IEA Committee on Energy Research and Technology

EXPERTS' GROUP ON R&D PRIORITY-SETTING AND EVALUATION

Towards a Consumer-Driven Energy System

Understanding Human Behaviour

Workshop Summary

12-13 October 2017

Hosted by the Technical University of Denmark

Lyngby, Denmark

iea Energy Technology Network

Experts' Group on R&D Priority Setting and Evaluation

International Energy Agency

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its mandate is two-fold: to promote energy security among its member countries through collective response to physical disruptions in oil supply; and to advise member countries on sound energy policy.

The IEA carries out a comprehensive program of energy co-operation among 28 advanced economies, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency aims to:

- Secure member countries' access to reliable and ample supplies of all forms of energy, in particular by maintaining effective emergency response capabilities in case of disruptions to oil supplies.
- Promote sustainable energy policies that spur economic growth and environmental protection globally, particularly by reducing greenhouse gas emissions that contribute to climate change.
- Improve the transparency of international markets through the collection and analysis of energy data.
- Support global collaboration in energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organizations and other stakeholders.

IEA Experts' Group on R&D Priority Setting and Evaluation

The research, development and deployment of innovative technologies are crucial to meeting future energy challenges. The capacity of countries to apply sound tools in developing effective national research and development (R&D) strategies and programs is becoming increasingly important. The Experts' Group on R&D Priority Setting and Evaluation (EGRD) was established by the IEA Committee on Energy Research and Technology (CERT) to promote the development and refinement of analytical approaches to energy technology analysis, R&D priority-setting and assessing the benefits of R&D activities.

Senior experts engaged in national and international R&D efforts collaborate on topical issues through international workshops, information exchange, networking and outreach. Nineteen countries and the European Commission are participating in the current program of work. The results and recommendations provide a global perspective on national R&D efforts that aim to support the CERT and feed into the analyses conducted by the IEA Secretariat.

For information specific to this workshop, including the agenda, background information and presentations, see www.iea.org/workshop/name,43381,en.html. For information on further EGRD activities, see www.iea.org/aboutus/standinggroupsandcommittees/egrd/.

Table of Contents

Table of Contents iii

Executive Summary vi

Introduction: Rationale and Background 1

Session 1. Introduction 4

Welcome
Dr Katrine Krogh Andersen, Dean of Research, Senior Vice President, DTU 4

Introduction
Rob Kool, Chair EGRD, Netherlands Enterprise Agency 5

Accelerating energy technologies in the Danish context
Anders Hoffmann, Deputy Permanent Secretary, Ministry of Energy, Utilities and Climate 5

Session 2. Setting the scene 8

Energy for society
Prof. Benjamin Sovacool, University of Sussex and Aarhus University 8

Behaviour change research collaboration: insights, tools and results
Sea Rotmann, CEO, Sustainable Energy Advice 10

What drives energy consumers?
Thijs Bouman, Faculty of Behavioural and Social Sciences, University of Groningen 12

Multi-perspective system analyses for robust energy decision support
Bert Droste-Franken, Head of Energy Department, EA European Academy GmbH 13

Session 3. Human-centred analytics to enhance policy effectiveness 15

Tapping the potential of prosumers
Matthew Kennedy, International Energy Research Centre, Ireland 15

Business models for a more effective market uptake of DSM energy services for SMEs and communities
Ruth Mourik, DuneWorks B.V. 17

Impacts of energy choices: examples of research approaches with quantitative data collection and analysis
Tiina Koljonen, Research Team Leader, VTT Technical Research Centre of Finland 18

Applying Behavioural Economics to move towards a more sustainable future
Karl Purcell, Programme Manager, Behavioural Economics Unit, Sustainable Energy Authority Ireland (SEAI) 20

Influencing business behaviours and decision-making to improve energy efficiency
Carrie Pottinger, Programme Manager, Energy Technology R&D Networks, IEA 23

SESSION 4. THE CONSUMER AT THE CENTRE OF A DISTRIBUTED ENERGY SYSTEM 26

The individual at the centre of a distributed energy system
Elisabeth Düttschke, Fraunhofer ISI 26

Residential behaviour-based energy-efficiency programmes and activities in Japan
Ji Xuan, Ph.D., Jyukankyo Research Institute (JYURI) 28

City of Tomorrow (E-PROFIL): neighbourhood profiles for optimised energy transformation processes
Prof. Daniel Latzer, Doctoral Researcher, Technical University of Vienna 29

Behaviour and decision-making concerning energy efficiency in the chemical industry
Lieven Stalmans, Borealis, Co-Chair, European Chemical Industry Council (CEFIC) 31

What do people want from (low carbon) heat at home, and how we find out?
Matthew Lipson, Head of Consumer Insight, Energy Systems Catapult, United Kingdom 32

SESSION 5. R&D POLICIES AND DECISION-MAKING 34

Knowledge-action networks
Erik Pihl, Future Earth Stockholm 34

R&D policies and programmes with (and for) citizens: approaches to understanding and changing individual energy consumption behaviour in Switzerland
Annika Sohre, Swiss Competence Centre for Research for Energy, Society and Transition (SCCER-CREST) 36

Social Science and the Humanities within Horizon 2020: meeting European Energy Challenges
Gerd Schönwälder on behalf of Estathios Peteves, European Commission 38

APPENDIX A. ABBREVIATIONS 40

APPENDIX B. SPEAKERS AND MODERATORS 41

APPENDIX C. AGENDA 48

APPENDIX D. PARTICIPATING ORGANISATIONS 50

LIST OF FIGURES

Figure 1. Wind and Solar PV capacity development in Denmark 6
Figure 2. Electricity consumption per capita in two regions 9
Figure 3. The behaviour changer framework........ 11
Figure 4. Individual values and Group values 12
Figure 5. Policy advice approach........ 13
Figure 6. PV installation in Germany........ 16
Figure 7. Transition from a product dominant logic to service dominant logic 17
Figure 8. Energy collectives and their main theoretical perspectives 19
Figure 9. Load curves segmentation 21
Figure 10. Test process 22
Figure 11. Modelling approaches to behaviour........ 24
Figure 12. The individual in the present and future energy system........ 27
Figure 13. Monthly saving rate of different programs 29
Figure 14. Location of households surveyed 30
Figure 15. Managing the change to more sustainable production........ 31
Figure 16. Systems should allow consumers to use heat in diverse ways........ 33
Figure 17. Knowledge-action networks 34
Figure 18. Illustration of the integrated framework........ 37

Executive Summary

The International Energy Agency's (IEA's) Experts Group on R&D Priority Setting (EGRD) held a workshop entitled "Towards a Consumer-Driven Energy System: Understanding Human Behaviour" to help decision-makers determine RD&D priorities and policy needs in a consumer-driven energy system. The Technical University of Denmark (DTU) hosted the workshop on 12-13 October 2017 in Copenhagen. The aims of the workshop were to explore individual and organisational behaviour and decision-making related to energy use and to identify novel approaches and social science needs, gaps and opportunities that could accelerate innovation and facilitate market uptake and transformation. Participating technology experts from research institutes, academia, government agencies and intergovernmental organsations located in 15 countries offered a wide range of perspectives and insights.

Social science in energy

Energy production, distribution and consumption all have technical and human components, though little research exists on the latter. However, there is an increasing focus beyond technology and economics towards the social aspects of energy technologies. In this regard, methods that capture the role of human behaviour (attitudes, habits and experiences) in energy use and consumption are essential. Individuals and their choices may influence patterns and modes of consumption far more than previously expected. Therefore understanding individual behaviour and decision-making is critical to accelerating the transition to an energy-efficient and low-carbon energy future.

The EGRD first examined the socio-economic aspects of the energy system at its workshop, "The Transition to a Low-carbon Economy: Socio-economic Considerations*" (*Baden, 2011). Since then there has been considerable progress in understanding the gap between social scientists and energy technologists and planners. This progress was convincingly illustrated in the workshop through the challenge-oriented, cross-disciplinary research programmes, pilot projects including human behaviour, policies considering the role of the individuals and stakeholders in the design and execution of policies, and research communities overcoming historical disciplinary silos (social science, engineering and natural sciences) to work together.

Understanding human behaviour

Despite recent progress in the contribution of the social sciences to energy sector decision-making, and given the essential role of human behaviour in a consumer-driven energy system, much more research in this area is needed. As described by Sovacool, social science research for energy is more than an afterthought and requires further development such as conceptual frameworks, methodologies and reliable and valid data to underpin decision-making. However, while key issues have been identified, researchers are still in the process of understanding human behaviour related to the energy system and its transformation to a more sustainable system.

A better understanding of the effects of human behaviour in energy systems is required at different levels of planning and policy making. Human behaviour underpins decisions made by individuals that are directly linked to the community, the region and to the whole of society. It should also be considered at all stages of planning processes, whether- short-, medium-, or long-term.

Balance between understanding and action

A better understanding of human behaviour enables informed actions. Including it throughout the knowledge value chain as a basic research topic in its own right and integrating it into technology demonstration projects would lead to a fully considered, dynamic, human-centred energy system. The most effective energy solutions are those which combine multiple disciplines in which social science plays an important role at all stages, including testing programmes or policies (e.g. questionnaires, surveys, semi-structured interviews, observations, case studies, scenario-building and foresight, expert judgement) before implementing a new initiative.

Better data and methodologies

While the contribution of social sciences has improved, addressing the challenges of developing complex energy systems requires accessing data sets across social science disciplines and combining qualitative and quantitative methodologies for analysis. These efforts would strengthen the impact of social sciences when considering the technical, resource and other rationally based scientific disciplines. Comparing cases across cultures, regions and countries would provide valuable further insights.

High-quality, valid and reliable data are paramount not only to understand - but also to stimulate – human behaviour. While data on energy costs (including levelised costs of energy) may be relatively straightforward to generate, further methodologies are required in order to capture the effect of individuals' decisions at the time and point of consumption.

Digitalization of the energy system is creating vast amounts of real-time data which could provide valuable insights into behavioural patterns and lead to guidelines for immediate action. Workshop participants touched briefly on the challenges and opportunities of accessing such data. Analysing other research areas such as marketing and artificial intelligence could provide valuable insights in understanding the role of human behaviour in energy choices.

Co-creation and co-design

Effective policies and programmes are those which are co-created by a range of stakeholders through a consultative, participatory process. While this may take more time, stakeholders are more likely to implement the agreed policies and the resulting policy or programme is more representative of the market as a whole. One interesting example of stakeholder consultations in a hospital involved 'story-telling' and visualisation techniques to brainstorm on ways to cope with complex energy-efficiency challenges and problems of the management, medical staff and patients.

Consumers and citizens are at the centre of the energy system. Empowering them to make informed decisions could improve the social acceptance of new technologies, encourage social innovation, and ultimately transform the energy system.

Conclusion and recommendations

Many governmental energy RD&D policies and programmes have made progress in facilitating problem- or challenge-based interdisciplinary research that engages both the producers and users of knowledge. There is an increasing understanding that the transformation of the energy system is inherently linked to the consumer. This requires a deep understanding of individuals' behaviour - and the effect of this behaviour on their communities and society as a whole.

Workshop participants developed two recommendations:

- Decision-makers should design RD&D programmes and projects that are challenge-driven, benefiting from an interdisciplinary approach which fully integrates social science considerations.
- Social science communities should continue to improve their conceptual frameworks, methodologies and data in order to translate insights of human behaviour into evidence for appropriate action.

Introduction: Rationale and Background

Introduction

Energy production, distribution and consumption all have technical and human components aspects, though little research exists on the latter. However, the focus in respect of these issues is increasingly extending beyond technology and economics to cover the social aspects of energy technologies as well. In this regard, human-centred methods are essential to capturing the role of humans in shaping energy use and consumption, including attitudes, habits and experiences. Individuals and their choices matter and may influence patterns and modes of consumption far more than expected. Therefore understanding individual and organisational behaviour and decision-making is critical to accelerating the transition to an energy-efficient and low-carbon energy future. To be effective, policies and measures should consider the consumer as central to current and future energy systems.

Analytical frameworks to enhance policy effectiveness

Although macro-economic consumer choice theory states that the consumer will choose the product with the highest quality or utility that is attainable within his or her budgetary constraints, this may not be an entirely accurate description of *how* or indeed *why* people make choices. Behavioural economics theory posits that choices are shaped in large part by how they are presented to us, rather than by what they represent. However, consumer choices for energy sources and technologies may be more complex in nature, involving a variety of criteria, such as culture, lifestyles, and knowledge and organisational dynamics.[1]

Human-centred analytical frameworks may enhance forecasts and policy effectiveness. Aspects such as describing norms, cultures and life-styles more accurately, explaining barriers to technologies, understanding the social acceptance of technologies, identifying opportunities for novel or non-commercial systems, and more accurately estimating and predicting the dynamics of individual choices are all influenced by cultural and social factors.

The consumer at the centre of the distributed energy system

Consumer choices are not made in isolation, but are a function of the society and conditions in which they are made. Geographical (local, regional, national) location, social identity and income may also be factors in making such choices. At a time when the energy landscape is undergoing a fundamental change towards decentralisation and decarbonisation, digitalisation of the energy system will provide opportunities for the uptake of new energy services and business models enabling consumers to participate actively in the energy system and markets. While policy-makers are beginning to understand consumers' views and concerns about such opportunities, in some cases the pace of innovation is outpacing the understandings.

---

[1] Sovacool, B.K. (2014), "What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda*", Energy Research and Social Sciences, 1*, 1-29.

For energy consumers, there is a trend towards enhanced, interactive technologies for managing energy use. This includes in-home devices to manage consumption, as well as technologies to manage time-of-supply pricing. The 'shared economy' has also resulted in joint ownership and management of distributed technologies such as wind or PV – the so-called 'prosumers' or 'aggregators'. These developments reinforce the role of the consumer rather as bottom-up 'drivers' of energy systems, but they also raise concerns regarding consumer protection and privacy and the sound management of consumer data, as well as other issues such as social equality and 'missing monies'.

In parallel, driven by environmental concerns such as climate change and water shortages, companies are also engaging in Corporate Social Responsibility (CSR) programmes, often driven by the need to maintain brand loyalty among consumers who are seeking environmentally sustainable options. As a result, designing appropriate framework policies that incentivise businesses to adjust while at the same time taking the consumer into account can be challenging.

R&D policies and decision-making

When designing programmes and policies, R&D strategists and planners could benefit from insights into people's aspirations, fears and choices within a multi-dimensional and changing energy and economic landscape.

Traditionally linear R&D frameworks are moving increasingly towards innovative processes (challenges, special programmes), funding (crowd-funding, co-funding) and ownership (co-operative, non-proprietary or open-source R&D). This "open" style of R&D includes a broader set of actors in decision-making processes, the participatory ownership of results, co-operation among stakeholders and users, experimentation and flexibility. R&D planners in energy institutions should take the role of the consumer in these developments into account along with socio-economic developments in the changing energy landscape.

Scope and participants

The theme of this workshop was "A Consumer-Driven Energy System: Understanding Human Behaviour". Participants explored individual and organisational behaviour and decision-making related to energy use in order to inform more effective R&D planning and policies.

In addition to EGRD members and national experts, input was provided from social scientists, behavioural economists, RD&D decision-makers, strategic planners and programme managers from industry, academia, think tanks, national laboratories, and both government and non-governmental entities.

Questions to frame the discussions

Which challenge-driven research methods include human-centred methods?

Which examples of combining human-centred research with quantitative data collection and analysis are the most appropriate?

Are there any methods that are incompatible with an interdisciplinary approach?

Which assumptions (risk, modernity, culture, time, materialism, cost and end-use) are most closely associated with specific forms of research or technologies? How can these risks be managed?

How can the advantages of decentralisation be coupled with those of centralisation?

How do consumer's past behaviour and attitudes towards energy influence their energy use today?

How can behavioural change advisories be introduced without consumers perceiving them to be controlling?

How do energy service conventions evolve?

Are “open” and “closed” styles of research mutually exclusive, or are there synergies between them?

What are the endogenous or exogenous causes of failed energy innovations?

Which best practices in governance (e.g. transparency, accountability, legitimacy, participation) affect R&D energy policy?

Session 1. Introduction

This session consisted of three introductory speeches: 1) by the Technical University of Denmark (DTU) host on the importance of energy research; 2) by the IEA EGRD chair on the expert group and workshop rationale; and 3) by the Danish government representative on the Danish energy model.

Welcome

Dr Katrine Krogh Andersen, Dean of Research, Senior Vice President, DTU

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/KatrineKroghPr%C3%A6sentationIEAoktober20171.pdf

The dean welcomed the workshop participants and gave a short introduction to sustainable energy at DTU, highlighting the social contribution of the natural and technical sciences as stated by the founder, H.C. Orsted. The foundation of this contribution is excellence in research, on which three pillars rest: education, innovation and scientific advice, all of which contribute to the UN's Sustainable Development Goals, in particular Goals 7 (affordable and clean energy), 11 (sustainable cities and communities) and 13 (climate action). DTU is an elite university with about a thousand researchers, PhD students and technical staff working in the area of energy.

Understanding human behaviour plays an increasing role in energy research activities at DTU. Examples included sustainable building design, energy renovation, optimization of indoor air quality, functionality and energy, intelligent energy systems, integration of electrical vehicles into the power system, energy systems analysis and climate resilient development, to mention just a few. High priority is given to international energy and energy research cooperation such as the European Energy Research Alliance (EERA), the European Climate Research Alliance (ECRA), the World Energy Council and IEA. In 2016 a total of more than 11,000 students were enrolled in Bachelor's or Master's programmes. They come from more than 99 countries and 28 are women. All are invited to participate in the annual Green Challenge Competition to pitch ideas and present projects that might one day lead to a more sustainable world. DTU students also provide much needed innovative and sustainable solutions at the annual Roskilde Music Festival, such as a solar-powered mobile charger, or a recycle waste bucket, and they are also engaged in extra-curricular projects such as the Solar Decathlon, ideation camps and venture cups.

Introduction

Rob Kool, Chair EGRD, Netherlands Enterprise Agency

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/RobKool_IntroEGRDKoolokt17.pdf

The chair of EGRD introduced EGRD in general and the workshop in particular. Previous workshops with strong social science and human behaviour components were mentioned, including "Will a smarter grid lead to smarter end-users or vice versa"[2] (Oslo, June 2015), "Life in the Fast Lane: Evolving Paradigms for Mobility and Transportation Systems of the Future"[3] (Washington, October 2016) and "Transition to a Low Carbon Economy: Socio-economic Considerations"[4] (Baden, May 2011). This shows that EGRD often acts as a pre-thinker in relation to topics that are important to energy R&D, in this case linking the technological knowledge of the IEA (TCPs) to the social sciences in order to maximise the impact of energy efficiency options.

When it comes to understanding human behaviour related to a consumer-driven energy system, important work concerns energy efficiency, which acts as the first fuel, with savings much greater than the contributions of other fuels. Important end-use sectors in respect of their respective savings potential include the residential sector (21%), manufacturing (25%) and transportation (35%). Changing behaviour matters in all of these sectors if we want to mine this potential. Moreover, in the transition towards a distributed energy system involving the integration of large-scale renewables and demand flexibility, the role of the prosumers will also play an important central role.

Accelerating energy technologies in the Danish context

Anders Hoffmann, Deputy Permanent Secretary, Ministry of Energy, Utilities and Climate

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/AndersHoffmann_AcceleratingEnergyTechnologies_AndersHoffmann_udennoter.pdf

Energy RD&D is an integral part of the Danish Energy Model, playing a key role in accelerating energy technologies to the benefit of the energy sector in Denmark and elsewhere. This Model has shown that, by means of a persistent, active and cost-effective energy policy with ambitious renewable energy goals, enhanced energy efficiency and support for technical innovation and industrial development, it is possible to sustain significant economic growth, a high standard of living and a high level of security of energy supply, while reducing fossil fuel dependency and mitigating climate change.

The ambition is to have an energy system that is independent of fossil fuels by 2050. The Danish economy's energy consumption is among the lowest in the world relative to its gross output. As a result, Denmark has become one of the world's most energy-efficient economies. Since 1990, Danish Gross

---

[2] See http://www.ieadsm.org/wp/files/Report_EGRD_workshop_on_smart_grid_and_endusers.pdf.
[3] See http://www.ieadsm.org/publication/life-in-the-fast-lane-evolving-paradigms-for-mobility-and-transportation-systems-of-the-future/.
[4] See http://www.ieadsm.org/wp/files/EGRD-transition-to-a-low-carbon-economy.pdf.

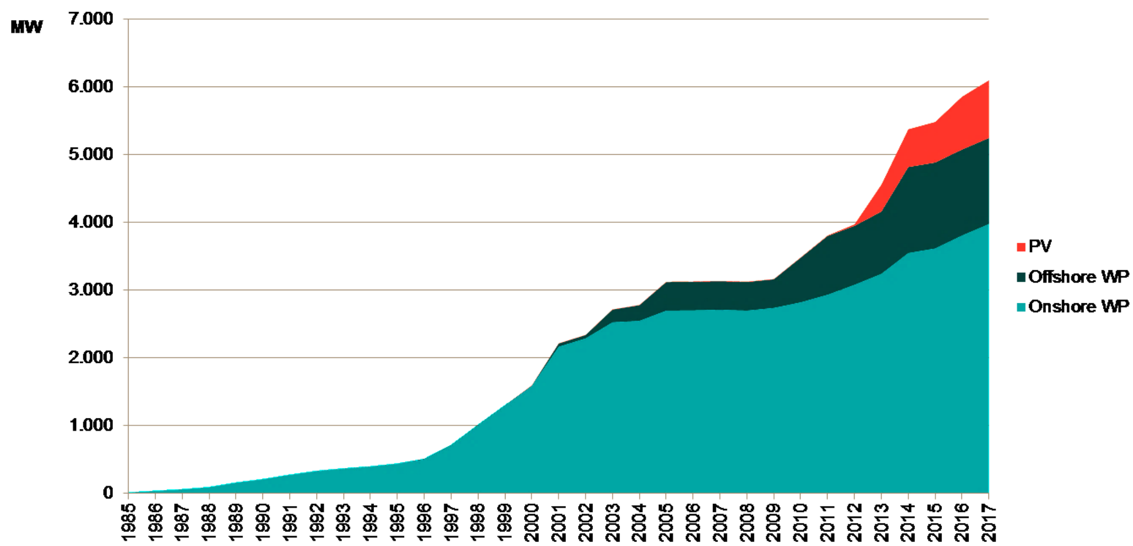


Figure 1. Wind and Solar PV capacity development in Denmark

Domestic Product (GDP) has increased by 44%. During this period, its domestic energy consumption has declined by 8% and its adjusted carbon emissions by 36%.

Wind energy has experienced tremendous development over the last thirty years (Figure 1), mostly onshore, but increasingly offshore and complemented by solar energy. On some days the production of power from wind turbines in Denmark exceeds the domestic demand for electricity, and on average the fluctuating wind energy supplied 42% of electricity consumption in 2015.

In this respect, the synergies between hydro, wind and thermal power, together with interconnections with neighbouring grids in Europe, are playing an important role, including the Nordpool power exchange. But other important factors include the integration of heat supply with electricity balancing, as half of Denmark's electricity is produced by small combined heat and power plants; the flexibility of thermal power plants, which can vary their daily output and quickly adapt to the fluctuating production from wind; and the incorporation of advanced wind forecasting into the operation of power system control and dispatch. Another factor is the advanced functioning of the electricity market in allowing combined heat and power (CHP) plants and coal-fired plants to benefit not only from selling to the wholesale market, in which their share of trade is decreasing due to increased priority production from renewables, but also from selling their services to the so called 'ancillary markets', which provides a number of services required for a well-functioning power system.

Further increasing the share of renewable energy will require greater flexibility in the power system. Denmark is therefore strengthening international connections and introducing technical measures to allow greater flexibility and more rapid response to the demand for power.

Being at the forefront of the energy transition has created competitive industries and jobs, in particular in the wind energy sector. To further facilitate the uptake of the Danish model in other countries, the Danish government supports bilateral cooperation with emerging economies such as Mexico, South Africa, Viet Nam and China. Likewise the government is engaged in multilateral cooperation in IEA, the

International Renewable Energy Agency (IRENA), the Clean Energy Ministerial (CEM)[5] and Mission Innovation (MI)[6].

In May 2018, Denmark, Sweden, the Nordic Council of Ministers and the European Union will co-host the ministerial meetings of the CEM and MI during the Nordic Clean Energy Week[7]. Anders Hoffmann welcomed EGRD members to join Nordic Clean Energy Week in the Oresund Region to share their expert knowledge on international energy R&D priority-setting and evaluation.

[5] The Clean Energy Ministerial (CEM) is a high-level global forum to promote policies and programs that advance clean energy technology, to share lessons learned and best practices, and to encourage the transition to a global clean energy economy. Initiatives are based on areas of common interest among participating governments and other stakeholders. See http://www.cleanenergyministerial.org/.

[6] Mission innovation is a is a global initiative of 22 countries and the EU to dramatically accelerate global clean energy innovation through a doubling ofgovernments clean energy research and development (R&D) investments over five years. See http://mission-innovation.net/.

[7] See http://www.nordicenergy.org/event/clean-energy-ministerial-2018-malmocopenhagen-2/.

Session 2. Setting the scene

This session outlined the importance of social science in problem-driven energy research, the non-technical dimensions of energy demand and consumption, and the issues of the acceptability of risks, distribution and fairness. It presented insights, tools and results from DSM activities, where knowledge dynamics, visualization tools and group discussions helped improve understanding of behavioural change. It also provided insights into the motivational factors of individuals and collectives, a multi-perspective energy system analysis and arguments in favour of interdisciplinary research using multiple methods and comprehensive data.

Energy for society

Prof. Benjamin Sovacool, University of Sussex and Aarhus University[8]

- Link to presentation slides:
  https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/BenjaminSovacoolIEAOct132017.pdf

A series of biases continue to handicap the energy studies field. Researchers often promote technological solutions to energy problems while ignoring the social processes that determine their acceptance and use, shaping the risks they can pose and offer opportunities to achieve energy policy goals with existing technology. Moreover, many assessments ignore the often hidden ethical, moral or social justice implications of energy technology and infrastructure.

The following elements illustrate the contributions that social science can make to energy and climate:

- Typologies to enable a fundamental understanding of the immediate usefulness of research
- A conceptual framework to understand energy behaviour and consumption
- Constructing and deconstructing the risk of energy technologies
- Determining the equality, fairness and justice of energy consumption on the global scale

The arts, humanities and social sciences are instrumental to problem-driven research which may advance scientific, conceptual or theoretical understanding. These domains refine our knowledge of the non-technical dimensions of energy end use, demand and consumption. They also help us to identify energy and climate risks and in determining acceptable solutions (as well as the distribution, framing and communication of risks). Moreover, they are also needed in order to address issues of morality, ethics, philosophy, equality and fairness and to humanise the discussion of energy topics and technologies. An example of how the issues of equality, fairness and justice may be determined by comparing of per capita electricity consumption is illustrated in Figure 2.

However, based on the results of a 15-year content analysis, social science-related disciplines, methods, concepts and topics remain under-utilised in contemporary energy studies research. The five key findings were:

[8] This presentation was made on the second day of the workshop due to scheduling constraints.

- **Human-centred and comparative research is under-utilised.** Approximately 13% of articles using human-centred research methods were dominated by surveys, with far fewer studies utilising field research, interviews or focus groups. Also, interdisciplinary and comparative collaborations were rare.
- **Particular disciplines and sources were under-represented.** Twelve under-represented topics included gender and identity, philosophy and ethics, communication and persuasion, social psychology and behaviour, anthropology and culture, research and innovation, politics and political economy, institutions and governance, energy and development, externalities and pollution, and the sociology of technology.
- **Novel research needs could be much better addressed.** Possibilities include funding, better social data and a focus on problems, including a broad range of stakeholders, experts, practitioners and researchers, as well as awareness and the priority to include inter-disciplinary, inclusive, comparative mixed-methods research in journal media.
- **Challenges still remain in this field despite some progress and the launch of a new journal, *Energy Research & Social Science* (*ERSS*).** Research designs remain weak, mostly in the form of single country studies (90%), and based on a single method. It is rare to include theory, policy relevance and application in a single study. Also, authorship inclusive of the global 'South', with strong research designs and comparative cases triangulated with mixed methods that contribute to both theory and practice is less than 1%.

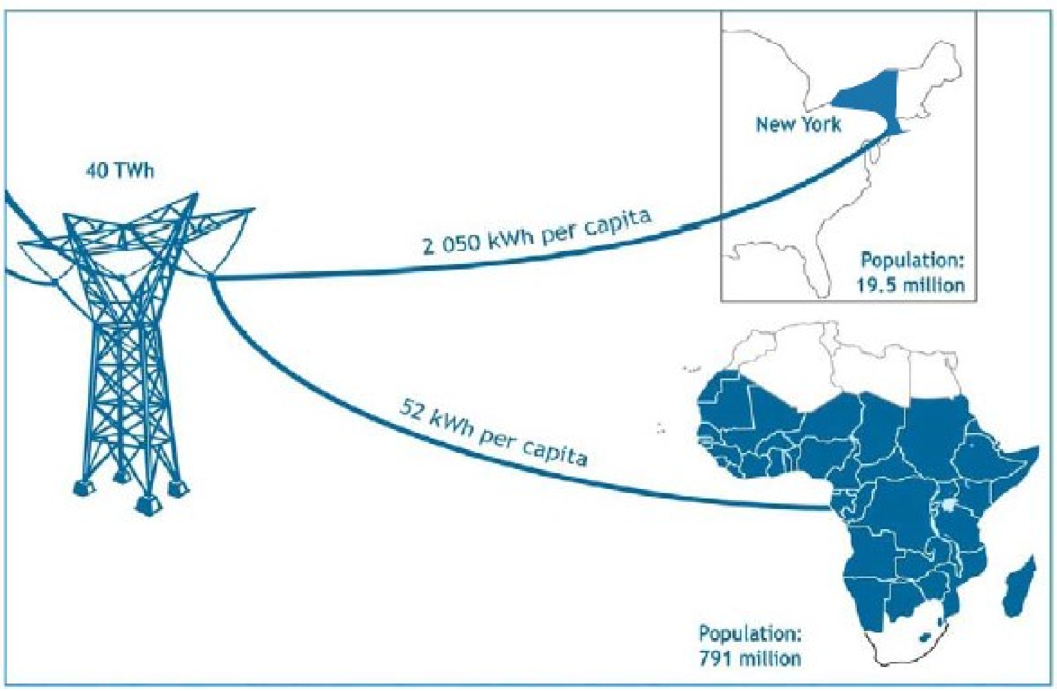


Figure 2. Electricity consumption per capita in two regions

Energy social science is more than a collection of disciplines: it is a social or epistemic community of scholars characterised by its methods of doing research (often qualitative), its collection of concepts or theories and its domain of, or interest in, particular topics.

In summary, the arts, humanities and social sciences have immense value to offer energy and climate communities. There is a growing recognition within funding bodies, journals, universities and knowledge users that energy social science research needs to be more than an afterthought. At least we are beginning to ask the right questions, even if we are not yet able to generate reliable, causal, robust and replicable answers. In short, realising a future energy system that is low-carbon, safe and reliable will require fuller and more meaningful collaboration between the physical and social sciences.

Behaviour change research collaboration: insights, tools and results

Sea Rotmann, CEO, Sustainable Energy Advice

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/SeaRotmann_EGRDCopenhagen.pdf

"Helping the Behaviour Changers" is the topic of project under the IEA TCP on Demand Side Management (DSM TCP) (Task 24). The project focuses on the people in the energy system, including the so-called 'behaviour changers' in government, industry, research and the third and service sectors[9]. It also adopts an end-user-centric approach to understanding collaboratively what people do in terms of their energy use and why they do it. It is also about connecting science and practice within a broad and systemic perspective with replicability and scalability in mind, as well as being geographically inclusive. Learning and sharing what works is also part of this Task, acknowledging that research is necessary at every policy stage, from problem to solution to evaluation of the outcome. Finally, it is about serving as a global research model and taking note of the dynamics between researchers, funders and implementers throughout a carefully designed knowledge process. In short, the overall objective is to provide a bird's eye view of best practice approaches to interventions encouraging behavioural change and practical guidelines and tools for how best to design, implement and disseminate them in real life. Language is critically important in the learning and sharing process. The target audiences are governments, industry, researchers, the third sector (e.g. community or consumer groups) and middle actors (e.g. service and technology providers).

The expert network consists of around 350 experts from 21 countries. The DSM TCP Task 24 focuses on multi-stakeholder facilitation. It is guided by a set of conditions for collective impact, including a common agenda with a shared vision for change, shared measurement of data and results across all participants, and mutually reinforcing activities, meaning that they will be differentiated while still being coordinated. Open and consistent communication also matters, as does the existence of a dedicated staff serving as the backbone for the collaboration. Workshops are organised with the different behaviour changers with the aim of providing the neutral, trusted and respected backbone support necessary to ensure open engagement. One behaviour changer framework, also dubbed the "magic carpet" by industry participants, was a visualization tool developed to enhance communications among the multiple stakeholders. Storytelling was the chosen method of "translation" between different sectors, culminating in a special issue of the journal *Energy Research & Social Science* (*ERSS)* on

---

[9] Rotmann, S. (2016), "How to create a 'magic carpet' for behaviour change", BEHAVE 2016, 4th European Conference on Behaviour and Energy Efficiency, Coimbra, 8-9 September 2016..

“Storytelling and Narratives in Energy and Climate Change Research”[10]. The project included a “Beyond kWh” tool (Subtask 9) for standardising and validating behavioural evaluation conducts psychological and behavioural analysis to measure an intervention’s actual effects on energy literacy, attitudes, behaviours and habits. The diagram illustrated in Figure 3 below describes the wider framework of the behaviour changer framework.

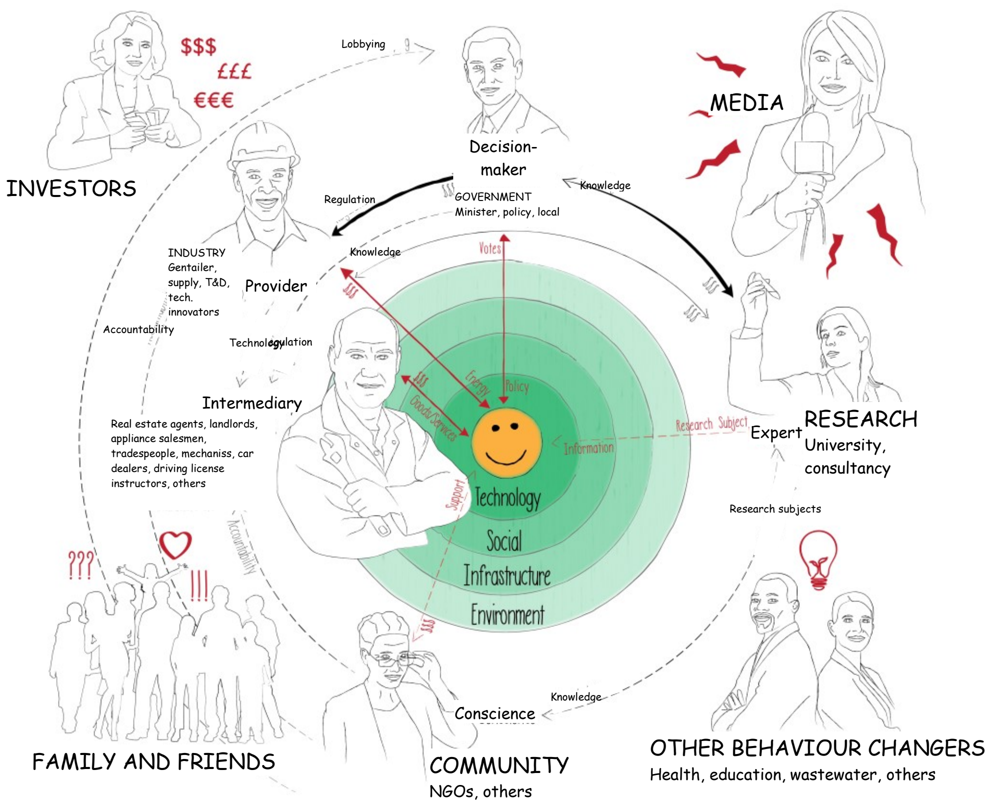


Figure 3. The behaviour changer framework

The project also included practical guidance (Subtask 11) on how multi-stakeholder collaboration works in practice. The Carolinas Healthcare System (North Carolina), the second-largest health-care network in North America, has pulled together an expert network under the guidance of Task 24 to design a behavioural intervention focusing on building operators. It tries to identify energy conservation potentials in hospitals using the Task 24 behaviour changer framework with contributions from the various actors in the hospital’s energy socio-ecosystem.

The resulting ’energy connect’ concept is based on participatory research, including surveys, focus groups, interviews, workshops and expert summits. It provides building operator training, as well as a design team responsible for establishing research procedures, test locations, interventions, baseline data and evaluation schemes. Energy connect interventions for building operators included making

[10] Mozzi, M., Janda, K., and Rotmann, S. (2017), Storytelling and Narratives in Energy and Climate Change Research, *Energy Research & Social Science*, Volume 31, pages 1-10.

energy and cost data visible, selecting a site-based energy-champion, developing call response process flows, documenting adjustments, and promoting conversation between occupants and facilities. In some facilities, up to 30% in energy savings were reported resulting directly from this behaviour change programme.

In summary, participants were invited to review the Special Issue of journal Energy Research & Social Science to understand the importance of energy stories.

What drives energy consumers?

Thijs Bouman, Faculty of Behavioural and Social Sciences, University of Groningen

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/ThijsBoumanWhatdrivesenergyconsumers.pdf

Consumers are active and central players in future energy markets. People need to accept and adopt sustainable solutions, change their energy behaviour, reduce and shift their demand for energy and invest in energy efficiency for a successful energy transition. The Self and the Collective have different types of motivation. Money, status, pleasure, the feel-good factor and social approval are motivations for the Self, while the Collective is motivated by moral considerations and doing ‘good’. Here human values are classified into four categories: ‘hedonic’ (characterised by pleasure), ‘egoistic’ (self-centred), ‘altruistic’ (unselfish regard for or devotion to the welfare of others) and ‘biospheric’ (relating to the biosphere). Sometimes these values conflict with each other, but this can be reduced by making sustainable behaviour more meaningful or strengthening and supporting biospheric values. Sustainable options can also feel good because they are meaningful. Groups and their identities affect individual norms and values. Norms may be injunctive or descriptive in form, while values work as objective and perceived biases. An example of a group norm is corporate environmental responsibility.

Sustainable energy behaviour is motivated by both personal factors and group factors. The former is characterised by personal values and environmental self-identity, the latter by group identity and group norms and values, as shown in Figure 4.

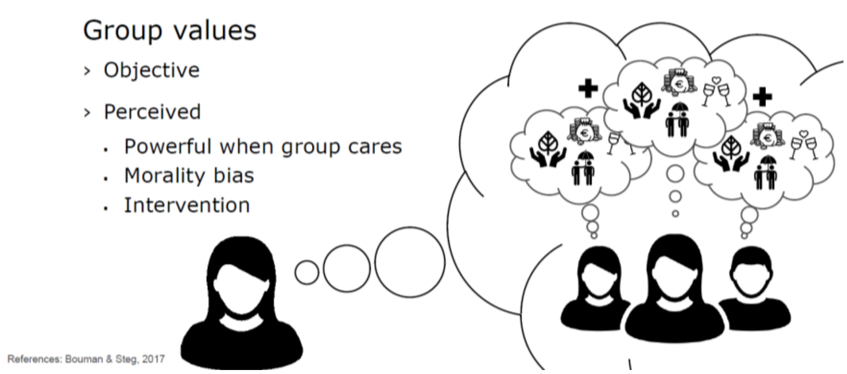


Figure 4. Individual values and Group values[11]

[11] Source: Boumen and Steg, 2017.

In summary, we need more knowledge on energy use behaviour, including understanding behaviour as a prerequisite to promoting sustainable use. For example, a framework of top-class European socio-economic energy research on the human dimensions of sustainable energy transitions to promote a secure, clean and efficient energy system, has been introduced through the European Platform for Energy Research in the Socio-economic Nexus (PERSON). Knowledge of the acceptability of energy systems and policies is also needed. Knowledge creation should be based on interdisciplinary research utilising multiple methods, both quantitative and qualitative, and collecting data across different cultures. Future research directions may focus on the interaction of technological and social solutions, intervention studies and the creation of representative national panels.

Multi-perspective system analyses for robust energy decision support

Bert Droste-Franken, Head of Energy Department, EA European Academy GmbH

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/BertDrosteFranke_EGRD_12_131017_fin_pdf.pdf

The technical elements of energy-supply systems, from resources to conversion to consumption, are surrounded by social framework conditions. Therefore, systems analysis from multiple perspectives is needed. The system is described by the purpose (e.g. energy supply) and the characteristics relating to certain operations (e.g. energy, chemical reactions, communication). System aspects are broadly speaking technological, physical, chemical, geo-scientific, biological, human-physiological, psychological, sociological, political-scientific, legal-scientific and economic.

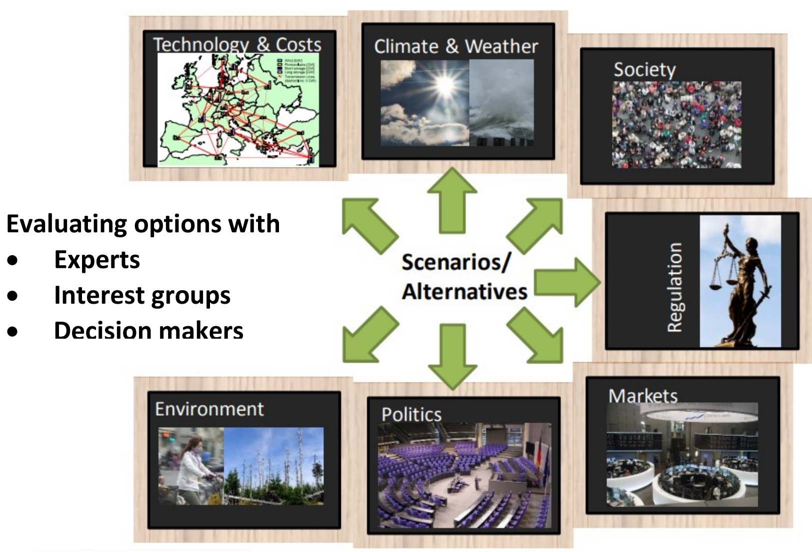


Figure 5. Policy advice approach[12]

[12] Presentation photos courtesy of Pixelio, Siemens, Wikipedia, Everystock, and dpa 2014. Background: Siemens online game "Power Matrix" (2014).

Responsible policy advice provides socially safe, secure and robust solutions which do not contradict major social values, fit well with evaluations by interest groups, and focus on decisive issues. In order for the policy advice to be reliable, it has to be factually robust, accounting for fluctuations or potential risk factors. It also must be socially robust, accounting for diverse interests and value commitments. The first step is to identify and analyse a broad range of options, followed by designing acceptable solutions which focus on decisive issues and possible correlations.

There are a range of challenging differences between scientific and academic expertise. These were found to be resolved through the following methods and instruments.

Combine expertise: Consider expertise from both scientific and practical domains. Facilitate reflective discussions of problems, uncertainties, and substantial societal evaluations. The EnAHRgie energy concept and sustainable land use consultation was cited as an example.

Identify workflows: Identify the questions, targets, models, surveys, data, analysis, and how to communicate the results (e.g. visualisation feedback loops, presentation, publication).

Transparent assumptions, evaluations and analysis: Enable interactive, web-based visualisations of data, indicators or maps where changes in assumptions may be visualised.

Extended systems analysis: Plot the innovation networks (information brokers, opinion leaders, actors) in order to foresee uptake. A lithium battery R&D network was cited as an example.

In summary, multiple perspectives are needed to analyse energy systems in the context of their social frameworks. Providing robust policy advice includes gathering relevant experts, considering a broad range of options, communicating analysis in a transparent way and selecting options based on relevant evidence. Today various supporting methods and tools are being developed, adopted, used and tested, e.g. regional energy concepts and innovation analysis.

Session 3. Human-centred analytics to enhance policy effectiveness

This section focused on how human-centred analytics may enhance decision-making and policies and make them more effective. The speakers presented perspectives and problem areas, including prosumer participation, business models, individual and collective energy choices and the impacts. Participants also discussed the challenges of integrating consumer behaviour into energy and climate models.

Tapping the potential of prosumers

Matthew Kennedy, International Energy Research Centre, Ireland

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/MattKennedyProsumers_IEAEGRD_final.pdf

The International Energy Research Centre (IERC), a collaborative energy research centre supported by the Irish Government, analyses industry-driven energy challenges within the commercial and residential sectors. IERC translates industry needs into research objectives and delivers impact from research excellence. The presentation focussed on case studies of the status and potential for onsite photovoltaics (PV) in the commercial sector in four countries. The studies developed possible actions, identified the primary drivers behind PV prosumers, and highlighted the conditions and barriers that were limiting widespread adoption of PV for own use. Buildings with the strongest potential to emerge as prosumers were selected for the studies.

While no internationally agreed definition of a commercial prosumer exists, for the purposes of the study it was considered as being interconnected behind the meter and as having a potential PV installed capacity of between 10 and 250 kW was found to be in use. Countries may track and classify PV data differently. In the United States data is obtained from the commercial systems while France and Germany obtain data from the feed-in tariff (FIT) at the time of consumption.

The cost of installing PV has fallen dramatically in recent years and this trend is expected to continue. Yet the market PV has stagnated. This is particularly striking in Germany, where PV capacity expanded rapidly between 2009 and 2013, yet during 2014-2016, total capacity slowed to 2008 levels (see Figure 6). This may be due to the lack of incentives for prosumers. Therefore support schemes are needed to compensate most or all of PV output (e.g. net metering, below-retail FITs). Without support, energy storage will be required, which would increase overall costs.

A complex picture of drivers (economic, behavioural and technological) and national conditions influence the PV stakeholder groups (prosumers, governments, grid operators, generators, consumers, PV supply chains). Drivers may either enable or constrain prosumer uptake. For instance, higher PV system costs would have a negative impact, whereas environmental awareness would have a positive effect. On the other hand, the interests of stakeholders are poorly understood, may be difficult to predict, and their actions could result in positive or negative impacts on prosumer uptake. Moreover, national conditions such as available roof space, share of rental property, renewable energy development and existing grid infrastructure may also affect prosumer development. Therefore to

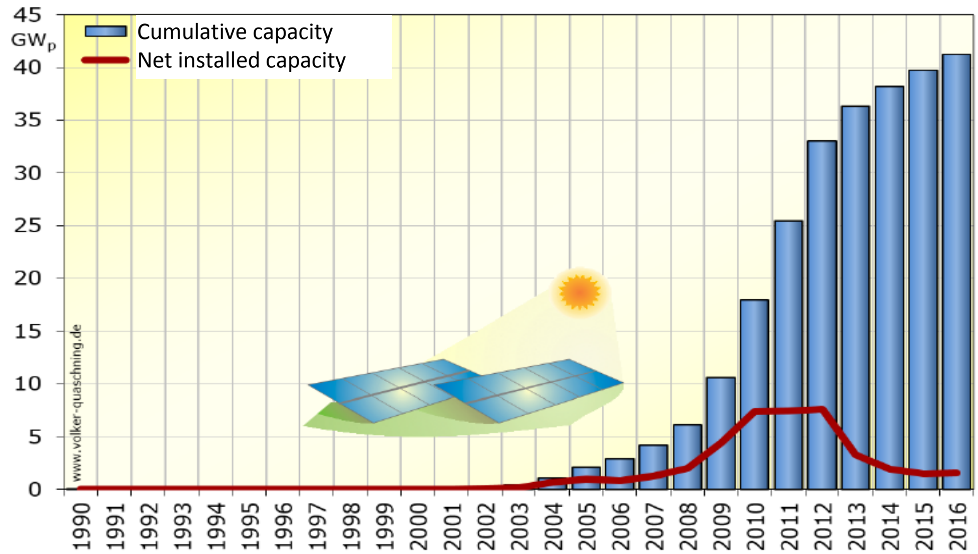


Figure 6. PV installation in Germany[13]

accelerate PV uptake, opportunities and risks need to be clearly articulated and balanced, and stakeholder interests aligned.

Regarding the technical challenges, there are already solutions that increase the ability of grids to accommodate more prosumers. These solutions can be grouped into three categories: solutions led by utilities and system owners (e.g. grid reinforcement, network reconfiguration), prosumer-led solutions (e.g. PV curtailment, storage) and interactive solutions (i.e. techniques based on supervisory control and data acquisition, demand responses). Additionally, prosumer strategies are required in order to sustain growth and to enable the market transition through new business models, new product and service offerings, and emerging technologies such as smart grids.

In summary, there is considerable further potential for commercial prosumers which could play a central role in a more decentralised, interactive, electricity network. But further scale-up will require policies which enable a market transition. Commercial prosumers have been slow to emerge on an 'incentive-free'" basis in many countries, yet with support schemes the pace could accelerate. Policy makers, regulators and the utilities need to develop effective strategies to anticipate, integrate and plan for a growing number of commercial prosumers. When defining policies and strategies they also need to evaluate the drivers and conditions and balance opportunities and risks. For example, designing new policies for net excess generation, facilitating improved data on the building stock and calculating the (local) advantages of involving prosumers in the decision-making process.[14]

---

[13] See https://volker-quaschning.de/datserv/pv-deu/index.php.
[14] For more information see http://www.ierc.ie/.

Business models for a more effective market uptake of DSM energy services for SMEs and communities

Ruth Mourik, DuneWorks B.V.

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/RuthMourik_EGRD2017presentationNewBusinessmodels.pdf

When it comes to energy efficiency, we are somehow still waiting for the big breakthrough. Case studies of 46 companies offering energy efficiency in technologies or systems (e.g. lighting, heating, smart systems), showed that many consumers simply do not value energy efficiency. This low interest in energy efficiency might be one of the main causes of the low market uptake, but it may be influenced through targeted tools and approaches.

There are a few measures that may influence the growth of the business, including those related to how energy-efficient business models are designed. As many companies in the field of energy efficiency began offering technologies, their businesses are built on selling more technologies. However, the key question is whether these business models meet the needs and expectations of the users. Three important factors are decisive in facilitating the transition from a product-dominant logic to a service-dominant logic. Figure 7 illustrates this transition.

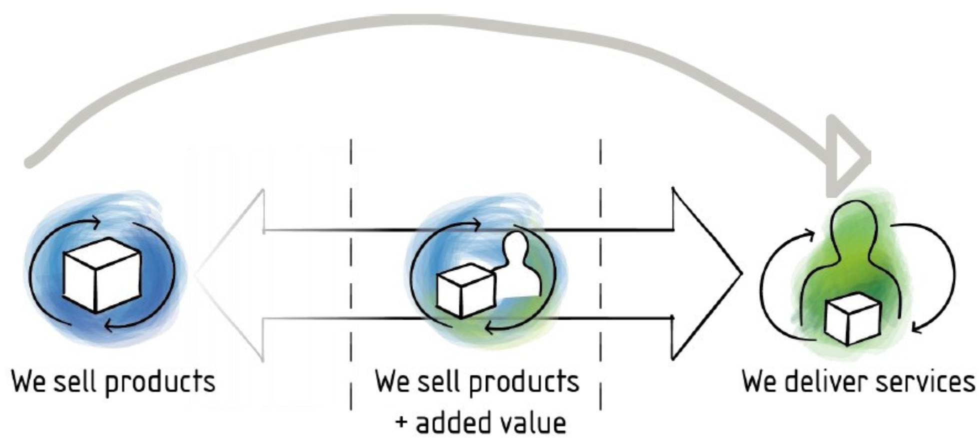


Figure 7. Transition from a product dominant logic to service dominant logic

Create a business model that adapts to the offering. When the offer is a good, the user has a passive role, as the offer is output-oriented. However, when the offer is a service, the user has a key role, as the offer is meant to enable the consumer to solve a problem or fill a need.

Be skilled in serving the user. This implies sensing the user needs, the context and the system. It also requires the ability to conceptualise the knowledge by transforming the data into a product or a service (or something in between). Successful businesses are also good at orchestration (understanding that energy efficiency is not a user's first goal), and are capable of scaling and stretching the organisation to meet user demand.

Understand what is relevant in the context in which businesses operate. The case studies reviewed a range of companies, including those unaware of the market contexts in which they operate as well as companies that are able to effectively and intelligently match the market context. Other companies may have varying levels of awareness or aim at becoming system transformers on a large scale. Regardless of the market situation, four ways of dealing with context were highlighted. Combining success factors with the business strategies results in 'business model strategies'. For example, the widely used 'pushing harder' strategy describes a product which is perceived as the solution, but consumers don't understand it. The 'reframing' strategy refers to a technology with an added process innovation which helps consumers to understand. The 'pushing something else' strategy describes an interface which involves the user in developing the technology. The 'servicing' strategy identifies users' actual needs and offers services that reflect their values (e.g. lifestyle, smart home).

In summary, service-oriented business models can be more successful as long as they understand that the value of energy efficiency is only experienced in use, not beforehand. The message for policy-makers is that you get what you design: good framework conditions are needed, especially for the many small and medium-size energy-efficiency companies, which rely on access to a client base, good client relationships, customer data, branding, sufficient time for experiments and learning, and continuous innovation. Policy makers need to stimulate the dynamic capabilities of entrepreneurs in the energy-efficiency business.[15]

Impacts of energy choices: examples of research approaches with quantitative data collection and analysis

Tiina Koljonen, Research Team Leader, VTT Technical Research Centre of Finland

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/TiinaKoljonen_Presentation.pdf

For the first time, the Paris Accord has made fighting climate change a common global cause, with each country doing what it can to keep temperatures from rising more than 2°C above pre-industrial levels. But it does not impose specific emission-reduction requirements on governments, and the transition towards a low-carbon future may take many pathways. Therefore methods and tools to support decision making are needed to develop effective policies and framework conditions and to facilitate choices of individual investors and consumers. Models and tools are also needed to evaluate the effectiveness of market-pull and technology-push policies. The EU's transition to a low-carbon future is a great challenge, one that requires a paradigm shift, including the transformation of energy systems, as well as radically changing the way we live, move and work. Analysing and modelling this multi-faceted transition requires modifying existing tools and methodologies, as well as the development of new ones in order to consider and analyse the techno-economic and socio-economic changes required.[16]

The ECHOES project was launched in 2016 to unlock the policy potential of an integrated social-science perspective on energy behaviour. It includes consideration of the socio-cultural, socio-economic, socio-political and gender-related issues that influence individual and collective energy choices, as well as social acceptance of the energy transition in Europe. The project also aims to foster the implementation of the SET (Strategic Energy Technologies) Plan Actions, advance towards the energy transition, and decarbonise Europe' future energy system.

---

[15] For more information, see http://www.ieadsm.org/task/task-25-business-models-for-a-more-effective-uptake/.
[16] See http://www.cres.gr/atest/pdf/D.6.1-Tools-and-Methodologies-Development.pdf.

ECHOES employs the innovative theoretical concept of 'energy collectives', or what determines energy choices - from the individual level to formal social units. Three main theoretical perspectives are integrated into this concept: (1) individual decision-making as part of collectives; (2) collectives as constituting energy cultures and life-styles; and (3) formal social units such as municipalities, states, energy providers and NGOs.[17] All three perspectives are displayed in the Figure below.

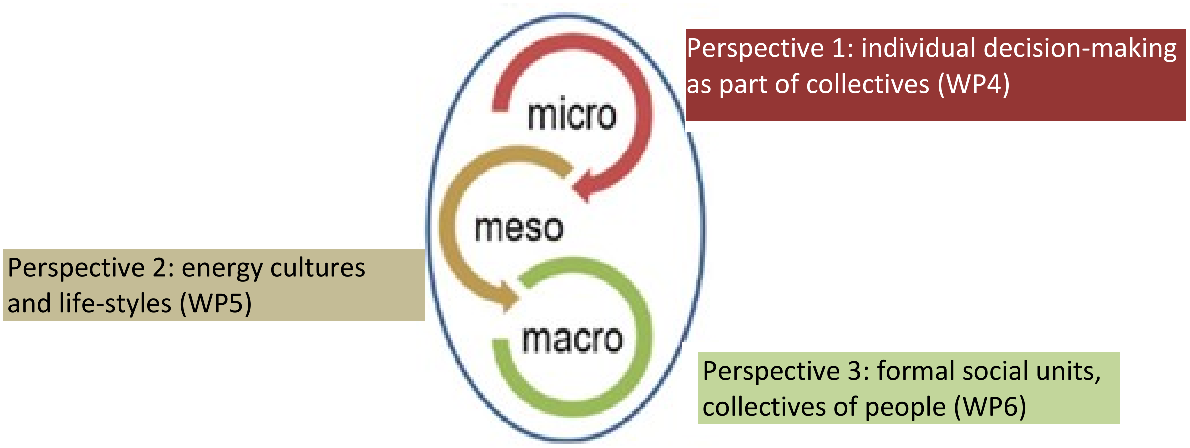


Figure 8. Energy collectives and their main theoretical perspectives

One task of the project is the creation of an open-access social science and humanities (SSH) database and SSH indicators to provide quantitative and qualitative data related to both social sciences and low carbon energy and its transition for use in the models.

The VTT Technical Research Centre of Finland has implemented some of the tools and methodologies to create low-carbon scenarios for Finland in 2050. These scenarios include different assumptions regarding Finland's economic and community structures and new technology RD&D, as well as norms, acceptance and behaviour. Results show that a significant reduction in the fuel consumption of passenger cars can be obtained through technical RD&D, new industrial products and processes, centralised urban structures and the 'smart economy'. However, the scenario planning tools need to take into account the behaviour of private consumers. Normative (back-casting[18]) scenarios produce simplistic future pathways to the future even with very complex models. On the other hand, transformative scenarios are usually based on qualitative assessments which are difficult to replicate. In both cases there is a lack of creative thinking and insight regarding the effect of social processes.

The challenge is therefore how to link social theories to the energy system transition. The next steps hence focus on gathering more evidence-based knowledge of how individuals and organisations perceive energy over time. Instead of focusing on technological innovations (e.g. Technology Readiness Levels (TRL) thinking), it is more important to focus on social innovations. And finally, integrated

---

[17] See https://echoes-project.eu/content/project-approach.

[18] Setting one or more desirable futures and exploring paths which could lead to them. VTT has examined three pathways, "Tonni" (ton), "Inno" (innovation), and "Onni" (happiness).

scenario planning and modelling of social systems should be obtained through improved methods, models, data and modelling frameworks.

Applying Behavioural Economics to move towards a more sustainable future

Karl Purcell, Programme Manager, Behavioural Economics Units, Sustainable Energy Authority Ireland (SEAI)

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/KarlPurcellApplyingBehaviouralEconomicstoMovetoaMoreSustainableFuture.pdf

Understanding the needs of energy consumers is critical in planning the transition to a low-carbon economy. Ultimately, if low-carbon solutions do not meet consumer needs or are unattractive to them, promoting behavioural change will be significantly more difficult. Designing effective interventions promoting behavioural change requires a human-centred research approach which combines quantitative and qualitative data collection and analysis. Through the inductive method and an interdisciplinary approach to understanding human behaviour, behavioural science provides a useful framework for designing and testing interventions relative to behaviour change.

Behavioural science combines insights from psychology, sociology and economics. When policy-makers are designing and implementing behavioural change interventions, it may be useful to follow the four-step framework[19]: define, diagnose, design and test.

Define: This involves describing the problem and its context, establish targets and specify how progress against targets and outcomes will be measured. It is also extremely important to define accurately the multiple levels of social and economic systems in which the behaviour takes place. The next step is to define the problem, including targets where possible. Fogg's Behaviour Change Grid[20] may be useful for policy makers as it defines the type of behaviours that are targeted (from a one-time behaviour such as install a PV panel, to a permanent change such as never litter).

Diagnose: This stage requires identifying behavioural barriers, i.e. things that could obstruct the process of inducing a behavioural change. Examples include deliberation costs, affective responses, cognitive load, procrastination, or hassle factors. It is also important for policy-makers to consider behavioural motivators that can be boosted to encourage the desired behaviour. Policy makers may also consider segmenting the population of interest based on its behaviour in order to target behaviour change interventions more effectively.

Figure 9 illustrates five load profiles which help explain how different groups of people typically use energy throughout the day.

---

[19] Datta, S., and Mullainathan, S., (2012), *Behavioral Design: A New Approach to Development Policy*, CGD Policy Paper 016, November 2012, Center for Global Development, Washington, D.C.

[20] See http://www.behaviorgrid.org/.

This stage also involved understanding the person within his or her context. For instance, airport officials had initially thought "door smokers" were mainly travellers who had just arrived in the airport and were smoking one last cigarette before entering the buildings. Yet, the figures revealed that 85% actually came from inside the building, with 33% of them staying in a non-smoking area for the entire duration of the cigarette before returning inside.

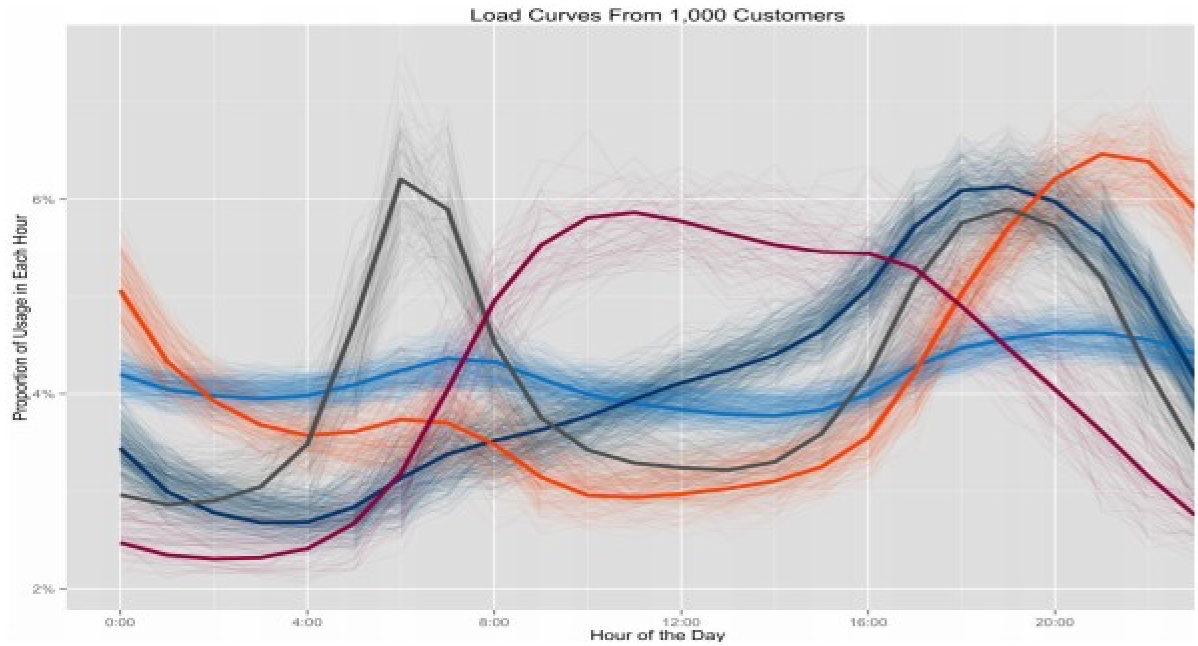


Figure 9. Load curves segmentation[21]

Design: This step requires connecting behavioural diagnosis to intervention design. Hypothesised behavioural concepts that could explain a bottleneck (mental accounting, loss aversion, choice conflict, identity) could be connected to different interventions (reframe choices, remove hassle factors, change comparison group). For example, if consumers find it difficult to learn about their energy usage because their energy bills do not provide timely feedback on their energy usage behaviour, policy-makers can consider introducing home energy reports which deliver monthly feedback with pre-specified actions consumers can take to reduce energy use.

It is also important to remember to prototype and trial proposed solutions on a small scale before rolling them out to a wider audience. For example, discovering that you have bought the wrong screws for 60 smart meters during an initial pilot is much better than discovering that you have bought the wrong screws for a national rollout of millions of smart meters!

Test: Testing helps policy makers understand whether a behavioural change has been effective or not, and the extent to which it was or was not effective. Figure 10 illustrates a typical randomised control trial (RCT) design. Randomised control trials typically consist of randomly splitting groups of energy users into two: one group which receives the energy behaviour change intervention, and one group which does not. The effectiveness of the intervention is measured by comparing the outcomes of both

[21] Source: Opower.

groups. Where possible, evaluators should use randomised control trials or other methods of comparative impact. These evaluations should incorporate sufficient pre- and post -measurements to control for changes in weather and temperature. Where possible, to avoid self-reporting, interventions should be assessed by measuring actual changes in energy consumption.

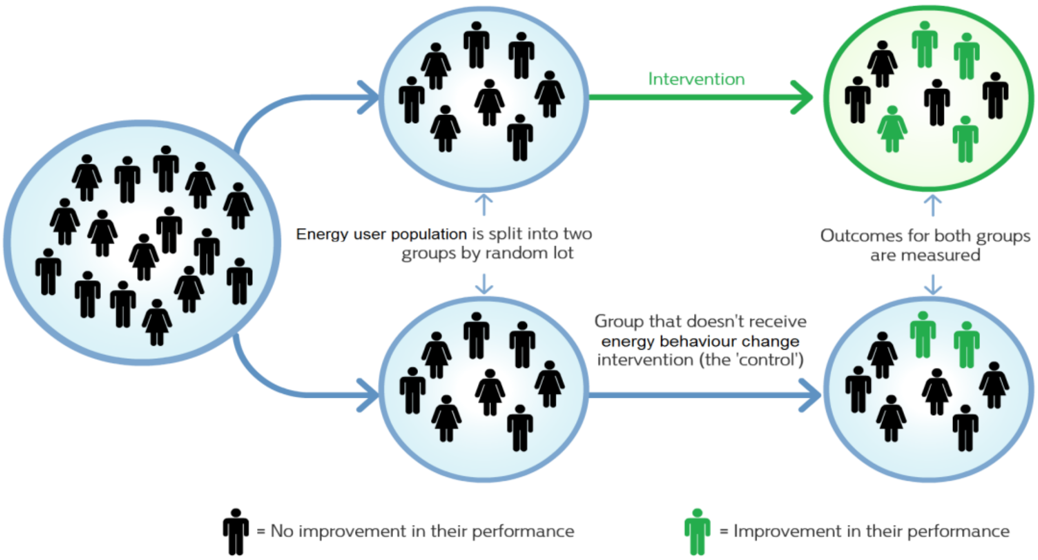


Figure 10. Test process

Providing a 'nudge'[22] is often effective in influencing choice. However, nudges may consider the individual within the community where increasing levels of engagement may be required to achieve sustainable energy solutions.

The process of designing an intervention to encourage behavioural change needs to embed fairness and respect for the consumer/citizen. Adopting co-design methodologies that combine policy inputs and inputs from citizens can help to design fair, sustainable and effective interventions. Respecting the autonomy of citizens and consumer and providing transparency are crucial when designing behavioural change interventions.

Applying behavioural science to improve energy-related outcomes has proven to be effective, and governments worldwide are now actively applying behavioural science to drive pro-environmental behavioural change. In recognition of the potential impact of behavioural science, SEAI is currently applying a phased approach to behavioural science in its energy policy in order to encourage sustainable behaviour. This approach consists of three main phases:

Quick wins: These are small changes made to existing processes based on insights from behavioural science that can improve the effectiveness of current policy programs. One example is making

[22] A nudge is any change to a choice architecture that influences people's choice without restricting any options or significantly altering the financial incentives, it must be simple to implement and easy to avoid.

(behaviourally tested) changes to communications to encourage consumers to partake in a free home energy upgrade.

Driving stronger behavioural change: These are larger behavioural change projects which may take longer to implement and evaluate. One example is introducing home energy reports to provide home-owners with better feedback about their energy usage.

Changing policy-making: At this stage, policy-makers are actively considering behavioural factors which impact on a policy's success at the design stage of a new policy program. One example is designing a home energy upgrade scheme that allows consumers to pay back the cost of energy upgrade financing via their energy bills over a long time period, thus reducing the impact of upfront costs on retrofit decisions.[23]

Influencing business behaviours and decision-making to improve energy efficiency

Carrie Pottinger, Programme Manager, Energy Technology R&D Networks, IEA

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/IEApresentation.pdf

Understanding the link between social science, behavioural economics and policies is a key factor in achieving the transition towards a low-carbon economy. Some methodologies and frameworks have aimed to explain energy consumption from a behavioural standpoint. For instance, Huebner et al. 2015 focus on understanding the underlying rationale and behaviour, measuring actions and modelling. Others[24] define behavioural economics as the relationship between economics and psychology, applying scientific methods to the study of economic activity based on repeated experiments and observations.

This relatively new science is rapidly informing policy. Among the strong features of early applications to regulatory design is the fact that the consumer choices are influenced by the simplicity of the information, by what they consider more convenient and/or by the attributes of the options. The way we take account of non-linear decisions in decision-making processes is also very relevant.

Regulatory policies, such as tax compliance or consumer policies which consider behavioural economics have proved the most effective. For example, the United States Environmental Protection Agency (EPA) originally issued a labelling system in miles per gallon, but as the incremental cost savings were so small, consumers did not see the advantage. However, when the EPA changed the fuel efficiency labelling to be on a yearly basis (showing greater cost savings) more consumers purchased more efficient vehicles. There are several other examples of policies which were informed by behavioural economics, though when evaluating success, it is easier to identify possible solutions than to measure the actual impact.

However, integrating BE into energy and climate models is not straightforward. Priority issues include accurately representing the intersection between energy technologies, economics and human behaviour modelling consumer behaviour, and understanding how consumer behaviour influences energy system

[23] For more information, https://www.seai.ie/.

[24] Source: Lunn, P. (2017), *Regulatory Policy and Behavioural Economics*, OECD, Paris.

transitions. Contributions of social science (behaviour) are more difficult to measure than the contributions of other disciplines (natural sciences, engineering, technology, medical, health) or of economics (financial). In addition, behaviour is based on intangible, indirect elements, whereas models comprise tangible, quantifiable elements. Translating social science learnings and quantifiable data for models is needed. As highlighted In Figure 11, this has been addressed in some models which include parameters such as technology uptake, societal impacts, and demand response. .

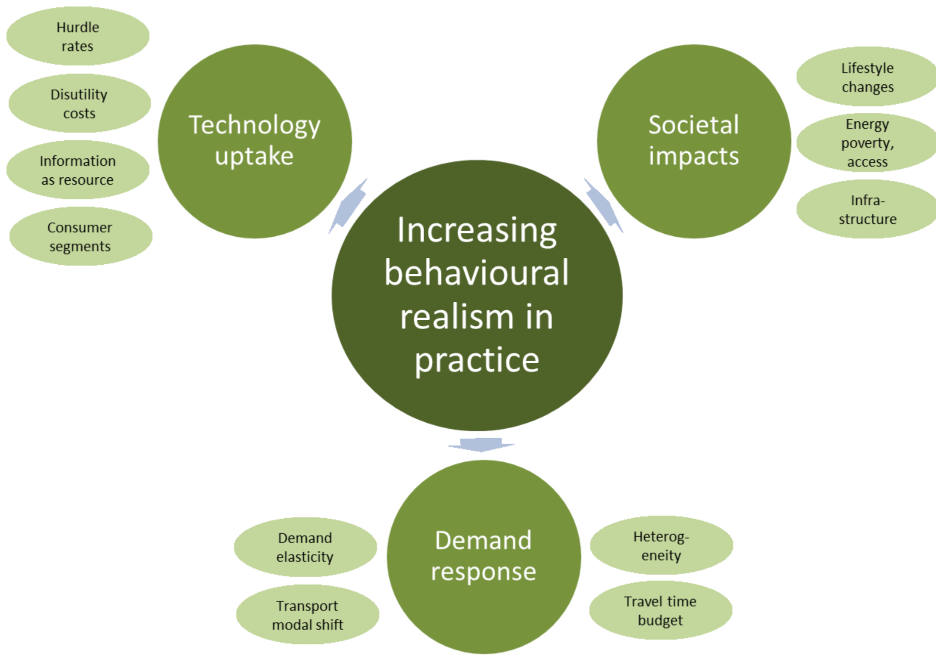


Figure 11. Modelling approaches to behaviour[25]

Though progress has been made in recent years, energy/engineering/economic/environment models typically neglect behaviour. Building sustainable energy systems requires a focus on a broad range of issues, including technologies, economics, energy-efficiency and low-carbon fuels and behaviour. The main challenge in modelling behaviour is the limited understanding of the term 'behaviour' as it relates to energy choices. Theories that fully explain the concept are lacking due to a lack of high-quality data and measurement issues, but also the range of behaviours involved.

However, attempts are being made to develop hybrid models that integrate complex behaviour into energy system optimisation models (ESOM). Drawing on best practice, guiding principles for ESOM models have been formulated which would enable broader integration of behaviour[26]. These include These include quality assurance procedures, sectoral detail, including uncertainties, transparency and "letting the problem drive the analysis – not the other way around". In addition, guidance on quantifying risk ('discount rate) and technology uptake ('hurdle rate') would enable modellers to refine the analysis.

[25] UCL Energy Institute (2015), "Addressing the behavioural gap in energy/economy models", BE4 workshop, UCL Energy Institute, composite of modelling approaches. See https://iea-etsap.org/index.php/etsap-project/be4-presentation.

[26] DeCarolis, J., et al (2017), "Formalizing best practice for energy system optimization modelling", *Applied Energy* 194, pp 184-198.

Further model improvements are possible through more realistic estimates of behaviour change potentials and associated costs, underlying the relationship between hypothetical and actual behaviour, having transparent rationale and hurdle rates, and ensuring consistency between hurdle rates, model results, and across technologies.

In summary, informing policies through behavioural economics has increased rapidly in recent years. Modelling provides valuable insights to policy makers. However a better understanding is needed of behaviour – including reported and actual behaviour. As a result, formalised guidance for ESOM models comes at a critical time to inform energy and climate policy.

Session 4. The consumer at the centre of a distributed energy system

The session raised two key questions: What challenges do we face in transiting towards a highly distributed energy system? How can the consumer / the individual be appropriately taken into account during this transition? These were answered through five presentations with different consumer perspectives, ranging from understanding the role of individuals in the energy transition to the energy efficiency and heating behaviour of households in residential areas of Japan, Austria and the United Kingdom to energy efficiency in the chemical industry.

The individual at the centre of a distributed energy system

Elisabeth Düttschke, Fraunhofer ISI

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/ElisabethD%C3%BCtschke_Consumeratthecentre.pdf

We are moving from a highly centralised to a more decentralised energy system, relying on more distributed generation, energy storage and the more active involvement of consumers through demand response[27]. In this new system, individuals will play a major role. Accordingly the Fraunhofer Institute for Systems and Innovation Research (ISI)[28] is researching where and how these individual needs will be taken into account in the energy transition.

This change can only be embraced if it is accepted by socio-political stakeholders, communities and markets. Acceptance can be observed at the attitudinal level (latent willingness for acceptance; emotional and cognitive evaluation) and at the behavioural level (acceptance is obvious and therefore observable in terms of first, one-shot investment behaviour, and/or secondly, curtailment (habitual) behaviour). Results from a recent study carried out by the Fraunhofer Institute[29] shows that the majority of German consumers have a positive attitude towards the energy transition, with some 93% strongly in favour of the 'energy transition'.

There are a number of implications of the energy transition which may be perceived as a radical change for the individual in the multiple social interactions and roles they may play. New technologies such as electric vehicles, new services such as DSM, and new infrastructure) will lead to changes in behaviour (e.g. home automation) and changes in systems (e.g. prosumers). Therefore, certain open questions in this energy transition need to be addressed:

---

[27] See http://www.europarl.europa.eu/document/activities/cont/201106/20110629ATT22897/20110629ATT22897EN.pdf.
[28] See http://www.isi.fraunhofer.de/isi-en/index.php.
[29] Special Eurobarometer 364 in 2011, n=13091, 12 EC-countries

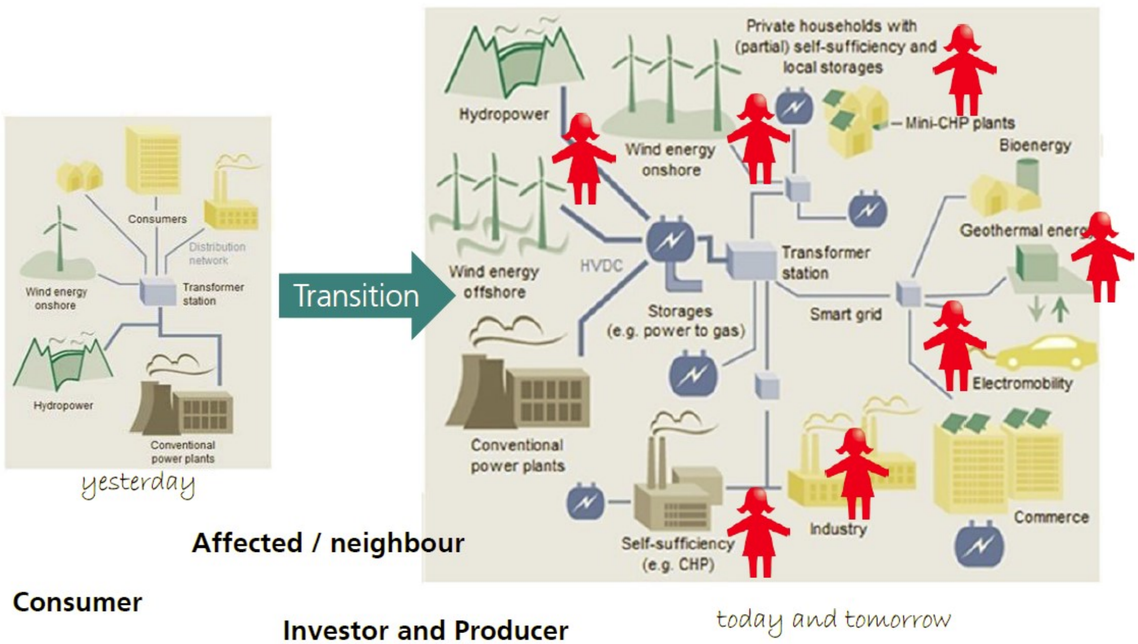


Figure 12. The individual in the present and future energy system[30]

Rebound and spill over - Behavioural responses to efficiency increases: what are the determinants? The total direct rebound effect of lighting (brighter light and longer burn time) amounts to 3%.[31] However, it was also found that behavioural responses to installing a more efficient light bulb differ, ranging from a reduction in additional demand to greater demand. We need to know more about what shapes this variation.

Decision-making in organizations: multiple actors and complex processes? Different actors and motivations contribute to the different steps: initiation, decision and implementation. However, research on these processes is just beginning, and energy issues are often not a priority.

Perception of policy-making: what shapes it and how does it translates into behaviour? German manufacturers' perceptions of the German government's will to promote renewable electricity generation was evaluated based on a ' credibility indicator' (clear political vision, firm political will, clear political signals, and strong support from the government). The results showed that there has been a clear decrease in credibility since 2011 which stabilised at a low level in 2014 for renewable energies. Third party influence: what is their role in the decision process? A range of thirdparty actors are likely to influence the consumer when making energy decisions. For example, a product installer may propose a particular technology depending on the profit margin.

In summary, the energy transition is real and requires radical change that is linked to complex relationships and phenomena that underline the need to put the individual at the centre of deliberations.

---

[30] Source: Fraunhaufer ISI.
[31] Schleich et al. (2014), "A Brighter Future? Quantifying the Rebound Effect in Energy Efficient Lighting", *Energy Policy,* Elsevier, 2014, 72, pp.35-42.

Residential behaviour-based energy-efficiency programmes and activities in Japan

Ji Xuan, Ph.D., Jyukankyo Research Institute (JYURI)

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/JiXuan_IEAEGRD.pdf

Final energy consumption in Japan in the commercial and residential sectors has increased in recent years, pointing to a need to improve energy-efficiency in Japan in these two sectors.

In the residential sector, energy consumption per household in Japan peaked around 2001 at 47.1 Gigajoules (GJ), and since then has reduced to 40.2 GJ in 2014. Over the same period the consumption of kerosene reduced by 8% yet the consumption of electricity (mostly produced from coal and natural gas) increased by 9%. In order to reduce energy demand in the residential sector, we need to have more detailed information on factors such as family composition, life-style, residential area, building characteristics and awareness of energy conservation. For this purpose, JYURI carried out a survey to identify actual conditions of CO_2 emissions from the residential sector. Behaviours ranged from turning off the modem/router when not in use (implemented by 12% of consumers) to boiling the proper amount of water (implemented by 89% of consumers). The results of the survey showed, for example, that there is the potential to reduce electricity consumption by 6% by changing behaviour related to stand-by power.

In 2017 the Ministry of the Environment created a Nudge Unit to disseminate a nudge approach to behaviour change in the public and private sectors. The Nudge Unit will deal with environment and energy, as well as many other fields including health and education. The information gathered is available to other governments, businesses and experts[32].

In addition the Ministry of Economy, Trade and Industry (METI) has commissioned Japan's first large-scale pilot study of Home Energy Reports (HERs). The study covers the service territory of the Hokuriku Electric Power Company and examines the impact of consumers' electricity usage and awareness of energy efficiency motivations and behaviours. The Opower HERS was used as the template which was adapted for Japanese consumers. Key elements in the Japanese HERS were as follows:

- 41 200 households randomly assigned to two groups (treatment and control)
- HERs were mailed twice to the treatment group during the winter
- The savings impact was analysed by comparing electricity usage across both groups
- Awareness and behaviour regarding energy efficiency were measured via a phone survey

The results of the program (Figure 13) showed that, one month after the first HER, there was an average of 0.9% savings with statistical significance, rising to 1.2% after two months. It was also shown that, comparing this programme to those in other countries, consumers in Hokuriku responded more quickly. If the program were to continue, steady savings in the range of 1.5–2% could be expected by the second year.

[32] See the portal side of official statistics of Japan, e-Stat (http://www.e-stat.go.jp).

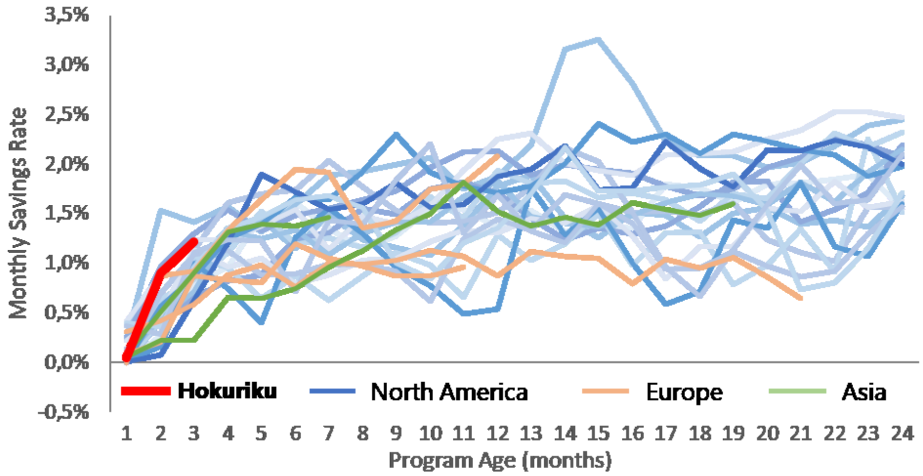


Figure 13. Monthly saving rate of different programs[33]

In line with the government's efforts to make an impact on emissions reductions, an annual Behaviour, Energy and Climate Change Conference (BECC Japan) has been organised since 2014 to share the latest trends in energy behaviour. The conference is supported by public entities and sponsored by private companies.[34]

City of Tomorrow (E-PROFIL): neighbourhood profiles for optimised energy transformation processes

Prof. Daniel Latzer, Doctoral Researcher, Technical University of Vienna

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/DanielLatzer_E_PROFIL_ProjectReport_EGRD_final.pdf

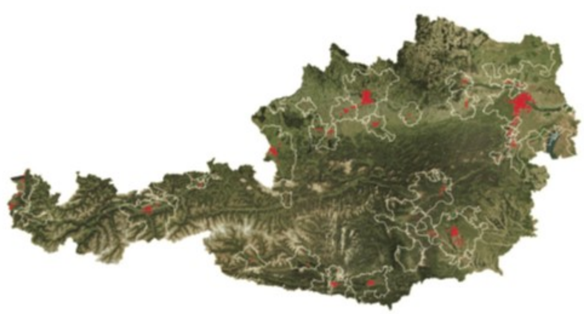
Climate targets, both regionally and globally, have driven the efforts of public administrations to reduce energy demand and decarbonise energy supply. So far, the main measures to be introduced have focused on the thermal insulation of single buildings, the expansion of district heating and specific technologies. In this context, the E-Profil (Neighbourhood Profiles for Energy-related Transformation Processes)[35] has been developed with two main goals: to reduce heating demand and to make use of solar technologies.

E-PROFIL focuses on the effectiveness in existing structures (measured by indicators showing the flexibility of neighbourhoods in respect to the transformation processes); and the efficiency of these processes, in particular transparency and participation.

[33] Hirayama S., Nakagami H., Tsurusaki T., and Haig, K. "Japan's First Large-Scale Home Energy Report Pilot Study: Impact on Japanese Consumers' Awareness, Motivations, and Electricity Consumption", BEHAVE 2016, 4th European Conference on Behaviour and Energy Efficiency, Coimbra, 8-9 September 2016.
[34] For more information, see www.jyuri.co.jp.
[35] See https://nachhaltigwirtschaften.at/en/sdz/projects/e-profil-neighborhood-profiles-for-optimized-energy-transformation-processes.php.

To capture these two dimensions an online survey of households was carried out in different regions (see Figure 14). It canvassed information on actors, buildings and attitudes, including the socio-economic context; building construction and energy-technology conditions; attitudes towards climate-friendly energy projects; and awareness of neighbourhood-scale energy projects and funding opportunities.

Households surveyed



Urban regions

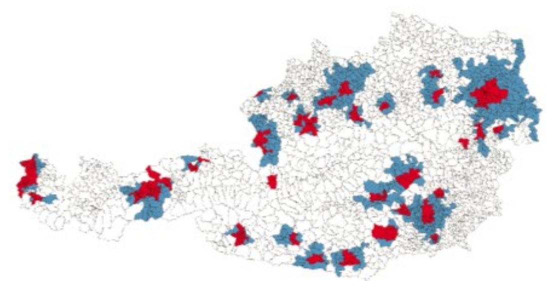


Figure 14. Location of households surveyed

Selected results show that 62% of interviewees preferred a shared PV system to lower the risks, costs, administrative requirements and maintenance. Therefore introducing financial incentives (subsidies and financing schemes) and simplifying the application process and enabling collaborative/shared projects would facilitate uptake. Overall the survey results showed that households are knowledgeable of energy topics and are willing to participate in such surveys, including geo-tagging. However, heterogeneous stakeholders have contradictory interests.

The results are made available through online tools which are easy to use and understand:

- Mapping potential reductions in heating demand to identify areas with high retrofitting potential through modelling
- An online “dashboard” which groups basic data in 12 indicators predefined in workshops with local stakeholders
- An Excel tool to estimate the heating demand of each building and the economic results of the retrofitting.

This data transparency created trust which in turn stimulated active participation among those surveyed. The data and tools obtained are an important asset for research and planning activities and can be applied to neighbourhoods in other countries.

Behaviour and decision-making concerning energy efficiency in the chemical industry

Lieven Stalmans, Borealis, Co-Chair, European Chemical Industry Council (CEFIC)

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/LievenStalmans_20171013Behaviourandenergyefficiencydecisionmakinginchemicalindustry_caseBorealis1.pdf

The transition towards a decarbonised energy system includes technical and social challenges for consumers as well as companies where vast amounts of energy are consumed, especially in the industrial sector. The energy intensity in the European chemical industry decreased significantly between 1990-2014, with 43.8% less energy needed to produce one unit of chemicals (including pharmaceuticals). Yet in order to shift to more sustainable forms of production, companies must continually identify and realise energy efficiency improvement measure to move beyond the 'business-as-usual'. Managing the change to more sustainable production requires commitment over several years by all aspects of business operations (see Figure 15 below).

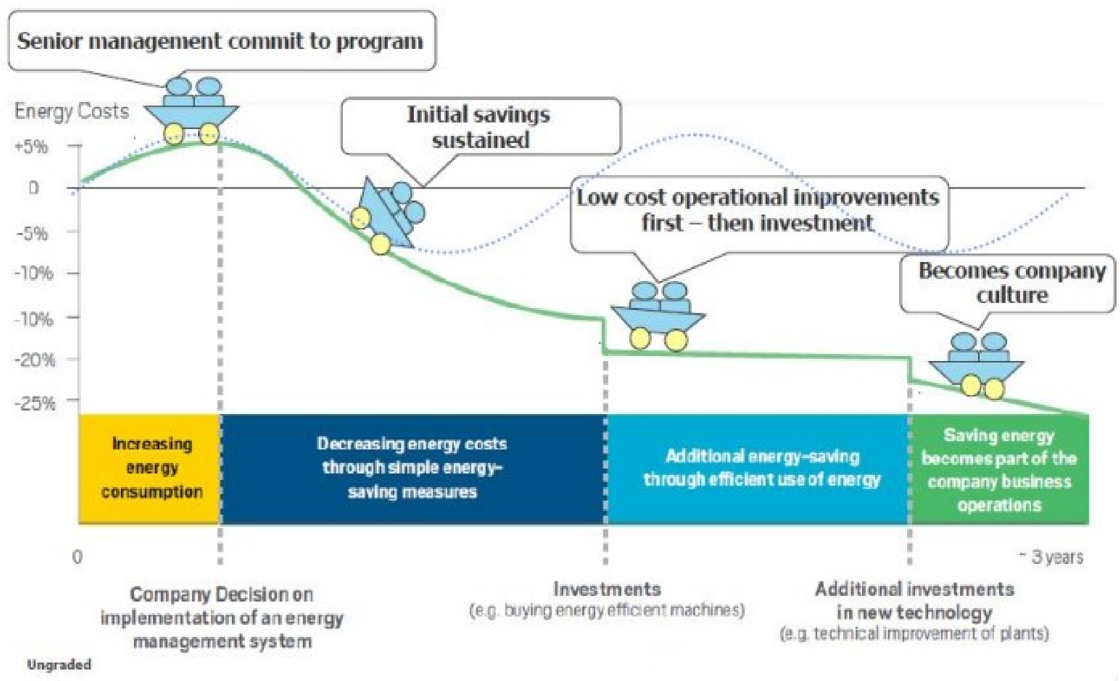


Figure 15. Managing the change to more sustainable production[36]

The aim is for energy savings to become a part of the company's 'culture'. BOREALIS is following this process by implementing the following measures.

International standards: International standards such as Energy Management System (ISO 50001) provide the framework of requirements for organisations to improve efficiency and energy savings. ISO management system standards follow the 'Plan-Do-Check-Act' process for continual improvement.

[36] Source: Kahlenborn et al. (2012), based on Lackner and Holanek (2007).

Corporate social responsibility: Transparent communication of the company's 'gold standard' to outside stakeholders ensures accountability. At BOREALIS this is the Responsible Care programme.

Planning: To increase energy efficiency and safeguard the competitiveness of assets planning is needed. At BOREALIS this is the Energy and Flaring Roadmap 2020+, which focuses on ideally operated plants, optimised design and control, and ideal processes and site integration. This is expected to lead to above-average efficiency of key assets and infrastructure.

Roles and responsibilities: Each level of a company has a responsibility to implement the plan, from the strategic level (boards and committees) to the operational level (technicians and operators). Ongoing monitoring of progress, including strategies for improvement where necessary, ensures successful achievement of the plan.

In summary, energy efficiency is a key element of competitive edge for energy-intensive industries. It requires strategic planning and internal consultation for it to become part of the company's 'culture'. [37]

What do people want from (low carbon) heat at home, and how we find out?

Matthew Lipson, Head of Consumer Insight, Energy Systems Catapult, United Kingdom

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/MatthewLipson_2017OctoberLipsonWhatdopeoplewantfromlowcarbonheatathomeandhowcanwefindout.pdf

In the United Kingdom fewer than 4% of the population currently heat their homes from low-carbon sources and 90% prefer natural gas. Yet rapid change is possible: in 1970 only 25% of homes were equipped with central heating compared to 90% today. Encouraging consumers to change to low-carbon sources requires addressing three key challenges: improving experiences with low-carbon heat, simplifying installations and enhancing the user's control.

Improving experiences: It is necessary to understand the purpose of the heat: to warm up, cool down, clean, enrich relationships, protect property, promote health, and others. These different uses are set out in Figure 16.

Simplifying installation: This requires designing low-carbon technologies that are as easy to install as a gas boiler. Other solutions include preparing the property for the new technology at the stage of renovation, considering thermal details when making renovation decisions, and explaining which solutions will work in each geographical area.

[37] For more information, see https://www.borealisgroup.com/.

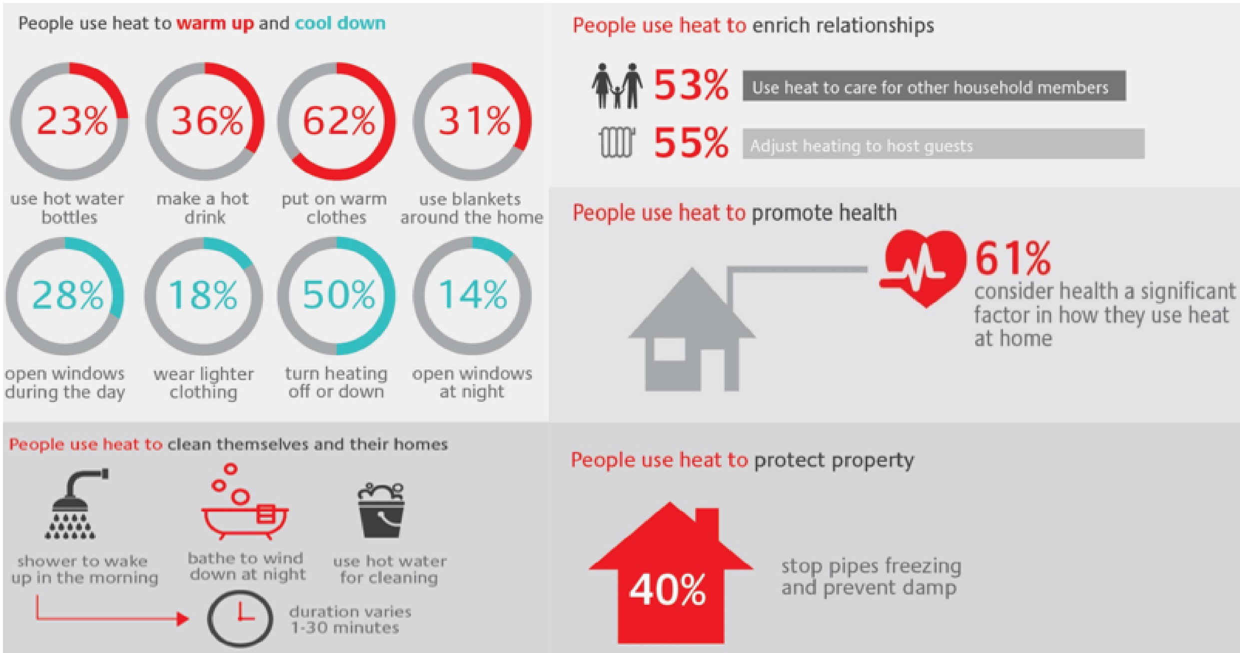


Figure 16. Systems should allow consumers to use heat in diverse ways

Enhancing control: Consumers care more about their experiences in using the heat rather than how the heat is delivered. If a heating system has to be replaced, the main concern is whether the new technology will provide the same level of service (using the heat to be clean and comfortable at an affordable price). Energy services enabled by the notion of the 'smart home' could be the key to unlocking high-quality, low-carbon solutions. The study showed that the emerging smart home could help households (to enjoy better energy experiences), businesses (to acquire and retain more customers), vendors (to improve and sell more low-carbon products), and governments (to harness market forces to decarbonise at the least cost).

For these reasons the Catapult created a 'living lab' designed to put consumers at the heart of the energy system. The living lab comprises 100 owner-occupied smart homes where businesses can work with governments to learn how to design and deliver low-carbon products and services that consumers are willing to pay for.[38]

[38] For more information, see https://es.catapult.org.uk/projects/home-energy-services-gateway/.

Session 5. R&D policies and decision-making

This session aimed to identify the best practices in governance which affect R&D energy policy. The speakers addressed knowledge action networks, R&D programmes with and for citizens, and the role of social science in empowering – and understanding - the consumer and the impacts on energy system transformation.

Knowledge-action networks

Erik Pihl, Future Earth Stockholm

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/ErikPihl_Future_Earth_IEA_EGRD_2017.pdf

Sustainable development has been defined as "a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[39]. Launched in 2015, Future Earth is designed to advance global sustainability science, build capacity in this rapidly expanding area of research, and provide an international research agenda to guide natural and social scientists. The Future Earth research platform, generated in partnership with academia, governments, NGOs, civil groups and companies, provides knowledge and support to accelerate transformations to a sustainable world.[40] Figure 17 illustrates the 11 knowledge-action networks of Future Earth.

Figure 17. Knowledge-action networks

Sudden changes may disrupt existing systems, resulting in a new state. An increase in the global temperature could lead to a 'tipping point' resulting in a loss of permafrost and ice or changes in weather patterns. From 1900 to 1913 the implementation of motor vehicles completely changed transport and related sectors, while creating new opportunities. The unexpected, significant expansion of solar photovoltaics 2008-2014 has affected electricity supply systems and created new markets.

---

[39] The term 'sustinable development' was first articulated in 1987 by the World Commission on Environment and Development report entitled "Our Common Future".
[40] See http://www.futureearth.org/who-we-are.

However as the past trends serve as the basis for future scenarios it is extremely difficult to predict disruptions. For these reasons setting pathways to a sustainable future are needed. One type of pathway is a roadmap with clear milestones. One such roadmap - the "carbon law" - calls for halving emissions every decade by 2050.[41] A scenario based on implementation of the carbon law shows that cumulative global CO_2 emissions could be maintained at 2020 levels and global warming could be limited to below 2^oC.[42]

The challenges are related not only to the uptake of technologies but also to transformations in societies. Understanding how societies can make the transition towards sustainability is equally important. For this reason Future Earth and the International Social Science Council (ISSC) works in tandem with the ISSC on the Transformations Project which includes a conference and a global Sustainable Development Goal (SDG) Transformations Forum.

Future Earth has also contributed to modelling exercises such as The World in 2050 (TWI2050)[43] launched by the International Institute for Applied Systems Analysis (IIASA), the Sustainable Development Solutions Network (SDSN), and the Stockholm Resilience Center (SRC). TWI2050 aims to address the full spectrum of transformational challenges related to achieving the 17 SDGs in an integrated manner so as to minimize potential conflicts among them and reap the benefits of potential synergies of achieving them in unison.

Finally, Future Earth organises workshops with local stakeholders on ways to drive low-carbon disruptions. Framing the challenges of disruptions to energy systems enables participants to formulate research questions. For example, business models are as important as technology when it comes to disruption and innovation. There is a need for a dedicated push, policy consistency, meeting users' needs, ensuring fair access to markets and addressing social resistance. The corresponding research questions could be: Do distributed patterns have any impact? Are there differences between countries? How should incumbents be dealt with? Are current modelling tools sufficient? Future Earth also supports decarbonisation at municipal level.

In summary, a sustainable energy future is possible with forward planning for potential disruptions. Research should aim to understand unexpected system-level changes and tipping points in order to stimulate and direct exponential change towards sustainability.

[41] Rockström J., et al. (2016), "A Roadmap for Rapid Decarbonization", *Science*, 24 March 2017.
[42] Ibid.
[43] For more information see www.twi2050.org.

R&D policies and programmes with (and for) citizens: approaches to understanding and changing individual energy consumption behaviour in Switzerland

Annika Sohre, Swiss Competence Centre for Research for Energy, Society and Transition (SCCER-CREST)

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/AnnikaShore_EGRD_UnderstandingConsumerBehavior_TalkSohre_13102017_final.pdf

Switzerland has long-standing experience in promoting and coordinating energy research programmes, including the Swiss Federal Energy Research Master Plan, led by the Federal Energy Research Commission, and the Swiss Energy National Programme. The Federal Council and Parliament are considering important changes to the country's energy supply. In accordance with the Swiss Coordinated Energy Research Action Plan, the Commission for Technology and Innovation has been given the mandate to finance and manage the creation and operation of research networks between higher education institutions and the Swiss Competence Centres for Energy Research (SCCERs).

One such SCCER, the Competence Centre for Research in Energy, Society and Transition (CREST), brings together researchers from psychology, economics, sociology, business science, the behavioural sciences and political science from nine major Swiss research institutions. CREST's Work Package 2 aims to gain a better understanding of behaviour and decisions of energy consumers, the determinants of energy consumption and the options for reducing energy demand.

CREST established an integrated framework to understand individual energy consumption behaviour and change and how it is changed (illustrated in Figure 18). In the framework the consumer is defined as an individual with internal factors (e.g. age, gender, knowledge) within a structural setting (e.g. culture, climate, institutions) which influence his or her behaviour. Given the multitude of combinations of internal factors, solutions may not respond to the needs of all consumers. Therefore in order to address individual and structural differences, measures to promote change in energy consumption behaviour need to be designed specifically for each particular group in society in a dynamic fashion.

The Swiss Household Energy Demand Survey (SHEDS) provides an empirical basis for understanding consumers' energy-related behaviour and changes in the household. The survey was carefully designed to consider perspectives of the scientific disciplines involved, providing a reliable basis for policy, business and civil society to influence individual energy consumption behaviour.

The survey results how that the highest energy demand comes from high-income households residing in large single-family houses outside urban areas. A positive outcome of the survey was that it was shown to promote green investments in electricity. It was also found that guilt was a motivation to reduce electricity consumption.

The survey results how that the highest energy demand comes from high-income households residing in large single-family houses outside urban areas. A positive outcome of the survey was that it was shown to promote green investments in electricity. It was also found that guilt was a motivation to reduce

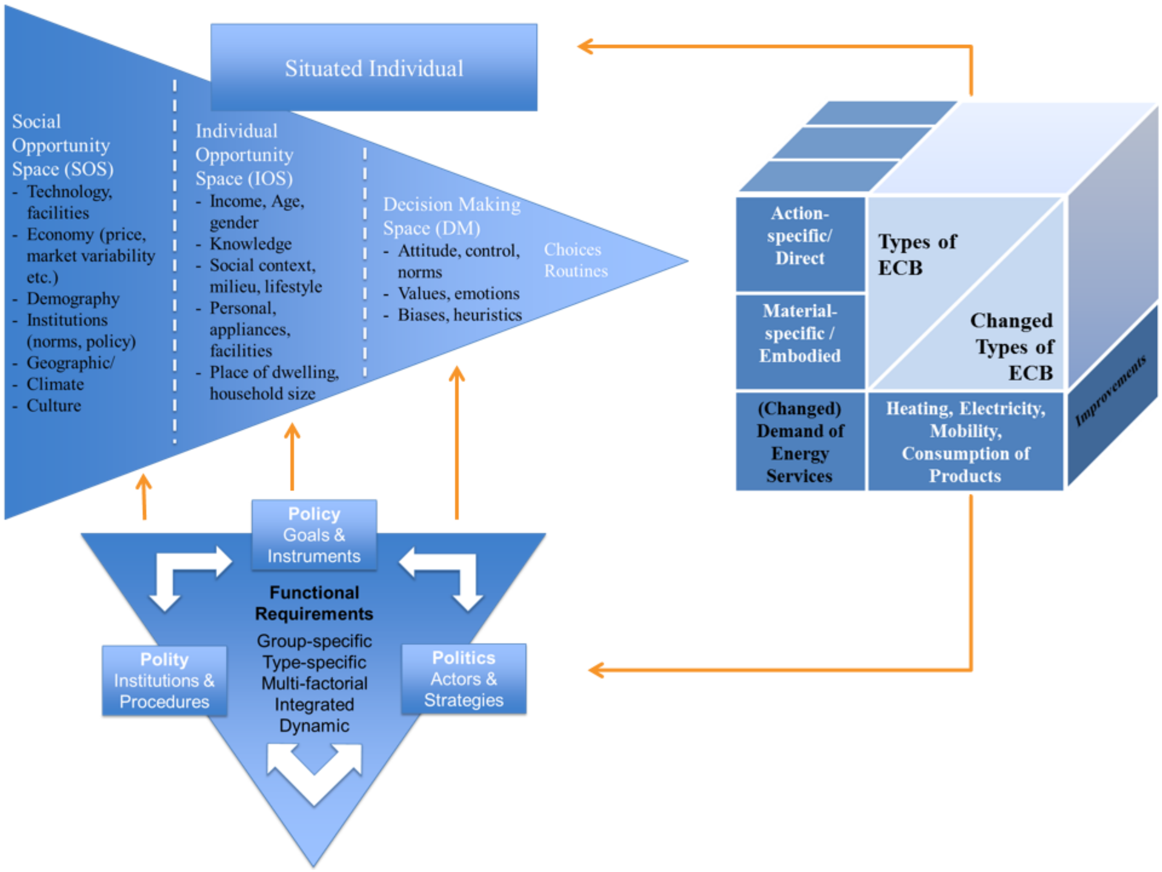


Figure 18. Illustration of the integrated framework[44]

electricity consumption. The survey results were further analysed to enable more targeted design of group-specific policy interventions through consumer 'segmentation approaches' summarised as follows:

Bottom-up, top-down: This approach clusters energy consumption and facilities into four categories. The 'wise majority' (47%) had moderate energy consumption; the 'drivers' (37%) had heavy private car usage; the 'heavy residential users' (10%) had high private consumption in all three areas; and the 'heavy users' (3%) had high consumption, especially in use of heat at home and frequent air travel.

Clustering: This approach plotted individual consumer groups by the consistency (consistent vs. inconsistent) and energy behaviour (energy-saving vs. energy-intensive). Results showed that consistent energy-savers (24% of the population) were females aged 54 (average), the inconsistent consumers

[44] Burger, P., Sohre, A., et al. (2015), "Advances in understanding energy consumption behavior and the governance of its change-outline of an integrated framework", *Frontiers in Energy Research*, Volume 3, 29.

(70%) were females aged 44 (on average), while the consistent energy spenders (6%) were females who were on average 39 years old.

Using Otte's lifestyle typology the bottom-up/top-down approach further classified consumer behaviour by the level of materialism and the modernity/ biographical perspective. This resulted in groupings such as 'advancement oriented', 'hedonists', 'liberals' and 'reflectives'.

Additionally, SHEDS set out to determine the energy literacy of consumers through Choice Experiments. For example, consumers were presented with a scenario of replacing a refrigerator, were provided with the efficiency and price of two models (less expensive, less efficient vs. more expensive, more efficient), and were asked which model would minimise their expenditure over 10 years.

In summary, there are many benefits of integrated and interdisciplinary energy research networks. However, there are very diverse findings about what drives energy consumption behaviour and its change. Intervention strategies need to focus on target groups, types of behaviour and determining factors. One size does not fit all.

Social Science and the Humanities within Horizon 2020: meeting European Energy Challenges

Gerd Schönwälder on behalf of Estathios Peteves, European Commission

- Link to presentation slides: https://www.iea.org/media/workshops/2017/egrdworkshopoctober2017/GSchoenwaelder_SSHPresentation_OCT17.pdf

The clean-energy transition is a top priority for the European Commission (EC). To achieve this transition we need to understand that the energy system comprises not only fuels and sectors but also consumers. Social sciences and humanities (SSH) enables policy makers to understand the role of consumers and citizens in European energy systems.

The EC aims to empower consumers by providing them with information necessary to make better energy choices, enabling a more active role in energy systems, and by protecting consumers against unfair practices such as breaches of privacy. Yet consumer empowerment is not the same as citizen involvement. Citizen involvement may improve social acceptance of technologies and encourage social innovation, provided the citizens are open and flexible with regard to change. However in some cases citizen involvement may be inconvenient for technology companies (i.e. strong citizen opposition to siting of wind turbines).

For these reasons socio-economic considerations are embedded across all areas and disciplines (including energy) in the EC's research and innovation support for the Horizon 2020 (H2020) programme[45]. Horizon 2020 is the financial instrument implementing the Innovation Union, a European flagship initiative aimed at securing Europe's global competitiveness through an additional EUR80 billion

[45] See https://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020

of research funds over 2014-2020. Looking beyond H2020, SSH is also playing a key role in the EU's energy policy-making.

The Strategic Energy Technology Plans (SET Plans)[46] aim to improve coordination of energy research and investment across Europe through technology or sector-specific platforms. One action of the SET Plan aims to develop an ecosystem for social innovation to occur through 'smart cities'. Citizen involvement, social dialogue and social innovation will enable successful implementation of the Energy Union strategy[47], comprised of five closely related and mutually reinforcing dimensions: security, solidarity and trust; a fully-integrated internal energy market; energy efficiency; climate action – decarbonising the economy; and research, innovation and competitiveness. Consumers and citizens will also play a central role in the Accelerating Clean Energy Innovations programme which aims to integrate smart, cutting-edge digital technologies into all aspects of the energy system[48]. Lastly, embedding socially innovative technologies will be part of the EU's pledge to Mission Innovation.

In summary, SSH is critical for delivering the EU's energy priorities as it enables a comprehensive, integrated approach to the energy system which underlines all aspects of the EU's energy research and policy-making. This integrated approach is reflected in the energy field, where a merging of products and services from the beginning (co-creation) to the benefit of both consumers and suppliers. However, more efforts are needed to overcome fragmentation of energy research communities and to fully integrate SSH into H2020.

[46] See https://ec.europa.eu/energy/en/topics/technology-and-innovation/strategic-energy-technology-plan.
[47] See https://ec.europa.eu/commission/priorities/energy-union-and-climate_en.
[48] See https://ec.europa.eu/energy/sites/ener/files/documents/1_en_act_part1_v6_0.pdf.

Appendix A. Abbreviations

BE	Behavioural economics
BECC	Behaviour, Energy and Climate Change Conference
CEFIC	European Chemical Industry Council
CERT	IEA Committee on Energy Research and Technology
CREST	Competence Centre for Research in Energy, Society and Transition
CSR	Corporate Social Responsibility
CTI	Commission for Technology and Innovation
DSM	Demand Side Management
DTU	Technical University of Denmark
EA	European Academy
EC	European Commission
ECHOES	Energy CHOices supporting the Energy Union and the Set-Plan
ECRA	European Climate Research Alliance
EERA	European Energy Research Alliance
EGRD	Experts' Group on R&D Priority Setting and Evaluation
EPA	Environmental Protection Agency
ESOM	Energy system optimization models
EU	European Union
GDP	Gross Domestic Product
HER	Home Energy Report
IEA	International Energy Agency
IERC	International Energy Research Centre
ISI	Institute for Systems and Innovation Research
ISSC	International Social Science Council
JYURI	Jyukankyo Research Institute
METI	Ministry of Economy, Trade and Industry
NGO	Non-Governmental Organization
PERSON	Platform for Energy Research in the Socio-economic Nexus
SCADA	Supervisory Control and Data Acquisition
SCCER	Swiss Competence Centres for Energy Research
SDG	Sustainable Development Goal
SEAI	Sustainable Energy Authority Ireland
SHEDS	Swiss Household Energy Demand Survey
SSH	Social sciences and humanities
TCP	Technology Collaboration Programmes
TRL	Technology readiness levels
VTT	Technical Research Centre of Finland

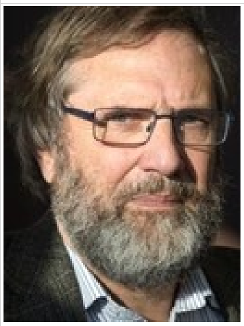
Appendix B. Speakers and moderators

	**Dr Katrine Krogh Andersen** is the Dean of Research and the Senior Vice-President at the Technical University of Denmark (DTU), where she strengthens the DTU's ability to attract external research grants and helps to coordinate and promote the University's research-related activities. Previously she was the Director of Research and Development at the Danish Meteorological Institute (DMI). Her career also includes research on climate modelling, statistical data analysis and ice-core drilling at the Niels Bohr Institute, and preparations for the 2009 UNFCCC Conference of the Parties (COP15) for the Ministry of Climate and Energy. Katrine is a Member of the Danish Council for Research and Innovation Policy, a member of the Danish Academy of Technical Sciences, Programme Board member of the Norwegian Research Council, and member of the Executive Committee of the European Energy Research Alliance. Katrine holds has a PhD in physics (University of Copenhagen).
	**Dr Birte Holst Jørgensen**, Technical University of Denmark, is Vice-chair of the IEA EGRD. She is an experienced researcher and practitioner in the field of new energy technologies and systems, where she has specialised in energy R&D strategies and technology policies at the national, European and international levels. She is Principal Coordinator in sustainable energy at the Sino-Danish Centre for Research and Education, a strategic co-operation between Danish universities, the Danish Ministry of Science, Technology and Innovation, and the University of the Chinese Academy of Sciences and the Chinese Academy of Sciences. Dr Jorgensen holds an MSc in Business Economics from the Copenhagen Business School and a PhD in Political Science from the University of Copenhagen.
	**Anders Hoffmann** is Deputy Permanent Secretary at the Danish Ministry of Energy, Utilities and Climate, where he oversees the areas of national power markets, telecommunications, digitalization, government-to-government cooperation on energy, membership of multilateral organizations such as the IEA, export promotion, and affairs related to the Arctic. Previously he held several leadership roles in the Danish government, including as Deputy Director General of the Danish Business Authority, and Deputy Director General of the Danish Business and Construction Authority. Other relevant posts include Creative Director of FORA and a Senior Economist at the Organization for Economic Co-operation and Development (OECD). Dr Hoffmann holds a PhD. in Economics from the University of Copenhagen.

Dr Atsushi Kurosawa is Director, Global Environmental Program, Research and Development Division, Institute of Applied Energy (IAE), where he has led many energy- and environment-related projects. Currently his research focuses on integrated assessments of global climate change and energy R&D strategy through the integrated assessment model GRAPE and TIMES-Japan model. He has held visiting positions at Stanford University and the Research Institute of Innovative Technology for the Earth. He also serves as a Visiting Professor at Kyushu University, a Lecturer at the Tokyo University of Agriculture and Technology, a Visiting Researcher at the Japan Science and Technology Agency, a Fellow of the New Energy and Industrial Technology Development Organization, and a Visiting Researcher at the University of Tokyo. He holds a B.S. in Nuclear Engineering from Nagoya University, an M.S. in Nuclear Engineering from the Tokyo Institute of Technology, and a PhD. in Electrical Engineering from the University of Tokyo.

Sea Rotmann is CEO of Sustainable Energy Advice, which focuses on translating behaviour change theory into (global) best practice. Sea is also the Operating Agent for the project "Closing the Loop. Behaviour Change in Demand-side Management: From Theory to Practice" for the IEA Technology Collaboration Programme (TCP) on Demand Side Management (DSM TCP). Previously Dr Rotmann was the Principal Scientist and Research Team Manager for the New Zealand Energy Efficiency and Conservation Authority, and held several positions implementing sustainability practices in the fields of energy efficiency, Green Star standards for commercial buildings, carbon-neutral public-service goals, carbon footprints, sustainable procurement and transport. Dr Rotmann holds a PhD in environmental impact assessment.

Thijs Bouman is a Researcher in Social and Environmental Psychology at the Faculty of Behavioural and Social Sciences, University of Groningen (the Netherlands). His research focuses on how personal and group factors affect environmental behaviour and beliefs. He also investigates how technological innovations could be used to motivate and promote pro-environmental behaviour among citisens and studies the interaction between smart technologies and consumers. Thijs also works as a Research Advisor for the European Commission's DG ENER and collaborates with various private and public partners on energy- and sustainability-related issues. He has worked as a lecturer at the Windesheim University of Applied Sciences and holds a PhD on the influence of threatening global situations on local intergroup relations, a Master's Diploma in Social Psychology and Social Sciences, and a Bachelor's of Science in Social Psychology, all from the University of Groningen.

	**Bert Droste-Franken** is Head of the Energy Department at the EA European Academy of Technology and Innovation Assessment GmbH, a scientific academy with thematic focus. Bert has more than twenty years of experience with energy-related issues, including assessments of environmental impacts and damage costs, sustainability and welfare indicators, integrated assessment modelling, model integration, technology assessments, energy system analyses for policy support, and innovation assessments in many national and international inter- and trans-disciplinary projects. Previously he was researcher at the Institut für Energiewirtschaft und Rationelle Energieanwendung (IER), Universität Stuttgart. Bert holds a Diploma in Physics from Universität Heidelberg, an External Thesis at the Max Planck Institute, Heidelberg (Atmospheric Physics Group) and a PHD in Engineering Science from Universität Stuttgart.
	**Rob Kool**, Chair of the IEA Experts' Group on R&D Priority Setting and Evaluation, is Interim manager at the Netherlands Enterprise Agency (RVO.nl). Rob has over thirty years of experience with a broad range of topics in the energy field, such as municipal energy policy, the design of new efficient suburbs, district heating, the built environment, joint implementation, CDM and leading international collaboration projects. Rob has had leadership roles in many international fora, including the Association of European Energy Agencies (EnR), as Vice-President of the European Council for Energy Efficiency. He is the Chair of the IEA Demand-Side Management TCP. Rob holds a business degree from the Netherlands Business School and a degree in biology from the University of Utrecht.
	**Dr Matthew Kennedy** is Head of Strategy and Business at the International Energy Research Centre, an Irish Government-supported, industry-led, collaborative energy research centre. He was previously the responsible National Delegate (Energy) for H2020 for Ireland and led Energy R&D for the Sustainable Energy Authority of Ireland. Matt was the lead EU Negotiator for technology transfer at COP21 UNFCCC and was a member of the UNFCCC Technology Executive Committee (TEC). He was also Chair of the UN's Climate Technology Centre, Chair of the IEA's Renewable Energy Technology Deployment Implementing Agreement and Chair of the Programme Board of the Renewable Energy and Energy Efficiency Partnership (REEEP). Matt holds a PhD in Engineering from Trinity College Dublin and Masters' degrees from NUI Galway and University College Dublin.
	**Ruth Mourik** is CEO of DuneWorks, a private research company. Projects she has worked on include projects on energy and behavioural change and new business models for the International Energy Agency Demand Side Management Programme, several FP7 and H2020 projects (UseITsmartly, Nature4Cities, DrBoB, ShapeEnergy), as well as more grounded projects with residents, housing corporations and municipalities. Previous employers include Maastricht University, Eindhoven Technical University and the Energy Research Centre of the Netherlands (ECN). Ruth has Masters in Anthropology, Sociology and Society and Technology Studies (STS), and holds a PhD in systemic technological and societal transitions.

Tiina Koljonen leads the Energy Systems and Climate research team at VTT Technical Research Centre of Finland Ltd. She has more than twenty years of experience in developing and analysing future energy systems and clean energy technologies on the national, Nordic, EU and global levels. She supports the Finnish Government and the EU in formulating and analysing effective energy, climate, and innovation strategies and policies. She has also coordinated several multidisciplinary national and international projects to improve the integration management of road-mapping processes and transition management to energy policy and business analysis. Currently her research interests focus on the analysis of human behaviour in energy system transitions. Ms. Koljonen holds a Master's degree from the Helsinki University of Technology and has studied energy economics, environmental impact assessment and systems analysis.

Karl Purcell is the Programme Manager for the Behavioural Economics Unit for the Sustainable Energy Authority Ireland (SEAI), which aims to improve the energy behaviour of Irish businesses and households by embedding behavioural economics in the communications and policies designed by the SEAI. Previously Karl worked in the Irish Department of Public Expenditure and Reform applying behavioural economics to public policy-making. He has published a number of papers on these topics, including "Exploring the personality profile of the 'green consumer': explaining individual heterogeneity in willingness to pay for environmentally friendly goods". He is an active member of the Irish Behavioural Science and Policy Network. Karl holds an Honours Bachelor's Degree in Business Studies (Finance) from Dublin City University and an MSc in Behavioural Science for Management from the University of Stirling.

Carrie Pottinger, IEA Programme Manager, Technology R&D Networks, oversees a vast network of 6,000 experts participating in the forty international R&D groups (Technology Collaboration Programmes, or TCPs). Carrie has more than 25 years cumulative energy knowledge and experience of analysis, particularly in the areas of energy statistics, energy policies and technology and R&D, including leading or contributing to 30 published works. She currently serves as Secretary to R&D-related groups, including the IEA Experts' Group on R&D Priority-Setting and Evaluation, the Fusion Power Co-ordinating Committee, and the Working Party on Energy End-Use Technologies. She has also designed and led evaluation and review processes for the international collaborative groups on behalf of the Committee on Energy Research and Technology. Ms. Pottinger holds a degree in Communications from the University of Washington and has studied economics, data analysis and price forecasting.

Dr Johannes Tambornino is the head of the Energy Strategies and Systems Analysis Unit at Project Management Jülich, where he is responsible for the R&D program on energy systems analysis funded by the German Ministry of Economic Affairs and Energy. He is leading a group that covers a broad range of topics along the energy innovation chain and currently serves as the German representative in the IEA Experts' Group on R&D Priority Setting and Innovation. He holds a PhD in Mathematical Physics and has actively pursued research in quantum gravity and cosmology at different laboratories in Canada, France and Germany before changing fields and devoting his time to energy-related issues.

Dr Benjamin K. Sovacool is Professor of Energy Policy at the Science Policy Research Unit (SPRU), University of Sussex (United Kingdom), where he serves as Director of the Sussex Energy Group and Director of the Centre on Innovation and Energy Demand, which also involves the University of Oxford and the University of Manchester. He is also Director of the Centre for Energy Technologies and Professor of Business and Social Sciences at Aarhus University (Denmark). Prof. Sovacool's work focuses on issues pertaining to energy policy, energy security, climate change mitigation, and climate change adaptation. More specifically, he works on renewable energy and energy efficiency, the politics of large-scale energy infrastructure, designing public policy to improve energy security and access to electricity, and building adaptive capacity to the consequences of climate change. He has held positions at the Vermont Law School, National University of Singapore and Oak Ridge National Laboratory.

Dr Elisabeth Dütschke is a senior scientist and project leader at the Fraunhofer ISI, where she focuses on technology acceptance, chances and barriers to energy efficiency, evaluation studies, and qualitative and quantitative methods. Outside academia she has carried out consulting for private and public organisations and journalism. Post-doctoral positions she has held include as a research associate at RWTH Aachen and a research associate and lecturer at Universität Konstanz. Elisabeth holds diplomas in psychology, business administration and marketing (TU Darmstadt and RWTH Aachen respectively) and a PhD summa cum laude from Universität Konstanz. She was also granted an award by Südwest Metall.

Dr Ji Xuan is a researcher at the Jyukankyo Research Institute (JYURI), where she focuses on energy consumption field surveys in the residential and commercial sectors, behavioural aspects of energy efficiency, and other topics. Since 2014, her work has focused on the field studies of household energy use in Southeast-Asian countries. Dr Xuan is one of the main staff members of the organising team for the annual Behaviour, Energy and Climate Change Conference of the Energy Conservation Council. She holds a Bachelor's degree in Architectural Environmental Engineering from the Jilin Institute of Architecture and Civil Engineering, China, and a Master's degree and PhD in Architectural Environmental Engineering from the University of Kitakyushu, Japan.

Daniel Latzer is a researcher and PhD candidate at the Centre of Regional Science at Vienna University of Technology, where he currently coordinates the research project E_PROFIL, which investigates energy-related transformation processes at the neighbourhood level (funded within the City of Tomorrow programme). In Daniel's previous positions he was responsible for urban and regional planning in Austria. His core competencies include regional and communal analysis, geographical information systems, development planning, energy and environmental planning, and public participation. Daniel also works as lecturer in the field of energy issues in planning at the Vienna University of Technology. He holds diplomas in Engineering for Spatial Planning from the Technical University of Vienna.

	**Lieven Stalmans** is a member of the European Chemical Industry Council. He joined Borealis in 2000 and became responsible for the energy-efficiency programme at the Borealis plants in Belgium in 2003. This responsibility further extended into the areas of CO_2 emissions trading and energy sourcing. Since 2009 he has been Group Manager, Energy and Environment, for Borealis. Lieven is active in associations on the national and European levels, in particular on the European Chemical Industry Council or CEFIC. He is Co-Chair of CEFIC's Energy and Climate Strategy Working Group and Chairman of the Working Party on Energy within the Flemish Chemical Industry Association, essenscia. He holds a Master's Degree and a PhD in Chemical Engineering from Leuven University, Belgium.
	**Matthew Lipson** is Head of Consumer Insight at the UK's Energy Systems Catapult (ESC), helping bring industry, academia and government together to accelerate the development of successful low-carbon energy products, services and policies to enrich peoples' lives. Matthew started his career working in small tech start-ups and Orange and has spent the last decade working with universities and businesses for the UK's Department of Energy and Climate Change, Committee on Climate Change and Energy Technologies Institute. He is currently focusing on harnessing the emerging 'smart' connected home to decarbonise home life. Matthew holds a BSc in Psychology from Sheffield University, an MSc in Environmental Technology from Imperial College and a PhD in Neuroscience from Oxford University.
	**Dr Herbert Greisberger** is the Managing Director of the Lower Austrian Energy and Environment Agency, where his projects focus on energy and innovation with a special focus on sustainable buildings and renewables. Dr Greisberger is also Scientific Manager of the Austrian Futurelab focusing on long-term developments and their consequences for society. He was formerly the Senior Scientist on R&D, innovation and energy technologies for the Austrian Energy Agency and the Austrian Society for Environment and Technology. He is also a Lecturer at the Institute for Research and Education focusing on energy economy and energy management. Dr Greisberger studied economics at the Universities of Graz and Vienna) and holds a PhD from the University of Stuttgart.
	**Dr Erik Phil** is the Research Liaison Officer at the Sweden Hub of Future Earth, based at the Royal Swedish Academy of Science, where his research focuses on decarbonising the energy system, mainly through the optimization of concentrating solar power and biomass energy power plants. As an expert on concentrating solar power, he has acted as the Swedish representative in work for the European Academies Science Advisory Council. His strong technical background is complemented by a diverse set of experiences, such as contributing to marine biological research, local politics, NGOs, and as TEDx speaker. He studied Environmental Engineering at Lund University and holds a PhD from the Chalmers University of Technology.

	**Dr Annika Sohre** is a postdoctoral researcher at the Sustainability Research Group, University of Basel, where she works on governance issues in the fields of individual behaviour in respect of energy consumption, sustainable development, energy transition, mobility and climate change for the Swiss Competence Centre for Research, Society and Transition (SCCER-CREST). Currently she works in interdisciplinary teams in different larger research projects such as the Swiss Household Energy Demand Survey (online surveys and experiments), which provides insights for developing successful intervention strategies. Previously she held positions as a consultant for energy policy at EnBW AG and as a project researcher at the Free University of Berlin. She holds a Diploma in Environmental Sciences from the University of Lüneburg and a PhD from the Free University of Berlin.
	**Gerd Schönwalder** is the Policy Officer for Strategy at the European Commission. He holds a PhD in Political Science for a thesis on "Activities and Societies: Fellows' Coordinator at Centre for Developing Area Studies (CDAS)". He is an experienced researcher, research manager and strategy developer. His background involves innovation support, scientific diplomacy, international development, public engagement and grant-making. He has work experience in the International Development Research Centre (IDRC) and the University of Ottawa.

Appendix C. Agenda

DAY 1. Thursday, 12 October 2017, Room S01

Session 1. Introduction			
Chair: Birte Holst Jorgensen			
9.00	1	Welcome	Katrine Krogh Andersen, Dean of Research, Senior Vice President, DTU
9:15	2	Introduction	Rob Kool, Chair EGRD, Netherlands Enterprise Agency
9:30	3	Accelerating energy technologies in the Danish context	Anders Hoffmann, Deputy Permanent Secretary, Ministry of Energy, Utilities and Climate
Session 2. Setting the scene			
Session moderator: Atsushi Kurosawa			
10:30	4	Behaviour change research collaboration: insights, tools and results	Sea Rotmann, CEO, Sustainable Energy Advice
11:00	5	What drives energy consumers?	Thijs Bouman, Faculty of Behavioural and Social Sciences, University of Groningen
11:30	6	Multi-perspective system analyses for robust energy decision support	Bert Droste-Franken, Head of Energy Department, EA European Academy GmbH
12:00	Discussion		
Session 3. Human-centred analytics to enhance policy effectiveness			
Session moderator: Rob Kool			
13:30	7	What do people want from (low-carbon) heat at home, and how do we find out?	Matthew Kennedy, International Energy Research Centre
14:00	8	Business models for a more effective market uptake of DSM energy services	Ruth Mourik, DuneWorks B.V.
14:30	9	Impacts of energy choices: examples of research approaches with quantitative data collection and analysis	Tiina Koljonen, Research Team Leader, VTT Technical Research Centre of Finland
15:30	10	Applying Behavioural Economics to Move to a More Sustainable Future	Karl Purcell, Programme Manager, Behavioural Economics Unit, Sustainable Energy Authority Ireland (SEAI)
16:00	11	Influencing Business Behaviour and Decision-Making to Improve Energy Efficiency	Carrie Pottinger, Programme Manager, Energy Technology R&D Networks, IEA
16:30	Discussion		
17:00	Close Day 1		

17:00 Visit to EnergyLab Nordhavn (http://www.energylabnordhavn.dk/)

DAY 2. Friday, 13 October 2017, Room S02

Session 4. The consumer at the centre of a distributed energy system			
Session moderator: Johannes Tamborino			
9:00	12	Energy for society	Benjamin Sovacool, University of Sussex and Aarhus University (virtual)
9:30	13	The consumer at the centre of a distributed energy system	Elisabeth Düttschke, Fraunhofer ISI
10:00	14	Residential behaviour-based energy efficiency programmes and activities in Japan	Ji Xuan, Jyukankyo Research Institute
11:00	15	City of Tomorrow (E_PROFIL): neighbourhood profiles for optimised energy transformation processes	Daniel Latzer, Doctoral Researcher, Technical University of Vienna
11:30	16	Behaviour and decision-making concerning energy efficiency in the chemical industry	Lieven Stalmans, Borealis, Co-Chair, European Chemical Industry Council (CEFIC)
12:00	17	What do people want from (low carbon) heat at home and how can we find out?	Matthew Lipson, Head, Consumer Insight, Catapult
12:30	Discussion		
Session 5. R&D policies and decision-making			
Session moderator: Herbert Greisberger			
14:30	19	Knowledge-action networks	Erik Pihl, Future Earth Stockholm
15:00	20	R&D policies and programmes with (and for) citisens	Swiss Centre for Excellence for Energy, Society and Transition (CREST)
16:00	18	EU: the role of behaviour past Horizon 2020	European Commission
Session 6. Summary and workshop close			
Chair: Birte Holst Jorgensen			
16:00	Final discussion		
16:30	Wrapping up		

Appendix D. Participating organisations

Organisation	Country
University of Vienna	Austria
Lower Austrian Energy and Environment Agency	Austria
European Chemical Industry Council (CEFIC)	Belgium
European Commission Joint Research Centre (JRC)	Belgium
Ministry of Energy, Utilities and Climate	Denmark
Technical University of Denmark (DTU)	Denmark
VTT Technical Research Centre of Finland	Finland
International Energy Agency	France
EA European Academy GmbH	Germany
Fraunhofer ISI	Germany
Project Management Jülich	Germany
International Energy Research Centre	Ireland
Sustainable Energy Authority Ireland (SEAI)	Ireland
ENEA	Italy
University of Sienna	Italy
Jyukankyo Research Institute	Japan
Institute of Applied Energy (IAE)	Japan
DuneWorks B.V.	Netherlands
Netherlands Enterprise Agency (RVO)	Netherlands
University of Groningen	Netherlands
Sustainable Energy Advice	New Zealand
Future Earth Stockholm	Sweden
Swiss Centre for Excellence for Energy, Society and Transition (CREST)	Switzerland
University of Sussex	United KIngdom
Catapult	United Kingdom