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Energy and environmental attitudes in the green state of Denmark: Implications for energy democracy, low carbon transitions, and energy literacy

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ABSTRACT

This article investigates how a mix of energy-users from Denmark perceives energy and environmental issues such as the affordability of electricity and gasoline, the seriousness of climate change, and preferences for different energy systems. Its primary source of data is a pilot survey and energy literacy test distributed in English and Danish to 328 respondents spread across the country. The survey results are used to test four propositions about energy prices, being "green," public knowledge and competence about energy issues, and self-sufficiency and sustainable technology. The data supports the propositions that Danes identify with "being green" and prefer national and local policies that endorse sustainable technology and being self-sufficient. However, the data also challenges the propositions that Danes would prioritize low energy prices and affordability as key energy concerns and that they are knowledgeable about energy and environmental issues. In this way, a problematic gap may exist between what many academic articles (and previous surveys) report Danish attitudes to be and what this study suggests they are. Given Denmark's ambitious low-carbon goals, these findings have clear relevance to other communities and countries seeking to decarbonize their own energy sectors.

1. Introduction

Denmark has one of the most aggressive energy and climate policies in the world. Since 1976, the Danish energy system has seen a large shift to cogeneration, renewable sources of energy, and energy-efficiency, supported by a political economy of democratic inclusion in decentralized energy planning and a cultural sensitivity to the social and environmental costs of using fossil fuels (Hvelplund, 2014). In 2006 the national government declared a long-term target of "100% independency of fossil fuels and nuclear power," a goal they have since re-emphasized at international energy forums (Rasmussen, 2011), and in 2011, a new energy strategy was published by the Danish Energy Agency with strong energy policy goals and instruments. If Denmark meets these targets, by 2050 primary energy supply will fall significantly and carbon dioxide emissions will equal zero. Though it may sound unrealistic, one independent assessment concluded that for Denmark "a 100% renewable energy supply based on domestic resources is physically possible" (Lund and Mathiesen, 2009).

Yet how is this plan perceived by energy users? How do Danish perspectives differ over issues of energy affordability, energy security, climate change, and technological development? This study directly answers these questions by exploring how a pilot sample of energy-users from Denmark reports their attitudes on energy, climate, and environmental issues. Its primary source of data is a survey distributed in Danish and English to 328 respondents throughout the country. The survey results are used to test four propositions rooted in the academic energy, environment, and climate policy literature.

Our study contributes to the environmental policy and energy studies literatures, and advances the state-of-the-art, in four ways. First, and most broadly, by investigating values, it enables us to get "behind" how energy users—and even suppliers—make decisions. As one study notes, it is "underlying values" that "have substantial and important indirect effects" on patterns of energy consumption, national energy policies, and the acceptance or rejection of new energy technologies (Bidwell, 2013). Though assessing individual

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attitudes and values about energy and the environment enables us to better comprehend consumer preferences, it remains an understudied topic in the field of energy studies (D'Agostino et al., 2011; Sovacool et al., 2012; Sovacool, 2014a, b).

Second, in approaching Danish attitudes this way, the article addresses the twin topics of energy transitions (Araujo, 2014; Hirsh et al., 2014) and the social acceptance of low-carbon technologies (Wustenhagen et al., 2007; Sovacool and Ratan, 2012). For instance, it reports what ordinary energy consumers and business leaders think about cutting-edge, state-of-the-art innovative energy systems capable of having a disruptive impact on society (Foxon et al., 2005) such as energy storage and the smart grid, hydrogen fuel cells, electric vehicles, and the residential application and use of small-scale wind turbines or solar panels. Furthermore, our study provides empirical evidence to how the public view and conceive of externalities (Hodbod and Neil Adger, 2014), and how some sources of energy (notably renewable ones) are valued or not valued for their positive externalities such as cleaner air and economic security while others are endorsed (or uncritically accepted) despite their negative externalities such as climate change, community displacement, and construction cost overruns (Sundqvist, 2004).

Third, and more narrowly for European policymakers, by including a diverse group of stakeholders—with surveys directed not only at business leaders but households—our study offers a broad perspective as to how these actors view the effectiveness of Danish energy policy. Previous studies have shown that energy attitudes are neither static nor consistent; they are instead multi-faceted, with often contradictory goals and aspirations (Sovacool et al., 2012; Sovacool and Saunders, 2014; Sagoff, 2004; Heberlein, 2012). These competing interests need actively managed in order for countries to make meaningful progress on attaining their energy goals. Our study thus helps identify the scope and severity of these potential tradeoffs.

Fourth, and for those in Denmark, by asking questions about alternative energy and potentially disruptive technologies on the horizon, our study provides insight into what Danish stakeholders frame as the key challenges and opportunities they see impacting them over the next five to ten years. It can help steer Danish analysts and regulators as they attempt to continue their transition to low-carbon fuels. This matter becomes of upmost importance because as other countries begin their own process of decarbonization, they may look to Denmark as a model or template from which to base their policy and regulatory interventions. Denmark—and the attitudes prevalent there—may be a harbinger for things to come in other nations.

2. Research methods

Our primary source of data for this study was two surveys, both distributed in 2014, one sent to household energy users and consumers and one distributed to business or industry leaders. Our structured questionnaire consisted mainly of multiple choice questions (some mutually exclusive, others not) that the authors have used previously in a series of studies researched in 2010 and published over the course of 2011–2013, to assess national energy security issues (Bambawale and Sovacool, 2011a,b,c, 2012; Sovacool, 2011; Sovacool et al., 2012; Sovacool and Vivoda, 2012; Knox-Hayes et al., 2013). We then, uniquely, supplemented our survey with questions about knowledge and competence (known within the field as "energy literacy") as well as values based on surveys distributed in the United States by the National Environmental Education & Training Foundation (known informally as the "Energy IQ Test" or "National Report Card" on energy literacy) (National Environmental Education & Training Foundation and Roper ASW, 2002; Coyle, 2005). The survey was made available online to respondents through a survey hosting website, and also distributed physically to improve response rates. Everyone was eligible to participate in the survey as long as they lived (and thus consumed energy) within Denmark. A total of 328 surveys were completed, 224 from households and 104 from business leaders—the authors had hoped for more respondents but believe nonetheless that our results serve as a useful pilot study. Fig. 1 provides an overview of both subsamples, and an English version of the household survey is available in Appendix I, an English version of the industrial survey in Appendix II.

The authors then used the results from our survey to test four propositions about energy and environmental attitudes in Denmark, derived in large part from the academic literature. As Table 1 indicates, one of these propositions centered on prices and affordability; one on green politics and national policy; one on knowledge and literacy; and one on technology and self-sufficiency.

Before the authors proceed to test these propositions, however, it must be noted that Table 1 and Fig. 1 do depict some biases within the sample. Nearly two-thirds of household respondents were postgraduates (higher than the national average), more than four-fifths worked at universities (higher), and more than half the sample was younger than 35 (higher), which is proportionately different than an unbiased sample would represent. Given the location of the authors' university, most respondents were also concentrated geographically in the region of Jutland. The business sample of respondents was non-representative in terms of location (half the respondents from Jutland), size (44% of companies had 10 employees or fewer, lower than the average), type (two-thirds were for-profit institutions, higher than the average), and sector (less than 20% working in the areas of energy and agriculture, lower than the average). Our survey also suffers from self-selection bias: that is, only those that already deem energy and environmental issues to be important (or those unusually interested in energy policy) would likely take the time to complete it.

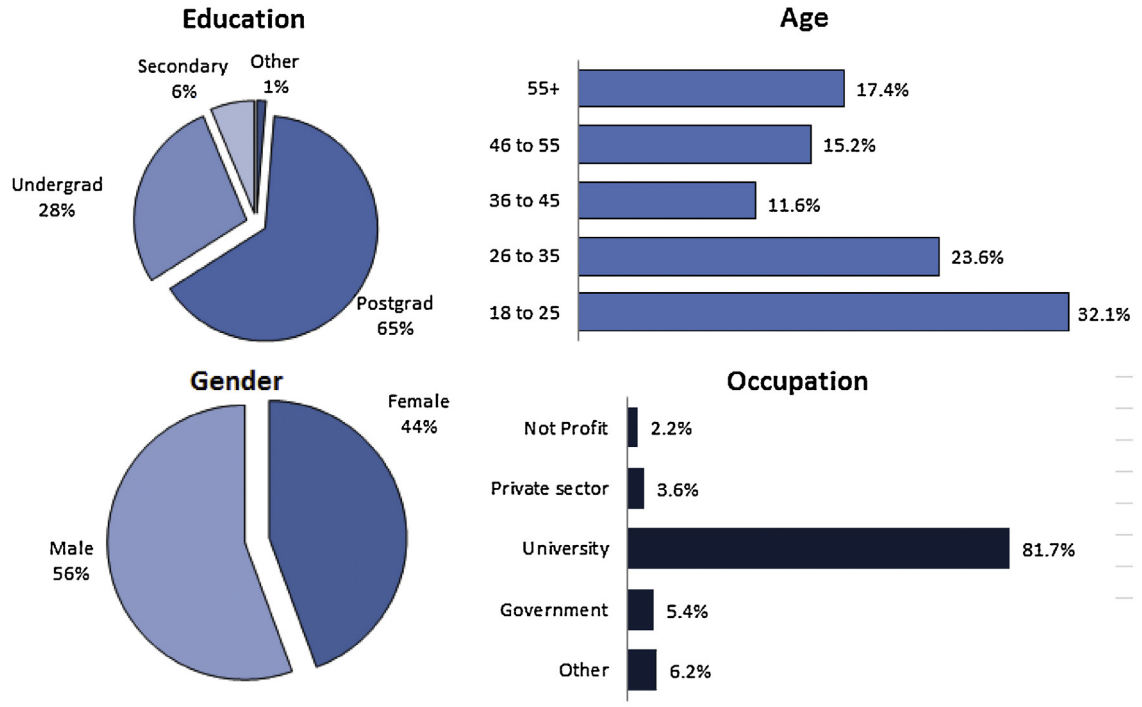
3. Discussion: testing four propositions

This section of the study first presents each of the four propositions and then "tests" them with the results from the pilot survey. As the section will indicate, survey responses supported propositions two and four (related to being "green" and national policy and to sustainable technology and self-sufficiency) but did not support propositions one and three (related to affordability and energy knowledge and literacy).

3.1. P1: The centrality of affordability

The authors reasoned that affordability would matter for Denmark given that household electricity prices are the highest in the European Union at about 29.8 Eurocents per kWh, and the price of petrol is the fifth most expensive in Europe (coming behind Italy, the Netherlands, Greece, and Spain) (European Commission Eurostat, 2012). The British newspaper *The Telegraph* featured Denmark as one of the world's "most expensive energy locations" (Graham Norwood, The Telegraph, 2013) and when adjusted for purchasing power parity the only countries in the world with higher electricity prices are small island developing countries in the Pacific which rely entirely on imported diesel (Lindsay, 2014). The topic of "environmental taxes" or "green taxes" has also become an important political issue in recent months (Jyllands-Posten, 2014a,b), given that "non-recoverable taxes and levies" account for the bulk of electricity tariffs. In 2014, electricity generation costs amounted to only 4.6 Eurocents per kWh and network costs added another 8.5 Eurocents; taxes accounted for

Household Survey, figures expressed in percentage, 100% = 224 respondents



Business Survey, figures expressed in percentage, 100% = 104 respondents

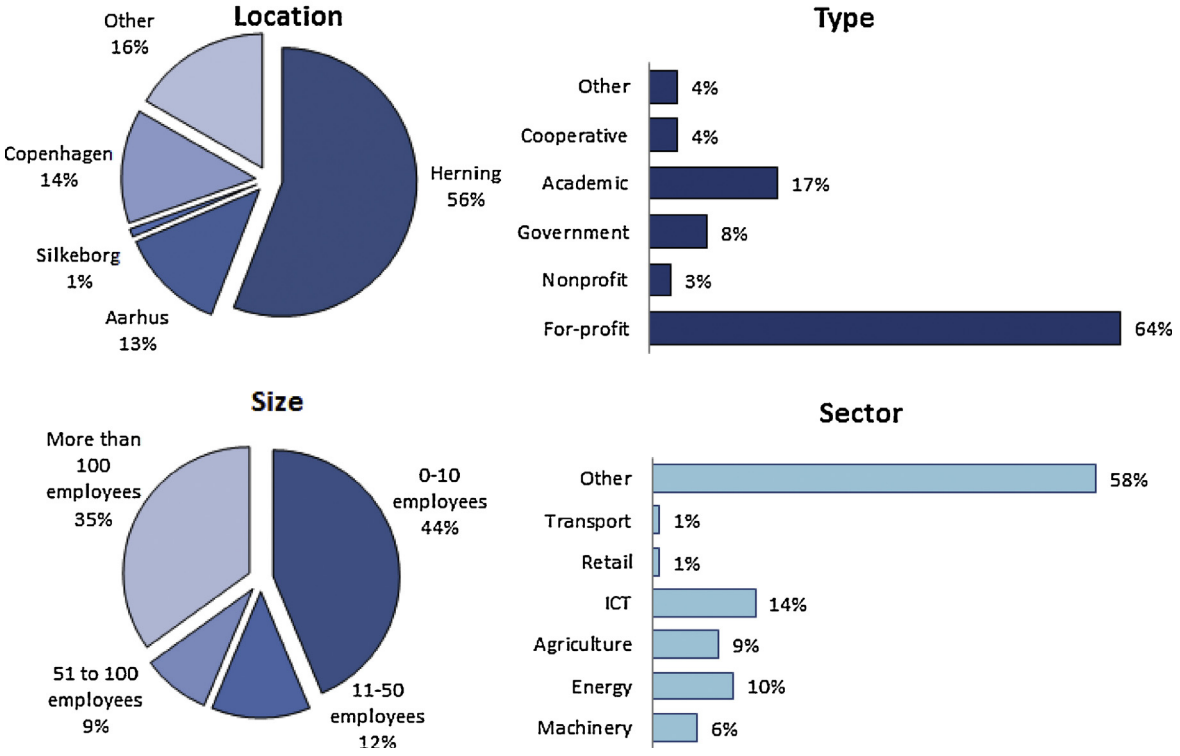


Fig. 1. Characteristics of our energy survey subsamples. *Note*: "Postgrad," "undergrad," "secondary," and "other" categories of education refer to the Danish categories of "lang videregående uddannelse (3–7 år), "kortere eller mellemlang videregående uddannelse (1.5–4 år)," "gymnasial uddannelse," and "andet." "University" and "Academic" refers to those working at colleges, universities, schools, and academic institutions. "Private sector" refers to those working in electricity supply, transport, industry, business, and for-profit organizations. "Government" refers to those working for local, state, and national governments as well as national institutes and regulatory agencies. "Nonprofit" refers to those working in civil society, nongovernmental organizations, and intergovernmental organizations. "ICT" refers to information and communications technology.

Table 1
Four propositions about Danish energy and environmental attitudes.

Proposition	Explanation	Survey questions
P1: The centrality of affordability	Higher prices for electricity and petroleum compared to most other European countries suggests that Danes should value the affordability of energy services	What do you see as being most important in energy policy? When you think about energy, which values are the most important to you? When you think about energy security for Denmark in the next five years, how important is it to have stable, predictable, and clear price signals, or to have affordably priced energy services?
P2: "Being Green" and national policy	One would expect Danes to value climate change and environmental issues favourably and to support local and national policies	How important is a party's energy policy for you when voting? At the present time, do you think your local municipality's energy, climate, and environmental decisions have gone too far, not far enough, or struck the right balance? Since 2003 the Danish energy sector has been liberalized—in your opinion has this been a positive or negative development? Do you agree, mostly agree, mostly disagree, or strongly disagree with the statement that "Denmark's climate and energy political goals are an advantage with regard to employment and economic growth?".
P3: Energy knowledge and literacy	One would expect Danes to be generally knowledgeable on energy and climate topics as well as appreciative of education related to energy issues and problems	How many renewable energy technology demonstrations, events, meetings, etc. have you visited locally in the last 12 months? Do you think that energy classes should be taught to children in our schools? In general, how much do you feel you yourself know about energy issues and problems? How is most electricity in Denmark generated? How much electricity do you consume every month inside your home? How much do you pay per kilowatt-hour (kWh) for electricity (including tax and distribution)? The last time you checked how much did a liter of petrol/gasoline/diesel cost at the local station? Which of the following—lighting rooms, heating and cooling rooms, refrigerating food, or running televisions and computers—uses more energy in the average home?
P4: Sustainable technology and self-sufficiency	One would expect Danes to prioritize self-sufficiency and reliability, to place faith in new technologies, and to support renewable forms of energy (and oppose fossil fuels)	At the present time, which energy technologies would you like to see supported more, with a view to using them in your home/business? Are you interested in generating your own energy, to become partially or wholly self-sufficient, at some point in the future? Do you agree, mostly agree, mostly disagree, or strongly disagree with the statements that: technology will find a way of solving our energy problems; the hydrogen economy is key to Denmark's energy future; solar energy is key to Denmark's energy future; biomass will play an important role and will create green growth; Wind energy is key to Denmark's energy future; coal oil and gas will still be the key to Denmark's energy future?

the remaining 17.3 Eurocents, or 56.9% of its total cost (Eurostat, 2015).

Additionally, there is some support for our proposition about the salience of affordability from earlier studies. One surveyed 390 families in Denmark and noted that the affordability of energy services "mattered" across various demographic classes of respondents. Those living in homes (which used more energy) rather than flats, those that resided in rural areas (incurring higher per capita transportation costs) rather than urban ones, and those with older household members (who have a greater demand for heating) all expressed preferences for lower energy prices (Lenzena et al., 2006). Another survey of roughly 5000 households in ten European Union countries and Norway noted that households with a high share of elderly members placed more importance on financial savings (Mills and Schleich, 2012), a finding with direct relevance for our sample of respondents given that about one in three were aged 46 or older. Another survey of energy attitudes among consumers in Frederikshavn, Denmark reported that affordability was mentioned as a key concern (Wale et al., 2009).

The study finds, however, that the proposition about affordability is not supported. According to our combined sample of both business and consumer respondents, prices and affordability issues come after a number of other pressing concerns. Fig. 2 shows that combined respondents rated the development of new and innovative energy technologies almost *twice* as important as low prices, and they also rated national policy as more salient. Fig. 3 shows that safety, security, environmental protection, and cleanliness were reported as more important to respondents than financial concerns such as investments and revenues, and Table 2 indicates that low energy prices came rated eighth in the list of national energy security concerns and stable prices came rated tenth (out of sixteen dimensions), hardly positions of prominence or significance.

Perhaps one reason prices are not rated as highly as expected is that energy use is not as visible in Danish society as other expenditures, or as coherent or meaningful a topic. Consumers have a complicated relationship with energy that goes beyond price, and that the institutional design of an energy system predicated on active producers and passive consumers can

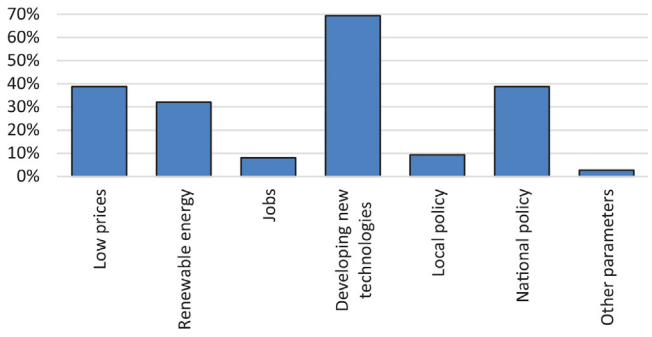


Fig. 2. Survey Responses to "What do you see as being most important in energy policy?" ($n = 227$). *Note*: Results are from the combined sample of respondents (consumers plus business leaders). Number of respondents is less than 328 because not all participants completed the question. Answers were not mutually exclusive.

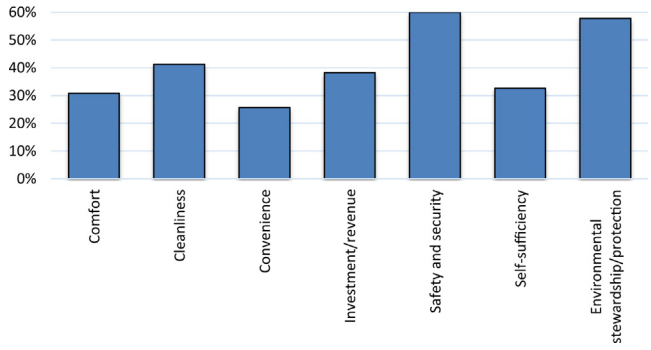


Fig. 3. Survey Responses to "When you think about energy what is most important to you?" ($n = 230$). *Note*: Results are from the combined sample of respondents (consumers plus business leaders). Number of respondents is less than 328 because not all participants completed the question. Answers were not mutually exclusive.

unintentionally remove the link between energy supply and consumption (Hirsh and Sovacool, 2013; Pasqualetti, 2000). Another possible explanation could be that Danes have a high acceptance of "green taxes" and investments in renewable energy infrastructure (both causing high energy prices, at least in the short term) and that price is therefore of secondary importance to Danes. Energy, put another way, may be invisible to most Danish consumers, even though it is relatively expensive. One survey of attitudes to heating bills by the Danish Realtors Association confirmed this when it noted that Danes moving into a new apartment were surprised by their heating bills, apparently not making the connection between higher desired thermal comfort and higher bills (Boligsiden.dk, 2014). A second survey of recent purchasers of new homes revealed that buyers rated heating consumption as low on their list of priorities (Beliggenhed, 2014), even though over an extended period of time expenses on heating can cost more than the price of the property itself.

A secondary factor supporting this invisibility of prices concern the "representational strategies" utilized by the energy industry to depict themselves as responsible stewards of the national energy sector, an efficient system that consumers do not need to waste their time engaging with (Mason, 2012). Electricity prices are generally depicted as an inevitable, deterministic result of market forces (such as spot prices in Sweden or pumped hydro storage practices in Norway) that Danish consumers have little control over. Consumers are framed as having little influence over such matters, a situation that can further reflect and entrench the interests of those behind the national energy system, since it enables them to retain their control.

A third factor potentially influencing public perceptions of price could be the complexity of those prices themselves. Danish electricity spot prices can vary greatly, depending on the electricity sources used, the region and the time of year (which codetermines demand). Danish prices are also influenced significantly by taxes as well as the decisions of suppliers well beyond its borders including Norwegian hydroelectric operators, Swedish coal and nuclear generators, and German renewable power facilities. In times of wind surplus, electricity prices can even be negative (Ritzaus Bureau, 2009; Hoje, 2009; Prisfald, 2009; Rigsrevisionen, 2012; Dansk Energi, 2011). The relative disinterest toward prices expressed in our survey may be indicative of consumers simply ignoring a complicated topic they view as not worth the effort to comprehend.

As a result, issues of price and affordability may be invisible to most Danish consumers or too complex to warrant further inquiry. For those that do take an interest, price may appear more a function of the logical result of national supply and demand and less a function of their own choices as consumers—being beyond their influence and therefore daily consciousness.

Table 2
Survey responses to "When you think about energy security for Denmark in the next five years, how important is it to have each of the following" ($n = 328$).

Average (mean)	Energy security question/dimension
4.67	To conduct research and development on new and innovative energy technologies
4.66	To provide available and clean water
4.56	To minimize air pollution
4.43	To reduce greenhouse gas emissions (i.e., mitigation)
4.4	To have low energy intensity (unit of energy required per unit of economic output)
4.36	To minimize the impact of climate change (i.e., adaptation)
4.36	To minimize the destruction of forests and the degradation of land and soil
4.31	To have affordably priced energy services
4.2	To assure equitable access to energy services to all of its citizens
4.16	To have stable, predictable, and clear price signals
4.09	To promote trade in energy products, technologies, and exports
3.99	To minimize depletion of domestically available energy fuels
3.96	To ensure transparency and participation in energy permitting, siting, and decision-making
3.89	To inform consumers and promote social and community education about energy issues
3.81	To have a secure supply of coal, gas, oil and/or uranium
3.41	To have small-scale, decentralized energy systems

Note: Results are from the combined sample of respondents (consumers plus business leaders). Respondents were asked to rate each dimension on a 5 point Likert scale.

3.2. P2: "Being Green" and national policy

The authors hypothesized that one would expect Danes to value climate change and environmental issues highly and to support local and national policies. For instance, with high, land-based wind power penetration in the energy system, multiple studies have concluded that public attitudes of wind turbines and wind electricity are more favorable in Denmark compared to other countries (Pasqualetti, 2011; Ladenburg, 2008; Ladenburg and Möller, 2011; Ladenburg and Dahlgaard, 2012; Sovacool et al., 2008; Ladenburg, 2015). Denmark was one of the first countries to move toward a comprehensive use of environmental taxes and Ecological Tax Reform (Klok et al., 2006). Comparative studies of energy and environmental attitudes have also found that Danes are more attuned to environmental and sustainable energy issues (Kilbourne et al., 2002; Lenzena et al., 2006; Tampakis et al., 2013) and that they regard climate change as a more serious problem deserving of national attention (Mills and Schleich, 2012; Glaas et al., 2015).

However, there is also some emerging evidence that Danish perceptions may be changing and that attitudes could start reflecting disaffection with energy and environmental policies. Although Ladenburg and Dahlgaard reported overall satisfactory Danish preferences toward wind energy, they have noted an increase in opposition. They have also found that, paradoxically, repeated exposure to wind turbines can diminish acceptance. As they conclude, "based on a sample of nearly 1100 respondents, the attitude toward existing on-land turbines is regressed on the perceived number of turbines encountered on a daily basis ... Thus, number of turbines has a significantly negative influence on attitude toward existing on-land turbines. Respondents who daily see more than five wind turbines are thus more negative" (Ladenburg and Dahlgaard, 2012). Klok et al. also found in their own survey that "most participants felt that Denmark had now paid the price of international environmental and social leadership long enough, that Denmark could not continue being superior to

Table 3
Survey responses to questions about climate and energy policy goals and fossil fuels.

	Strongly agree (%)	Mostly agree (%)	Neither agree nor disagree (%)	Mostly disagree (%)	Strongly disagree (%)
Denmark's climate and energy political goals are an advantage with regard to employment and economic growth (n = 228)	17.1	34.6	37.3	5.3	5.7
Coal, oil, and gas will still be the key to Denmark's energy future (n = 229)	3.5	17.0	25.8	29.3	24.5

Note: Results are from the combined sample of respondents (consumers plus business leaders). Number of respondents is less than 328 because not all participants completed the question. Answers were mutually exclusive.

the other EU countries (as it was believed Denmark was), and that it was time other countries now took over some of the burden of going in the lead" (Klok et al., 2006). The Danish Council of Environmental Economics, whose members include trade and labor unions, employer's federations, government institutions and nongovernmental organizations, has consistently argued that environmental taxes hurt households and businesses (Jyllands-Posten, 2014a; Danish Council of Environmental Economics, 2014). Moreover, though it has green aspirations, the Danish energy system still includes a large share of electricity and heat produced by coal (about 30%), as well as an almost complete dominance of petroleum-based fuels in the transport sector—the implication being that many consumers and business leaders have come to tacitly accept fossil fuel.

Nonetheless, our own pilot study found support for this proposition about being green. As Table 3 indicates, more than half of all respondents (51.7%) mostly or strongly agreed with the statement that climate and policy goals were an advantage concerning the country as a whole or their business, and 53.8% mostly or strongly disagreed that coal, oil, and gas had a future in Denmark. Fig. 4 also illustrates survey answers concerning local energy and climate plans, with 38% indicating that Denmark has "not gone far enough," 29% reporting that they have "struck the right balance," and only 5% indicating that they have "gone too far." In addition, Fig. 5 suggests that more than one in three respondents consider energy policy important or extremely important to them when voting, and Fig. 6 demonstrates that almost 50% more respondents believed that liberalization and restructuring of the Danish energy sector has been a positive development compared to those that did not agree with that statement.

This finding does concur with a wide body of literature on Danish cultural attitudes and environmental protection. Denmark is renowned for being a "green" country where its residents recycle, bicycle to work, favor wind turbines, and purchase ecological or organic food (Jamison and Baark, 1999). One study noted in the 1980s Denmark was emerging to be "one of the pioneers in waste recycling, through legislation and government subsidies and a unique combination of public and private participation" (Torben, 1986) and a travel guide for foreigners argued recently that "Denmark is extremely environmentally conscious" and that recycling is "practically a religion" (Nagan, 2012). In the realm of bicycling and transport, Denmark is famous for its emphasis on healthy, active, non-motorized transport (Pucher and Buehler, 2007; Bunde, 1997; Ogilvie et al., 2004; Nielsen et al., 2015) and features "ample bike parking, full integration with public transport, comprehensive traffic education and training of both cyclists and motorists, and a wide range of promotional events intended to generate enthusiasm and wide public support for cycling" (Pucher and Buehler, 2008). The capital city of Copenhagen has been awarded the European Green Capital Award for 2014 for planning to have 50% of commuters cycling to their offices in 2015 and to become carbon neutral in 2025 (Environment: Copenhagen European Green Capital, 2014). Positive attitudes on wind energy have already been noted above. In terms of food, 7% of Danish farmland is organically grown and 8% of food products sold in Denmark are organic (Ministry of Food, Agriculture, and Fisheries of Denmark, 2012), leading one industry association to conclude that "Danes lead the way when it comes to the consumption of organic products ... the consumption of organics in Denmark has risen steadily by more than 80 per cent

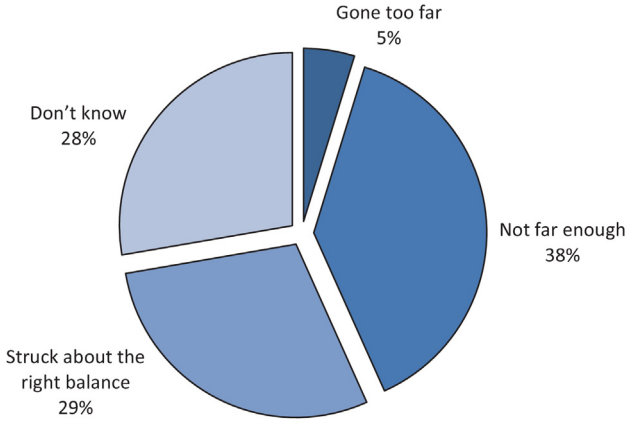


Fig. 4. Survey responses to "At the present time, do you think your local municipality's energy, climate, and environmental decisions have gone too far, not far enough, or struck the right balance?" (n = 231). *Note*: Results are from the combined sample of respondents (consumers plus business leaders). Number of respondents is less than 328 because not all participants completed the question. Answers were mutually exclusive.

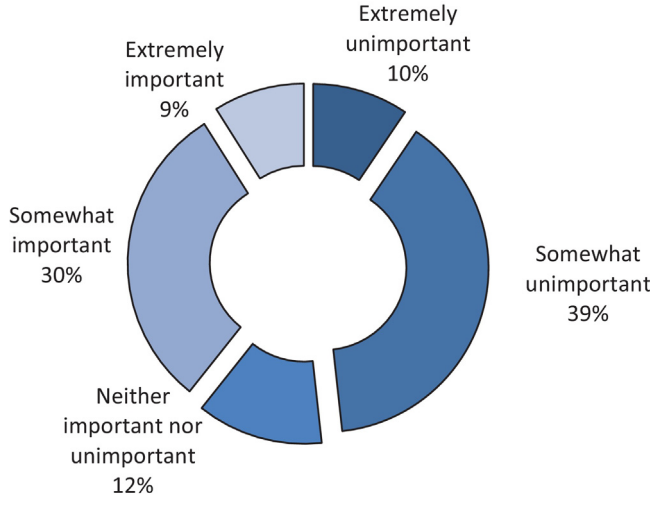


Fig. 5. Survey responses to "How important is a party's energy policy for you when voting?" (n = 201). *Note*: Results are from the combined sample of respondents (consumers plus business leaders). Number of respondents is less than 328 because not all participants completed the question. Answers were mutually exclusive.

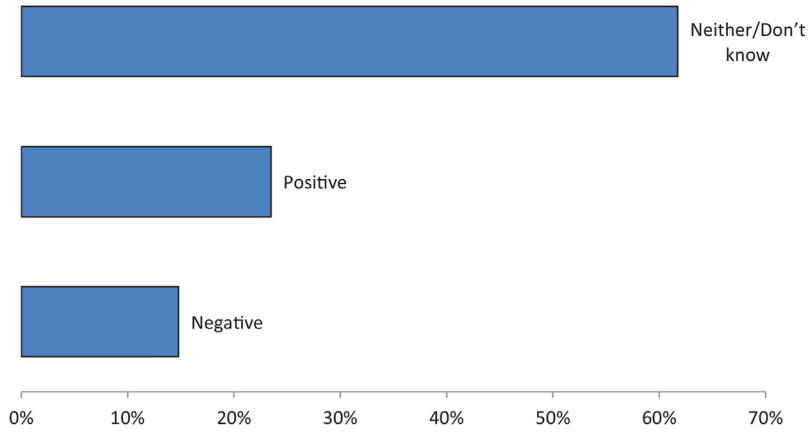


Fig. 6. Survey responses to "Has the liberalization of the Danish energy sector been a positive or negative development?" ($n = 230$). *Note*: Results are from the combined sample of respondents (consumers plus business leaders). Number of respondents is less than 328 because not all participants completed the question. Answers were mutually exclusive.

since 2003" (Organic Denmark, 2014). Pro-environmental attitudes have also been enshrined in a number of other Danish organizations (Grunert-Beckmann et al., 1997).

3.3. P3: Energy knowledge and literacy

The authors proposed that one would expect Danes to be generally knowledgeable on energy and climate topics as well as appreciative of education related to energy issues and problems, given the country's leadership role on energy and climate, its high standard of living, and its higher energy prices (which, the logic runs, would motivate people to learn more about energy, especially how to save it and save money). Indeed, a host of studies on attitudes and values have suggested that "socio-economic factors like higher education levels, higher income, larger households, and higher electricity prices" are "positively correlated with respondents' knowledge" about energy and environmental issues, especially energy efficiency (Mills and Schleich, 2012). Other studies have found that university education generally leads to attitudes and values reflecting a greater tolerance for more "progressive" climate and energy policies (Sovacool et al., 2012).

One way of assessing the energy literacy of respondents is to simply ask them their preferences about energy education—which the authors did in our survey. When the survey asked if respondents agreed with the statement that "energy classes should be taught to children in our schools," 81.6% of the 230 respondents answering the question strongly or mostly agreed. And when the survey asked "In general, how much do you feel you yourself know about energy issues and problems—would you say you know a lot, a fair amount, only a little, or practically nothing?," two thirds of respondents—67%—indicated they knew "a lot" or "a fair amount."

Yet another way of assessing the energy literacy of respondents is to ask them what they *do*, rather than what they *say*. And here, less than 15% of the 328 respondents filling out the demographic component of our survey have actually installed energy efficient equipment and/or renewable forms of energy on their home or business, less than one-third take mass transit consistently (the rest rely on private automobiles), and of the 230 respondents that answered the question "How many renewable energy technology demonstrations, events, meetings, etc. have you visited locally in the last 12 months?," 51.3% of respondents had been to none and 24% had only been to one. The actions of respondents imply that they may be less literate than they think they are.

Yet a third way of assessing the energy literacy of respondents is to focus not on what they say or do, but on what they know. This, perhaps obviously, is what we intended to test with the part of our survey dealing with competence and knowledge. Most critically, here the results from our basic energy literacy test, summarized by Table 4, were surprising. When broken down by subsample, more than two-thirds of residential respondents did not know how much electricity an average Danish house uses (279 kWh per month for 2012), and about 85% of business leaders did not know how much electricity the typical Danish company or industry uses (between 1000 and 10,000 kWh per month). More than 63% of household respondents and 85% of industrial respondents did not know how much electricity cost them per kWh (2.22 kroner/kWh

Table 4
Survey responses to the Danish energy literacy test by total sample.

Question	% Answering correctly	Sample included	# Total respondents
How is most electricity in Denmark generated?	88.1	Both groups	227
How much electricity does the average Danish house use?	34.2	Household	149
How much electricity does the average Danish business use?	15	Industry	80
How much do you pay per household kilowatt-hour (kWh) for electricity (including tax and distribution)?	37.6	Household	149
How much do you pay per industry kilowatt-hour (kWh) for electricity (including tax and distribution)?	14.8	Industry	81
The last time you checked, how much did a liter of petrol/gasoline/diesel cost at the local station?	88.6	Both groups	229
Which of the following uses more energy in the average home?	70.5	Household	149

Note: Number of respondents for each question is less than the absolute total since not every participant answered every question.

for homes and 0.7 kroner/kWh for businesses), and about 30% of residential respondents did not know which devices used the most energy inside a typical home (heating and cooling rooms). Indeed, less than 11% of business respondents and fewer than 16% of household respondents answered at least four of the five energy literacy questions correctly, meaning if this was an actual graded test in school, most would have failed it, and less than 4% answered all of the questions correctly. Put another way, across the whole sample, less than one in 25 Danes would have scored an "A" on our energy literacy test. This poor performance is even more telling given that our sample of respondents was overwhelmingly postgraduates and those working at universities and academic institutions, meaning the study likely overestimates nationally representative energy literacy rates. Interestingly, energy literacy levels (better scores) did not seem to increase or decrease with any significant affect with age or even levels of education.

When one delves into the academic literature, this low literacy rate may be expected, however. Equivalent studies in the United States (the only country the authors know of where energy literacy has been tested systematically) have noted that "just 12% of Americans can pass a basic quiz on awareness of energy topics" (National Environmental Education & Training Foundation and Roper ASW, 2002). One study of 1503 Americans aged 18 and older conducted by phone in 2001 found that only one in eight Americans can correctly answer such questions as how most electricity is generated, whether gas mileage is rising or falling, and what the fastest growing sector of the economy is with regard to energy consumption, and that just 1 in 100 adults would have received the grade of an "A." Embarrassingly, a series of surveys conducted there by the National Environmental Education & Training Foundation have found that 45 million Americans think the ocean is a source of fresh water; 120 million think spray cans still have CFCs in them even though CFCs were banned in 1978; another 120 million people think disposable diapers are the leading problem with landfills when they actually represent about 1% of the problem; and 130 million believe that hydropower is America's top energy source, when it accounts for just 10% of the total (Coyle 2005). Yet, similar to the Danish sample, these respondents rated themselves as being energy literate. Three in every four rated themselves as having "a lot" or "a fair amount" of knowledge about energy.

What is perhaps more interesting is that our preliminary findings do validate one conclusion from the body of work looking at energy attitudes and values yet invalidate one other. Firstly, theories have suggested that energy literacy should be higher for petroleum products than for electricity. The explanation is that electricity is largely invisible, entering the home effortlessly; it is consumed passively, by flipping a switch; and it is paid in lump sums, usually (in Denmark) every quarter or three months (Edwards, 2003; Hirsh and Sovacool, 2013; Sovacool, 2009a,b) Petrol or gasoline, by contrast, is more visible, entering someone's automobile as they pump it; it is consumed actively, usually why they drive that vehicle and maintain its speed and acceleration; and it is paid more frequently, whenever somebody has to refill their tank (Kempton and Layne, 1994; Borg, 2012). Our results validate this finding, showing a large discrepancy in literacy between the two topics, with 37.6% of respondents (across both samples combined) knowing the price of electricity but 88.6% knowing the cost of petroleum and gasoline.

Secondly, theories have suggested that business leaders—because they are generally more educated than the average person, and run institutions that consume greater amounts of energy—are more knowledgeable on energy topics than laypersons. Klok et al., for example, conducted focus groups at a glass wool manufacturer, chemical manufacturer, printing company, courier company, and haulage company in Denmark to determine their thoughts about environmental taxes, and supplemented their site visits with 829 research interviews. They concluded that, in Denmark, "four out of the five companies investigated seemed to have a relatively high awareness of environmental issues in general. They all showed a fairly good general knowledge about the major environmental problems and more importantly, they were all aware of the harmful environmental consequences of their particular production and able to state concrete activities taken to reduce these consequences" (Klok et al., 2006).

However, the results of our energy literacy test, summarized in Table 5, suggest otherwise. When broken down by each subsample, Table 5 demonstrates that household respondents, by a wide margin in some cases, answered more questions correctly than their business counterparts. The only situation where business participants outperformed household ones was for the question about Danish electricity generation, and here the difference between the two was marginal at 0.6%. More than twice as many household respondents answered questions correctly about electricity consumption and cost compared to the business ones, and more (by about 1.5%) knew actual petrol prices.

3.4. P4: Sustainable technology and self-sufficiency

The final proposition was that Danes would prioritize self-sufficiency as an energy concern, would place faith in new technologies, and would support renewable or innovative forms of energy supply. One cross-cultural comparison of energy attitudes, for example, noted that Danish respondents tended to prioritize the preservation of environmental quality and the promotion of technological progress through cleaner supply of energy, pollution prevention, and energy efficiency (Lenzena et al., 2006). Other studies have shown that styles of energy research and policy-making in Denmark are more inclusive, cooperative, hands-on, and bottom up than other countries due to a highly educated rural population and a commitment to "learning by doing" (Hheymann, 1998; Jorgensen and Karnoe, 1995; Garud and Karnoe, 2003; Buen, 2006; Toke et al., 2008; Sovacool and Sawin, 2010; Sovacool, 2010; Mendonca et al., 2009). Kilbourne et al. go so far as to argue that "faith in technology" and "protection of the environment" has even become part of the "dominant social paradigm" in Denmark (William et al., 2002).

Our pilot survey results confirm this proposition. Of the 232 persons answering the question "Do you agree that technology will find a way of solving our energy problems," 85.4% indicated

Table 5
Survey responses to the Danish energy literacy test by household and business subsample.

Question	% Households answering correctly	*n*	% Businesses answering correctly	*n*
How is most electricity in Denmark generated?	87.9	149	88.5	78
How much electricity does the average house/business use?	34.2	149	15.0	80
How much does household/industrial electricity cost?	37.6	149	14.8	81
The last time you checked, how much did a liter of petrol/gasoline/diesel cost at the local station?	89.2	148	87.7	81

Note: Number of respondents for each question is less than the absolute total since not every participant answered every question.

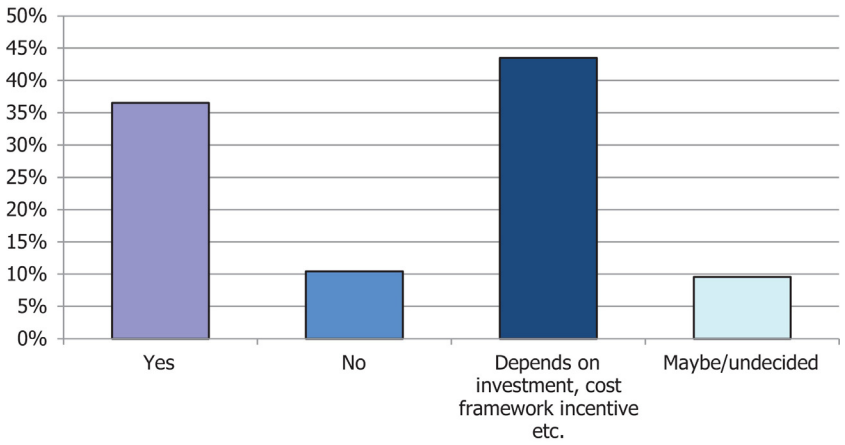


Fig. 7. Survey responses to "Are you interested in generating your own energy, to become partially or wholly self-sufficient, at some point in the future?" (n = 230). *Note*: Results are from the combined sample of respondents (consumers plus business leaders). Number of respondents is less than 328 because not all participants completed the question. Answers were mutually exclusive.

that they strongly or mostly agreed. Similarly, as Fig. 7 shows, about 80% of respondents were interested in becoming more energy self-sufficient, either without qualification or if the right investment frameworks were in place. Fig. 8 reveals that almost 60% of respondents reported a personal preference for supporting solar panels, 50% efficient insulation, more than 40% wind energy and between 15 and 30% a variety of other novel energy systems. And as Fig. 9 demonstrates, one in five respondents also strongly or

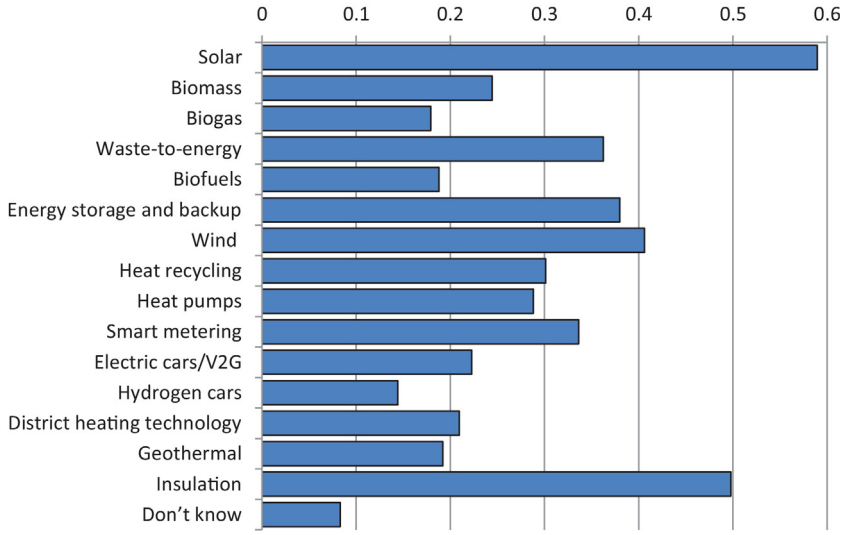


Fig. 8. Survey responses to "At the present time, which energy technologies would you like to see supported more, with a view to using them in your home/business?" (n = 229). *Note*: Results are from the combined sample of respondents (consumers plus business leaders). Number of respondents is less than 328 because not all participants completed the question. Answers were not mutually exclusive.

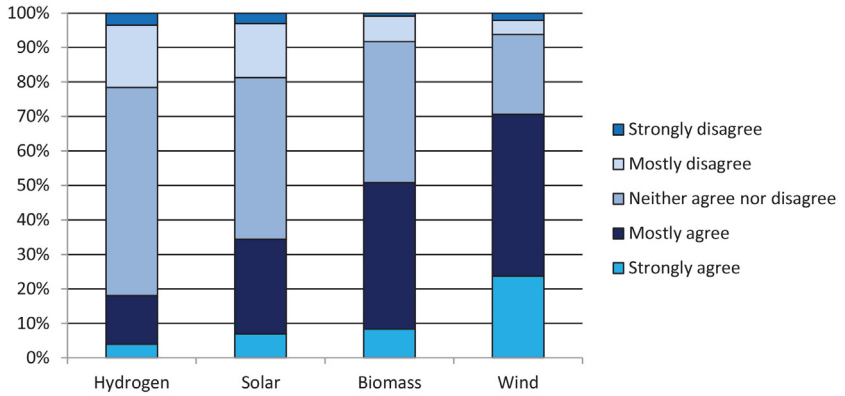


Fig. 9. Survey responses to questions about the national role of hydrogen, solar, biomass, and wind energy (n = 228). *Note*: Results are from the combined sample of respondents (consumers plus business leaders). Number of respondents is less than 328 because not all participants completed the question. Answers were mutually exclusive.

mostly agreed that hydrogen would be key to Denmark's energy future, one in three solar energy, half biomass, and more than 70% wind energy.

4. Conclusion and policy implications

Our pilot study of 328 energy users in Denmark has produced some thought-provoking results. Our central conclusion, though drawn from a limited sample of respondents, is that the dataset tends to support the propositions that Danes identify with "being green" and support national and local policies and also endorse sustainable technology and being self-sufficient. However, the data also tends to challenge the propositions that Danes would prioritize low energy prices and affordability as an energy concern and that they are knowledgeable on energy and environmental issues. In this way, a problematic gap may exist between what many academic articles (and previous surveys) report Danish attitudes to be and what this study suggests they might really be, given that the survey results were unable to support *half* of the propositions it expected to affirm.

Furthermore, though future research beyond a pilot study would be needed to confirm it, our survey suggests that a relatively large gulf exists between real and imagined Danish knowledge about energy topics. Four out of five respondents agreed that energy education was important enough to be taught to children in school and two out of three regarded themselves as knowing "a lot" or "a fair amount" about energy, yet fewer than one in 25 respondents scored an "A" on our energy literacy test, and less than one in six household respondents, and less than one in nine business respondents, were able to answer more questions correctly than incorrectly. Interestingly, Danes are not as knowledgeable as they think they are. The problem may be particularly acute given that one earlier multinational survey of energy attitudes found that Danish respondents were less accepting of change, and more set in their values, than every other country studied except for the United States (William et al., 2002). So Danes may be intolerant of or resistant to attempts to alter their entrenched attitudes. This finding is also worrisome given the amount of effort the Danes make to "brand" themselves in the area of energy and climate as a global thought and development leader with respect to renewable energy development, deployment and policy.

Whether this energy illiteracy bodes well or ill for Danish energy policy, however, is uncertain. On the one hand, it could create obstacles to energy outreach and education programs. (The old adage that the "first step to wisdom is learning how much you don't know" comes to mind.) However, on the other hand, widespread lack of public knowledge—an inability to properly assess energy challenges or to grasp energy facts—may make progressive Danish energy policy possible by (unintentionally) suppressing or at least diluting opposition. It may be that four decades of Danish energy planning focused largely on technical solutions at a system level have resulted in creating a renewable energy industry and set of institutions understandably focused on infrastructure and supply—a trend that certainly seems to exist in policymaking circles and in the energy studies literature today—(Sovacool, 2014a,b) rather than on more complex topics such as energy behavior, democracy, and empowerment, or on systematically engaging with the users of the system. If true, and this is only speculation and certainly needs contextualized within the limitations of our sample, then one of the world's greenest states only persists to the extent that its people remain uninformed about energy and climate issues.

And here we come to the most troubling implication of our study. It is sometimes argued that large, centralized sources of energy such as nuclear reactors or mega-scale coal-fired power plants need authoritarian, exclusive forms of policymaking or siting to function, and low levels of environmental activism to avoid opposition. Emerging work on the political economy of nuclear power, for instance, has confirmed this trend true in eight major national nuclear power adopters (Sovacool, 2012; Valentine and Sovacool, 2010; Sovacool and Valentine, 2010). Other work on energy justice has concluded that high levels of community involvement and/or education and information on energy issues is a prerequisite for ensuring fair and equitable outcomes in the energy sector (Heffron and McCauley, 2014; Sovacool and Dworkin, 2014).

This study's findings, bracketed within its limitations, does not support these conventions. Although it seems logical that consumers that are better informed about the need for an energy transition and the technicalities of energy supply and distribution would be more willing to engage in energy saving practices or alter their behavior, that finding is not supported by our sample of survey respondents, who, despite having a preponderance of educated people living near the part of Denmark (Jutland) most populated with wind turbines, were unable to state even basic facts about the Danish energy system. Sometimes, it seems, people adopt pro-health or positive behaviors without fully considering why they are acting differently or absent a new mindset (Valente et al., 1998). One explanation could be that the success of a transition may depend on consumer illiteracy about energy. It could be that the reach of a given energy transition may work only insofar as it does not impede meaningfully upon individual attitudes or behavior.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2015.07.011.

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