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Understanding values embedded in offshore wind energy systems: Toward a purposeful institutional and technological design☆

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ABSTRACT

The challenge of a purposeful design addressed in this article is to align offshore energy systems not only with technical and economic values like efficiency and profitability, but also with moral and social values more generally. We elaborate a theoretical framework that allows us to make a systematic inventory of embedded values of offshore energy systems and relate them to their societal acceptability. By characterizing both objects and subjects of acceptability, we shed light on ways to identify areas of value conflicts that must be addressed in purposeful design. We suggest the capabilities approach as a normative theory to deal with the arising value conflicts.

1. Introduction

Currently, many industrialized nations in Northwest Europe seek ways to promote energy transitions from fossil-based to renewable energy sources. The German *Energiewende* illustrates the high social and political ambitions toward renewable energy supply and use (Von Hirschhausen, 2014). National policy and regulations aim to produce 80% of the electricity consumed from renewable resources by 2050 and to decrease greenhouse gas emissions 70% by 2040. This can only be achieved with improved renewable energy technologies stimulated and supported by institutional change.

Even in countries such as Germany where sustainable technologies are generally supported by their populations, concrete technologies for large-scale renewable energy such as offshore wind parks are, however, greeted with skepticism and even protest. Scholars who have analyzed these seemingly contradictory reactions usually discuss this as an issue of social acceptance, often in terms of conflicting interests of various stakeholder groups after the technologies have been developed and deployed (Haggett, 2011; Huber and Horbaty, 2010; Wüstenhagen et al., 2007; Firestone and Kempton, 2007; Kempton et al., 2005).

In this paper, we aim to expand this discussion in two essential ways. First, we take a normative perspective. We refer to social *acceptability*, which reflects the moral and

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societal values that are shared by all members of society. A purposeful design would then relate to technologies and institutions that embed certain moral values (Oosterlaken, 2014). In this way, we relate societal convictions of what is perceived as good or bad to different technological and institutional designs of future energy systems. Those convictions, for instance values related to distributional justice or environmental sustainability, need to be considered a priori in the design process of potential future energy systems (Grunwald, 2014; Taebi et al., 2014). Our approach is illustrated for the case of social acceptability of offshore wind energy systems. It brings together social science in the field of institutional economics (Ostrom, 2005; Williamson, 1998), with applied ethics, particularly the capability approach (Sen, 1999; Nussbaum, 2001). We thus position our work at the interface between these two fields, providing an innovative perspective on purposeful institutional and technological design.

Second, given that moral and social values are important to foster societal acceptability, we propose a framework that systematically relates these values to different dimensions of institutional and technological designs of future energy systems (Karlsruhe Institut für Technologie, 2013; Wüstenhagen et al., 2007). This approach also informs us about possible value conflicts that might lead to societal unacceptability (Albrechtslund, 2007; Van de Poel, 2009). In this sense our approach can serve as an 'early warning system' that identifies possible societal concerns in a very early stage of planning and development of future sustainable energy systems (Grunwald, 2014). Hence, our framework is instrumental for specifying further what particular values are supported by different future energy systems and, perhaps even more important, what kind of value conflicts might arise. This can be helpful to derive purposeful design, in our case illustrated for offshore energy systems.

With this contribution we aim to bring moral values into the discussion of technical and institutional change. This is the first theoretical step intended to facilitate a more detailed empirical analysis of energy transitions. While our approach is illustrated for the case of offshore wind, the analytical process we employ need not be limited to energy systems but rather can be expected to aid researchers studying the development of very different socio-technical systems. In addition, we need to keep in mind that shared societal values might differ between cultures. The approach we are elaborating in this paper primarily builds on societal convictions that can be attributed to 'western-type' societies with a strong emphasis on individual freedom and choice. This does not however preclude its applicability to other cultural contexts.

In Section 2, we introduce the case of offshore wind by providing some insights into typical technical and institutional challenges, as well as values associated with this means of energy provision. In Section 3 we describe our normative approach. Section 4 provides a framework for identifying different objects and subjects of social acceptability. In Section 5, we explain how this framework leads to a better understanding of values embedded in institutional and technological designs of offshore wind energy systems. In the conclusions, Section 6, we argue that a deeper understanding of moral and societal values as well as of potential value conflicts will facilitate purposeful technical and institutional design in energy transitions.

2. The case of offshore wind energy systems

Offshore wind energy systems are expected to make a significant contribution to the energy transition (Esteban et al., 2011). It is an interesting example for our approach because the development of offshore wind can be characterized as a Greenfield process. This part of the electricity supply system is just emerging in the past few years. Its main components like the network and wind farms need to be newly developed and policy and regulatory support need to be provided to realize the ambitious targets. Offshore wind has the potential of becoming a significant extension of the existing infrastructure and transforming existing energy system configurations. Implementation of such large-scale technical modification and institutional arrangements raises questions about the possible social acceptability that arise from new systems or their components. The case of offshore wind provides some typical illustrative examples to elucidate our approach.

2.1. *Technological challenges*

The designs of far offshore wind systems need to meet very specific requirements that differ greatly from those developed for wind parks on land and near shore (Bilgili et al., 2011; European Wind Energy Association, 2012). For example, the height of near shore and onshore turbines is limited by air traffic restrictions that do not apply to far offshore thus higher masts and longer blades are constructed to generate significantly more electricity at the higher winds at sea. Larger and heavier turbines require strong foundations currently fixed to the seabed though new types of floating and sinking foundations are being designed as constructions easily dismantled and, if necessary, changed in the future (Athanasia and Genachte, 2013; Joselin Herbert et al., 2007). Unlike onshore and near shore systems that usually feed energy directly and easily into the existing electricity grid, cable connections to wind parks tens of/hundreds of kilometers offshore must be made to the grid onshore in the current system design. Construction of turbines and offshore transformers, the laying of cables on the sea floor, and later maintenance work must take place safely in the severe conditions at sea (Shafiee, 2015). Because these far offshore wind parks with a large number of turbines generate enormous amounts of electricity particularly during high winds, systems for electricity transportation, storage, or transformation frame both design challenges and opportunities for purposeful infrastructural change. This requires substantive technical adaptations of the onshore power system as well. All of these necessary large-scale technological adaptations and changes lead to questions informed by societal values (Oosterlaken, 2014). What are the impacts of the large scale developments of offshore wind systems on the marine ecosystem (Van der Molen et al., 2014)? What extensions of the transmission lines are needed to facilitate this sustainable power production (Rodríguez et al., 2014)?