting and facilitating the following objectives: a shift towards renewable energy sources, emission reduction in electricity production and heating, 'smart' and flexible transmission and distribution systems, advanced mobility options and management, and energy-efficient buildings. Although there is a large focus on the supply side, improvements in energy efficiency, energy demand reduction, and decupling of energy demand from economic growth are considered important elements. As end-consumers often do not consider energy as a relevant aspect of products they purchase or activities they undertake, our current energy system is the outcome of consumption that is only partially accounting for energy efficiency considerations or sufficiency aspects.

Given the extent and novelty of the challenge to change the existing energy system, it is obvious that the scientific community will be needed to provide solutions and answers to inform decision makers on a multitude of issues regarding the transformation process (see e.g., [92], for a discussion on the contribution of the social sciences, or [127] for an example on the supply side). One significant, but not exclusively energy-related, challenge of this process is the need for cooperation between different scientific disciplines and the integration of different perspectives (for an overview of obstacles and challenges regarding interdisciplinary research see [83]). However, due to the variety of disciplines applied and their different theoretical frameworks, collaboration in energy research is not a trivial task. A holistic approach, which is capable of integrating multiple disciplines, will be needed to answer emerging questions (for this argument, see also [111,14]). Thus, in energy-related research practice, interdisciplinary research projects are necessary to tackle the energy market transformation process (see also [105]).

Given the above described challenges, this article aims to provide a framework for fostering interdisciplinary research and achieve the envisioned holistic evaluation. The presented methodological framework takes up experience of interdisciplinary collaborations and focuses on applied research objectives and a common research agenda thereby avoiding the 'clash' of theoretical foundations. To highlight the suitably of the developed approach and link it to our initial motivation we apply and exemplify the methodology via a review of economic and social science literature on energy consumption.

Consequently, the paper at hand is split into two main parts. First, the underlying interdisciplinary framework is shortly presented. To achieve a productive collaboration between different disciplines we envision an output oriented framework based on a common research agenda following the three guiding question 'What', 'Why' and 'How'. The focus on a common objective and what the different disciplines can contribute in answering the underlying questions avoids the need for defining a unifying cross-discipline theoretic foundation.

Second, we test the approach with an exemplary review on the topic of 'energy demand within the ongoing energy transformation'. Given the extent of this topic we limit the review to aspects focusing on the energy consumer and its role in the transformation, i.e., directing the analysis towards the microeconomic and individualistic approaches such as social psychology and behavioral economics. The review highlights what the socio-economic disciplines already contribute in their respective domains, presents existing interdisciplinary collaborations, and identifies potential fields for further joint research. The review provides an example of how the three guiding questions help to structure different bodies of literature and link them beyond classical disciplinary boundaries: the 'What' question links observations and the research objective, the 'Why' question then links the research objective with the different disciplinary theories, and the 'How' question aims to link this knowledge with the problem at hand and represents the basis to develop the necessary solutions.

Summarizing, the presented framework provides a suitable outline to structure existing research for a particular research objective within a multi- and interdisciplinary context. It helps to identify research gaps, synergies between different disciplines, and potential next steps as well as new fields for joint research projects. Albeit we apply the framework within the specific context of energy demand and energy consumers the approach is designed to be applicable for a multitude of topics. The review on socio-economic energy research can also be extended to address further problems in the ongoing energy transition.

2. Benefits and challenges of interdisciplinary collaboration—what, why and how?

As indicated in the introduction this paper is motivated by the observable lack of interdisciplinary collaboration in energy research, especially among socio-economic disciplines. Most of the existing interdisciplinary research in energy topics is technology related. One of the major fields of collaboration involves techno-economic studies based on market modeling with a high detail on the energy supply side (e.g., see [62]). As observed by other scholars, too (e.g., [75,72,107]), energy research and related policies have had its focus on either technological change or simple one-sided psychological approaches especially to enhance energy efficiency. Given the importance of the demand side within the ongoing transformation processes we envision that socio-economic research can play an important role in providing important insights and answers to the challenges at hand.

We also take up the broader discourse on integrating social sciences into energy research and appreciate the achievements to foster this debate in contemporary journals and publications (see [106]). Whereas a large number of contributions argue for a general undervalued presence of the social sciences in energy research (e.g., [91,74,73,72]), this paper aims to strengthen the perspective that even if social science approaches are introduced and considered, they only have limited utility to clarify the pressing questions of the energy system transformation due to its focus on single disciplinary approaches in theory as well as in practice (see also [76,92,105,116]). While the benefits of the collaboration between the various social science related disciplines and non-classical economics are evident in general socio-economic literature (e.g., [102]), they can be rarely found in energy research.

The complexity of most questions and problems leads to difficulties when attempting to integrate different perspectives within a common theoretic framework. Although economics can be understood as a sub-discipline of the social sciences, its methods and approaches are quite distinct from those applied in other social sciences, such as sociology or political science (for a detailed overview on the variety of approaches, see [91][91]). These differences can hamper joint research projects, as these fields present theories and methods that are hard, if not impossible, to merge.

To avoid such a 'clash' of theoretical foundations we envision an approach focused on applied research to lay the ground for collaborations. We envision to establish a *common research agenda* as a guideline for joint research in combination with associated research fields. This approach demands that we first focus on a specific applied research topic instead of relying on an established

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