The human dimensions of sustainable energy transitions
Research agenda
Platform for Energy Research in the Socio-economic Nexus (PERSON)
November 2014
Background

Responding to the challenges imposed by climate change and energy supply security, the EU and its member countries have set ambitious goals regarding de-carbonisation of energy production and consumption. To reach these goals, a range of stakeholders needs to take many different actions, including investing in renewable energy technologies, increasing the energy efficiency of buildings and appliances, and changing energy use behaviour into energy saving habits and practices.

Although extant research has started to deal with all the mentioned challenges, the current literature and data contain gaps that need to be addressed. The need for more research on the human dimensions of transitions to sustainable energy systems is widely advocated, and seems pivotal to address the key challenges we face in making a successful transition (Hackmann et al., 2014; ISSC, 2013; Sovacool, 2014; Weaver et al., 2014). More research is needed on a range of behaviours that influence current and future energy consumption as well as energy transitions. Below, we identify key questions to be addressed that have been identified by scholars from different EU countries who have been studying the human dimensions of energy systems for many years. These questions

It is very likely that consumers will play a rather different role in new sustainable energy systems than today. Individuals will be actively involved in the production and trade of energy, and will become so-called prosumers. This may not only affect their involvement in energy issues in important ways, but also requires substantial changes in energy demand to increase the efficiency of sustainable energy systems. Individuals and households are thus a key but often neglected player in sustainable energy transitions.
reflect three main research themes. First, it is key to understand **which factors encourage different stakeholders to engage in sustainable energy use actions**. Second, it is unlikely that private actors will make the necessary behaviour changes in time without additional inducements. Hence, governments at all levels need to implement policies including laws, standards, rules and economic and social incentives that facilitate energy conservation and the transformation to renewable energy systems. A key question is **which interventions are most effective in realising these goals**. Third, the needed governmental actions may be hampered by voters’ and other stakeholders’ resistance. Also, new energy systems and technologies need to be acceptable to potential users and to communities. Hence, it is key to **increase our understanding of which factors predict public support**.

Next, we discuss important issues related to the research approach to be followed. To effectively address these issues, a **multi-method approach** is needed. Furthermore, given the international challenges that have to be dealt with, these issues need to be studied from an **intercultural perspective**. Besides, as energy-related behaviours depend on many factors, including individual, situational and institutional factors, these issues need to be studied from an **interdisciplinary perspective**. Finally, we describe the expected impact and added value for the EU.
Various studies have been conducted to better understand household energy consumption. Research has mostly produced knowledge of everyday energy-related behaviours. Some important research gaps in the literature can be identified. First, given its high impact on total (fossil) energy demand, it is important to have a better understanding of drivers and impediments of household energy investments, including investments in sustainable energy systems for the home (e.g., solar panels), building renovation, insulation, home energy management systems, as well as fuel-efficient and alternative fuel vehicles.

Second, research on how different types of behaviours (e.g., everyday energy-consuming behaviour, investments, and policy acceptability) are linked and how broader lifestyle effects can be realised is still emerging. A key question in this respect is whether and to what extent rebound and spillover effects may occur, and particularly how positive spillover can be promoted (Truelove, Carrico, Weber, Raimi, & Vandenbergh, 2014). For example, how can we prevent that energy saving actions lead to a “rebound” effect (e.g., increased driving when switching to a more fuel efficient car, or use financial savings of energy saving measures to go on a holiday by plane)? Will engagement in energy saving actions provide a license to refrain from other energy-saving actions (i.e., “negative spillover”), and if so, under which conditions is this most likely to be the case? More importantly, under which conditions is “positive spillover” more likely, in which case people are more likely to engage in many different energy-saving actions over and again, which is needed to realise a truly sustainable energy transition?

Third, it is important to better understand the ways in which general factors such as values may affect many different behaviours at once, and under which conditions they are more likely to do so. Research suggests that so-called self-transcendence values that reflect concern with others, nature and the environment may be an important factor in this respect. Yet, people do not seem to consistently act upon these values, as reflected in a so-called value-behaviour gap. Hence, understanding which factors cause the value-behaviour gap conditions, and which factors induce people to act more consistently upon their self-transcendence values may improve the chances of influencing many behaviours through single types of intervention rather than only seeking to influence behaviours one at a time.
Fourth, more research is needed into the effects of **judgements and decision biases on energy-related behaviour**. Such biases can inhibit good judgements and rational decisions. Important questions to be addressed are which judgmental biases inhibit sustainable energy behaviour, and which processes underlie such decision-making. Based on this, improved decision and choice frames can be developed and tested leading to more accurate assessments of consequences of energy behaviours, which will encourage sustainable energy use.

Important biases in decision-making exist not only among **individuals and households**, but also among **firms and in decision-making by policy makers**. For example, even though the need for transition to renewable energy sources is widely acknowledged, many governments use much more money on subsidies for fossil fuels than for renewable energy sources (IEA, 2012). Although some policy makers and experts acknowledge such inconsistencies in polices, they seem reluctant to change such subsidies, suggesting irrational decision-making is taking place. We need to understand which mechanisms underlie this supposed irrationality in policy making, and which biases play a role here, as to enhance the overall effects and cost-efficiency of energy policies.
Various studies have evaluated the effects of interventions aimed at promoting sustainable energy use. Most of these studies examined the effects of informational strategies and economic incentives on individual or household energy use behaviour (for reviews see Abrahamse, Steg, Vlek, & Rothengatter, 2005; Abrahamse & Steg, 2013; Bolderdijk & Steg, in press; Dietz, Gardner, Gilligan, Stern, & Vandenbergh, P., 2009). These studies provided first important insights in how to promote energy conservation and factors underlying the effects of interventions on energy conservation. However, some important questions remain.

First, more research is needed into the effects of social norms and networks on sustainable energy use, and the conditions under which such strategies seem most effective. A recent meta-analysis suggests that social influence strategies are particularly effective when they involve social interaction (Abrahamse & Steg, 2013). Promising developments in this respect are local initiatives and self-organisation to promote sustainable energy use. However, it is unclear to what extent and under which conditions such bottom-up initiatives can be effective, and more effective than top-down policies. Research is needed to examine under which conditions local initiatives can be a successful driver of change. This requires not only insight into factors that drive energy behaviour, but also into factors that influence the willingness to take initiative or join a local energy initiative. Furthermore, it asks for a more thorough understanding of how collectives that are formed from the bottom-up function and sustain. This collective level of human behaviour has so far mostly been neglected in research on energy transitions.
Second, more research is needed into **effective ways to strengthen intrinsic motivation to act pro-environmentally**. Recent research suggests that people are intrinsically motivated to do the right thing, which elicits positive feelings. We need to better understand how such intrinsic motivation can be strengthened. A first strategy would be to increase the relative strength of biospheric (or more generally, self-transcendence) values, as acting pro-environmentally should be particularly intrinsically rewarding to those who strongly value others and the environment. Although some studies revealed that value strength can change over time, little is known about how such changes can be realised, and under which conditions people are likely to reconsider the prioritisation of their values. A second strategy would be to increase the accessibility of biospheric values in a given situation via situational cues that activate these values. There is some initial evidence how such value activation can be realised, but more systematic research is needed to test this account more thoroughly.

Third, smart grids that increasingly rely on renewables provide the opportunity to inform, involve, and engage consumers by providing them information about their energy use, as well about the consequences thereof, including financial costs and carbon emissions. We need to understand **how to best design and convey such feedback** to motivate consumers to reduce their energy use and to balance their energy demand and production as to increase the efficiency of smart grids. More generally, we need to examine **how to best design energy-related information to increase energy literacy**, and identify potential misinterpretations to enhance the understanding and persuasiveness of such information.

Fourth, we need to better understand the **psychological and behavioural effects of energy policies that aim to change choice infrastructures that make energy saving behaviour more attractive or feasible**, including pricing policies, laws, and changes in infrastructure and technologies. More particularly, we need to increase our understanding of the conditions under which such strategies are most effective.
We not only need a better understanding of **how to change behaviour of individuals and households**, but also how to change actions by **firms and organisations**. How can we create successful **business models** for sustainable energy innovations and energy systems, and which governmental policies are needed to secure profitability of innovative energy business? The energy transformation already has a huge impact on the economy where incumbent power producers face the erosion of the capital base due to zero marginal cost producing solar panels and windmills. This impacts on the incentives to develop and invest in demand management, storage facilities and (reserve) capacity. Therefore, it is of crucial importance to study different business models, industry transformation, start-ups, upscaling, collaboration between small and larger firms and academia and governments in connection with the energy transformation. This highly connects with the financing challenge for the energy transformation. Who is willing to make the required investments and at what price? Are institutional investors willing to participate, do we need public funding, what is the scope and potential for crowd-sourcing?

Another promising research venue is the analysis of decision-making, assessment and valuation process and principles in case of unclarity about emerging technologies and/or environment of business. Here, the study of institutional context and arrangements, (in)formal regulation, cooperatives, governance, inter-organisational networks, the commons, open innovation processes, ownership of responsibility are of importance. Examples are the roles of different business models in energy generation (Van der Schoor & Scholtens, 2015), and the interaction between different types of energy generation, such as electricity sourced from renewables and from fossil fuels (Mulder & Scholtens, 2013).
There is a need for more research on **tools and decision aids for improving energy policies**, including how decision makers could employ intuitive and deliberative thinking to improve decisions and climate policy choices, and the effectiveness of experiential methods like simulations, games, and movies in improving our understanding and perception of climate change processes.
Potential effective energy policies and innovations may not be implemented because of lack of public support. Therefore, it is crucial to better understand which factors affect the level of support in energy policies, energy systems, energy infrastructure and innovations. As yet, studies on public acceptability are fragmented, and general processes influencing public acceptability are not well understood. A recent review proposed that public support depends on perceived costs, risks and benefits of the relevant entity, which in turn depends on complex interaction between individual factors (including values, trust) and situational factors (Perlaviciute & Steg, 2014). A systematic test of how such interactions affect acceptability of many different components of sustainable energy systems is needed.

It is important to better understand the main factors driving acceptability of siting and design of installations; a special focus should be placed on power grids, as there is only little research on this issue, especially in the context of the energy transition. In particular, we need to better understand how to improve decision-making, communication and procedural issues (on a local and national level) related to siting and design of installations.
Also, research into the acceptability of energy policies aimed to improve the decision and choice infrastructure, including new energy standards, energy labelling and energy-related taxes and subsidies, nudges (e.g., defaults), and acceptability of policy measures facilitating transitions to a more energy efficient transportation system is needed. Also, acceptability of technologies that aim to increase efficiency of smart grids should be studied by matching the production and use of energy. In particular, more knowledge is needed on how to effectively address privacy concerns when data on energy production and use should be shared. In addition, more research in needed into the acceptability of smart grid technologies that aim to improve the matching of production and use of energy, as to increase the efficiency of the system. For example, under which conditions are people likely to accept automated control systems that can steer energy use from a distance (e.g., how can we meet people’s need to feel in control over the relevant systems, which factors affect trust in the relevant systems)? Which factors affect acceptability of storage technologies, such as batteries and electric vehicles?

The continuing growth in global consumption in both material and economic terms contributes to environmental degradation, but in the industrialised countries it apparently contributes little to our wellbeing. Research has identified a complex and interacting set of causes of consumption growth (Thøgersen, 2014). Understanding how people may live a satisfactory life with less has major practical and policy implications for the environment, economic development, and energy security issues. More insight is needed into alternative models of prosperity and sustainable growth. Research is needed to develop alternative economic models on the link between energy consumption and wellbeing.
Research approach

Multi-method approach

The issues above should be studied following a multi-method approach, including experimental, field studies, and correlational studies. Also, cross-sectional and longitudinal studies are needed to get a thorough understanding of the issues at stake, thereby enhancing internal and external validity.

Cross-cultural research

Energy transitions require changes on a global level, in Europe and all nations around the world. New technologies and energy systems are currently developed within Europe. The development is mainly based on research and expertise in specific European countries and regions. However, they often will be implemented in very different cultural European countries and regions. To date, many new energy introductions fail because people in other countries for example do not use them. Thus, it is crucial to increase our understanding of specific cultural factors to overcome and enhance sustainable energy transition. These cross-cultural differences are important to develop effective policies and implementations across Europe. In addition, even outside Europe this insight is important to successfully export innovations to new markets. Especially in Africa new markets are opening up for millions of people who so far do not have access to energy. This research will provide concrete guidelines on how to design and implement culturally-robust programmes that result in the successful adoption of new energy systems that facilitate a sustainable energy transition worldwide.
Interdisciplinary research is needed as many different players and markets influence the role of consumers in sustainable energy systems, the opportunities they face, as well as costs and benefits of different sustainable energy concepts offered to consumers.
Expected impact

The research will improve and accelerate the decision-making and planning processes needed to realise a sustainable energy transition that is acceptable, feasible and (cost-)efficient and secures quality of life of citizens. The research will refine and increase effectiveness and acceptability in both design and implementation of behavioural intervention strategies to promote sustainable energy transitions in Europe and elsewhere, including promotion of renewable energy sources, investments in energy saving technologies and refurbishments, and energy-saving behaviours, habits and practices.

The insights presented in this paper are expected to contribute substantially to reaching the EU’s energy “20-20-20” targets by motivating prosumers to reduce green-house gas emissions, increase the use of renewable resources and improve their energy efficiency.
To successfully implement its ambitious long-term energy transition strategy, the EU and its member states urgently need better knowledge on the human dimension in energy systems. The proposed research will increase theoretical knowledge about consumers’ readiness to change their behaviours and to accept policies and technological changes. This will help to design practical recommendations and guidelines on how to develop and proceed with the sustainable energy transition. Public acceptability is needed for a fast realisation of these projects.

The EU would also profit from cross-cultural research in developing countries. First, European companies who produce and sell these technologies would learn how to best reach the new market and adopt their marketing and systems to the local needs. Second, the EU could strengthen its position with respect to energy transition in developing countries in which the population is growing rapidly.
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