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Comparing consumer perceptions of energy security, policy, and low-carbon technology: Insights from Denmark☆

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ABSTRACT

This study investigates how energy-users from one low-carbon country – Denmark – perceive energy security threats and dimensions compared to those from ten other countries. The purpose, in part, is to discuss the relationship between consumer perceptions of energy challenges, adoption of renewable energy, climate change, and the prices of energy services. The article's primary source of data is a survey distributed in eight languages (English, Danish, Mandarin, Portuguese, Russian, Arabic, German, and Japanese) to 2495 respondents in Brazil, China, Denmark, Germany, India, Kazakhstan, Japan, Papua New Guinea, Saudi Arabia, Singapore, and the United States. Survey results are used to test five propositions about energy security related to Denmark: the influence of culture, being "green," the centrality of oil and gas, the salience of energy trade, and the necessity of affordable prices. The study concludes that Danish respondents rate energy security dimensions lower than most other countries, that responses invalidate a number of propositions stated in the academic literature, and that energy security is a complex topic both in theory and in practice. Furthermore the results suggest that consumer perceptions and attitudes about decentralized policy options (from the bottom-up) rate lower than governmental and institutional ones (from the top-down).

1. Introduction

Denmark is one of the most energy secure and sustainable countries in the Organization of Economic Cooperation and Development [65]. The country has reduced its dependence on foreign sources of energy from above 90% in the 1970s to practically zero today and become net self-sufficient in its own energy production and use. Over the past thirty years, Denmark has transitioned from being almost 100% dependent on imported fuels such as oil and coal for their power plants in 1970 to becoming a net exporter of fuels and electricity today. Denmark has the lowest energy dependence of the EU27 countries [20]. The country uses wind energy to generate upwards of 30% of national electricity annually (2013) and on some days, like recently, more than 100% [63]. It was able to phase out the use of virtually all oil-fired power plants in less than five years and implemented a progressive moratorium on future coal-fired power plants in the 1990s. Their most recent strategy seeks to achieve 30% of total energy supply from renewable energy by 2025 and 100% by 2050 [11,72].

Yet how are these issues perceived by energy users, and how do Danish perspectives differ from others around the world? This study directly answers these questions by exploring how a mix of energy-users from Denmark perceive energy security threats and dimensions compared to those from a collection of ten other countries. Its primary source of data is a survey distributed in eight languages (English, Danish, Mandarin, Portuguese, Russian, Arabic, German, and Japanese) to 2495 respondents in Brazil, China, Denmark, Germany, India, Kazakhstan, Japan, Papua New Guinea, Saudi Arabia, Singapore, and the United States. The survey results are used to test five propositions about energy security related to some of Denmark's national energy challenges.

2. Research methods and propositions

This section describes our methods of data collection (elite interviews, a workshop, two focus groups, and a survey) before presenting five propositions or hypotheses that the study aims to test about perceptions of energy security, policy, and technology.

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To begin, as part of a three year grant project, one of the authors first broke the concept of energy security, policy, and technology into its requisite dimensions. Historically, much literature has focused on security of supply and availability, or on cost and affordability of energy services. Because we believed these approaches were incomplete, we first conducted an extensive review of the academic literature to see if we could parcel out additional dimensions. We reviewed more than 90 studies in peer-reviewed journals published on the topic of energy security and energy sustainability over a 10 year period, with the results presented in Ref. [65]. To triangulate this data, we then conducted 68 semi-structured research interviews over the course of two years with senior energy experts, including visits to the International Energy Agency, U.S. Department of Energy, United Nations Environment Program, Energy Information Administration, World Bank Group, Nuclear Energy Agency, and International Atomic Energy Agency. Participants were selected based on a critical stakeholder approach that sought to include a balance of perspectives from civil society members, academics, government officials, and private sector managers, results which have been summarized in Ref. [73]. Thirdly, one of the authors hosted a three-day workshop in Singapore, attended by 37 participants from 17 countries to discuss both the dimensions to energy security and how it can be questioned, with results summarized by Pasqualetti [54,55], Cherp [6], and Sovacool [69].

The resulting data from the literature review, expert interviews, and workshop suggested that energy security and sustainability cut across five separate dimensions: availability and energy resources, affordability and energy prices, energy efficiency and innovation, social and environmental stewardship, and regulation and governance. Rather than conceiving of energy security or sustainability only in terms of security over access to fuel or protection of the environment, our research advanced a broader notion encompassing technology, fuels, trade, behavior, institutions, the environment, and education. Similar arguments in favor of the broad nature of energy security and sustainability policy have been presented in [12,27,28,32,60,66,84].

Our final step of this part of the research process was to synthesize this broad conceptualization of energy security and sustainability into distinct questions. We did this through two focus groups, and the final results suggested, strongly, that we ask questions along these 16 different dimensions to energy security:

- Securing a supply of fossil fuels and uranium;
- Bolstering trade in energy fuels and commodities;
- Minimizing depletion of domestically available fuels;
- Providing predictable and clear price signals;
- Enabling affordably priced energy services;
- Providing equitable access to energy services;
- Decentralizing to small-scale energy supply;
- Lowering energy intensity (energy use per unit of Gross Domestic Product);
- Researching and developing new energy technologies;
- Ensuring transparency and participation in project siting and decision-making;
- Offering energy education and information;
- Preserving land and forests;
- Enhancing the availability and quality of water;
- Minimizing air pollution;
- Responding to climate change/adaptation;
- Reducing greenhouse gas emissions/mitigation.

To translate these sixteen dimensions into questions, we created a structured questionnaire consisting mainly of multiple choice questions that we have used previously to assess national energy security issues [2–4,82,83,66–68,70,31].

This survey in particular asked participants to rate our 16 dimensions of energy security and sustainability according to a five point Likert [40] scale:

1. Extremely unimportant.
2. Somewhat unimportant.
3. Neither important nor unimportant.
4. Somewhat important.
5. Extremely important.

As Table 1 reveals, the survey was made available online to respondents across all eleven countries through a survey hosting website, and also distributed with physical, printed copies to improve response rates (though in the case of Papua New Guinea none of the participants utilized the online version). A total of 2495 surveys were completed and a copy of the survey in English is provided in Appendix A. This number of responses is well above those published in the past year by social science energy researchers in many other top journals, including Lozanoa et al [41], Guo et al. [23], Carlisle et al. [5] and Sagebiel et al. [62] who all published studies with fewer than 700 respondents.

Fig. 1 provides an overview of the demographic characteristics of respondents for Denmark compared to those for the rest of the sample. Distribution of the survey was random and respondents were not necessarily experts in the field of energy. Those who elected to participate did so only based on their willingness to participate; they were not compensated. To be eligible, a person needed only consider one of our eleven countries their home and consume and use energy fuels or services there.

As Table 1 and Fig. 1 also reveal, some significant biases exist within the sample. Surveys were incredibly difficult to distribute in Papua New Guinea meaning they account for less than 3% of respondents, whereas respondents from the United States, Japan, China, Denmark, and Saudi Arabia each represented more than 11% of responses. Nearly half the respondents were postgraduates in our sample (and almost two-thirds in our Danish sample), more than a third worked at universities (almost four-fifths in our Danish sample), and more than one-third were aged 26–35 (though our Danish sample was older), meaning our respondents have a higher-than-usual level of education. This led us to frame our results as being an "elite" sample since their education, income, and age are not representative of "ordinary" or "normal" people [14,59,88]. Lastly, our survey reveals how respondents perceive energy challenges, not necessarily how they actually are in reality. It thus presents subjective interpretations rather than objective facts. In one way this is a strength of our study given that popular and public sentiments can be determining factors in national energy policymaking.

Our survey also possibly suffers from self-selection bias [7]: that is, only those that already deem energy security or sustainability to be important (or those unhappy with energy security in their country) would ostensibly take the time to complete it. We did not weigh responses to represent actual proportions in the global population. For example, the United States accounts for about 17% of our respondents even though it has less than 5% of the global population, meaning our results reflect a bias towards US (and Japanese, Chinese, Danish, and Saudi Arabian) respondents. It should be noted that our aim was not to generalize the survey results to any population. Instead, the results represent the opinions of an informed audience with a mix of demographic characteristics.

Notwithstanding these shortcomings, we used the survey data to test the five energy security and sustainability propositions shown in Table 2, matched to a particular set of survey questions.