IRGC Project Work

Risk Governance of Energy Transitions

Demand Anticipation and Consumer Behaviour

This note describes the purpose and objective of IRGC's work to facilitate energy transitions.

Update of original note of August 2014

Summary

Many institutions work to facilitate the transition to more sustainable, efficient and affordable energy systems. Most of their work predominantly focuses on the supply side, i.e., understanding the needed generation and distribution infrastructure, operation and policy needs. However, it is widely acknowledged that acting on the demand side also provides opportunities for overall improvement of long-term energy sustainability. But instruments and processes for demand-side management have so far received less attention and resources than its supply side counterparts. For example, experts highlight the need to expand research on consumer behaviour such as energy technology choices and patterns of consumption.

In view of IRCG's role as an independent authority synthesizing research, IRGC aims to make a valuable contribution to the understanding of how to develop and implement the management of demand-side of the energy transitions. More specifically, IRGC emphasises the need to explore opportunities and challenges at the technical, behavioural, policy, and the governance levels taking into account long-term energy demand dynamics.

The overarching goal of the project is to provide recommendations that help policy makers and the private sector craft and implement robust policies and strategies to:

- slow down any unsustainable increase in energy demand, especially when it is associated with high levels of CO_2 emissions and other pollutants that have large health and environmental effects;
- develop energy efficiency and sufficiency strategies that are truly consumer-centric and which consumers would choose to implement, for example, because it does not involve sacrificing personal well-being or quality of life;
- unlock more of the opportunities afforded by the demand-side of the energy equation; and
- provide leadership in the transition (drawing lessons from past transitions as well as from contemporary examples such as Germany and the US States of California and Vermont).

Elaborating on research work conducted by its scientific partners, the Helmholtz Alliance Energy-Trans, the German National Academies (specifically, the Ensys project), Carnegie Mellon University's Center on Climate and Energy Decision Making, and EPFL's Energy Center, and based on a review of literature and current debate, as well as discussions at a workshop organised in November 2013 about "*Governance of energy transition: dealing with uncertainty in energy scenarios, and communicating and understanding consumer behaviour*,"[1] IRGC articulates its contribution on five main topics, namely:

1. Improving methods to assess future energy demand
2. Evaluating the potential of demand response programmes to add flexibility to the demand side
3. Understanding and assessing consumer behaviour
4. Facilitating consumer behaviour change and improving policy decision
5. Managing transition processes

Some of these topics are addressed in dedicated workshops, each preceded by a background paper produced by the IRGC in collaboration with the academic institutions and selected participants. Participants are selected on the basis of their expertise in the field. The workshops are also attended by IRGC sponsors, who can thus benefit from engaging with a diverse pool of experts from academia, industry and policy/governmental agencies. Workshop reports are published and widely disseminated.

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Energy transitions: demand anticipation and consumer behaviour

Motivation

Globally, the transition towards more sustainable and less fossil-fuel intensive energy systems is made possible by technological advances and resource availability, but nuanced with considerations of national energy security, and competitiveness priorities. Deficient governance of energy systems could jeopardize both national and global economic prosperity. While political will and public acceptance are essential, so too is a clear-eyed assessment of the likely cost, performance and scalability of future strategies and alternatives.

Many institutions, including the International Energy Agency (IEA), the World Energy Council (WEC), the European Commission (EC) and national governments work to facilitate the transition to more sustainable, efficient and affordable energy systems, in particular in light of addressing climate change issues and curbing the unsustainable increase in energy demand. However, this work predominantly focuses on the supply side of the energy system. Figure 1 shows the world primary energy flow from sources to services, highlighting the extremely large task that will be required globally to transition to a sustainable, affordable and low carbon energy system. International and national organisations that help policymaker better deal with energy related challenges and design energy policies primarily work on energy generation and distribution. They recognize that acting on the demand side includes potential opportunities for overall improvement of long-term energy sustainability, but instruments and processes for doing it are less common. For example, experts highlight the need to expand research on consumer behaviour to better understand barriers to the adoption of energy efficiency technologies, measures and strategies (for example, issues such as the rebound effect were reviewed in IRGC's report "The rebound effect: implications of consumer behaviour for robust energy policies."[2]

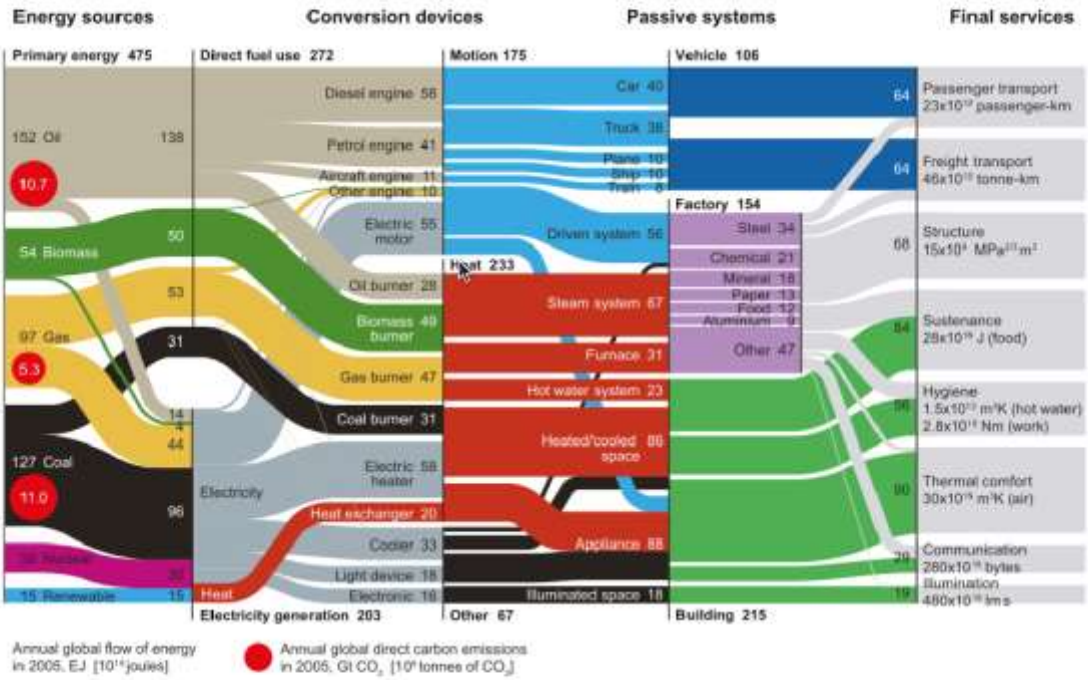

Figure 1: World energy flow diagram in 2010, in primary energy by energy source and final services. Source: Cullen. & Allwood (2010)

In view of IRCG's role as an independent authority synthesizing research, IRGC aims to make a valuable contribution to inform the management of the demand-side of the energy transition. Specifically, IRGC addresses issues related to anticipation of the energy demand, mechanisms to add flexibility to energy demand, consumer behaviour and dynamic of the energy transition.

Objective and focus of IRGC work

Given the need for energy policies to address the demand side (such as energy efficiency technologies, measures and behaviour-strategies to reduce or adapt energy demand) in addition to the supply side (such as shifting the mix from fossil fuels to renewables), IRGC explores the technical, behavioural and the governance opportunities and challenges of demand-side management, and energy efficiency and conservation, in the context of current waves of energy transitions.

In line with IRGC's mission, the overarching goal of the project is to provide recommendations that help policy makers and the private sector craft and implement robust policies and strategies to:

- Slow down the unsustainable increase in energy demand, especially when it is associated with high levels of CO_2 emissions and other pollutants that have large health and environmental effects;
- Revise business models and regulatory frameworks to create the right incentives;
- Develop energy efficiency and sufficiency strategies that are truly consumer-centric and which consumers would choose to implement, for example, because they do not impede personal well-being or quality of life;
- Unlock more of the opportunities afforded by the demand-side of the energy equation; and
- Provide leadership in the transition (drawing lessons from past transitions as well as from contemporary examples such as Germany and the US States of California and Vermont).

IRGC's work elaborates from research work conducted by its scientific partners -and in particular the Helmholtz Alliance Energy-Trans and Carnegie Mellon University at the Department of Engineering and Public Policy-, from a review of literature and current debate, and from discussions at a workshop organised by IRGC and the EPFL Centre for Risk Analysis and Governance (CRAG) on 21 November 2013 about "Governance of energy transition: dealing with uncertainty in energy scenarios, and communicating and understanding consumer behaviour".

IRGC articulates its contribution in work packages as described below.

IRGC work on energy transitions

1. Improving methods to assess future energy demand

Goal: *Help relevant authorities select relevant tools – forecasting methods and different types of scenarios – for better demand anticipation and better planning for energy transitions.*

Most past energy forecasts have failed to anticipate correctly the evolution of energy consumption.[3] This is not surprising since there are sources of uncertainty within the models used to make scenarios and predictions, as well as fundamental changes in policy or other exogenous drivers that may change the level of energy demand. Yet, "people persist in making deterministic forecasts when it is very clear that such forecasts are often close to meaningless."[4]

However, *some* information and models are needed in order to inform and guide policy makers. Since understanding and anticipating future energy demand is critical for managing the many transitions needed to move towards a sustainable and affordable path, the following questions need to be asked:

- What improvements can be made in the understanding of fundamental components of the energy demand for planning future needs, and in the assessment of associated uncertainties?
- How can national policies better account for future energy needs and demand and their associated uncertainty?
- How can different scenarios – such as trend-extrapolating scenarios, large scale models of the economy (such as general equilibrium models), exploratory scenarios and backcasting scenarios[1] – be used, whether singly or jointly, to improve planning for energy transitions?

For more details, see Appendix A.1

The outcome of a workshop organised in October 2014 and further literature review is available as an IRGC concept note: ASSESSMENT OF FUTURE ENERGY DEMAND - A methodological review providing guidance to developers and users of energy models and scenarios.

2. Opportunities and challenges of demand response

Goal: *Evaluating and unlocking the potential for demand response programmes*

The rapid pace of technological advancement as well as regulatory and societal changes in the context of energy transitions are influencing the way electricity is generated, distributed and consumed. In particular, additional flexibility is expected to be provided by the demand side. Demand-side flexibility requires that end-users adjust consumption in response to fluctuating supply, rather than the other way round. The integration of smart grids, smart meters, flexible appliances and decentralized electricity generation and storage provides an opportunity to rethink how electricity is produced, distributed and consumed.

[1] IRGC refers to the concept of "backcasting" as a strategic approach for long-term planning. It involves imagining a particular successful outcome in the future, comparing the envisioned future with the present and finally identifying the necessary steps to achieve the objective.

"Demand response" is a "mechanism to adapt electricity demand to grid conditions or in response to market prices". Objectives are complementary to energy efficiency improvement, with a view to enhance the electric system's capacity to cope with increasing demand (e.g. due to electrification of transportation), rising costs of conventional transmission and distribution grids, and increasing share of intermittent renewable energy (solar and wind).

Various countries in the world consider or implement demand response programmes, as activities that hold the potential to facilitate the transition towards sustainable energy systems. IRGC and the Energy Center at EPFL aim to shed light on the following questions:

- Is it worth engaging in demand response programmes?
- Is adding flexibility on the demand side a viable alternative to additional generation capacity?
- If so, how to successfully deploy demand response programmes?
- How to assess and manage the risks involved?

Work will emphasise the importance of four themes and their alignment:

- Quantification of possible gains from demand response activities
- Revision of regulatory frameworks
- Active and sustained consumers engagement
- New business models.

A public international conference and invitational workshop will be organised on 10-11 September 2015, at EPFL, Lausanne.

3. Understanding and assessing consumer behaviour

Goal: *Understand consumer behaviour for improving energy choices and energy saving behaviours*

Consumer behaviour change is critical for successful energy transitions, in which governments, industry and opinion leaders, together, will suggest strategies to achieve new and more sustainable consumption patterns. To this end, we need to understand better how consumers behave and respond to price signals, information, advertising, and several other stimuli, such as incentives and regulation. More understanding is needed from researchers and more attention is needed from policy makers, in particular to clarify the causes and prevalence of the energy efficiency gap. The energy efficiency gap is the difference in energy consumption that we see occurring versus the level of energy consumption that would occur if consumers were to adopt all the technologies and strategies that provide the same level of energy services, but at a lower cost.

IRGC and its academic partners seek to:

- Identify the key barriers that prevent consumers in different countries from adopting energy efficient technologies and measures;
- Clarify the key issues that prevent the energy efficiency gap from being closed;
- Map programs and policy designs that have had the most success in the past

See Appendix A.2: "Understanding and Assessing Consumer Behaviour"

4. Facilitating consumer behaviour change and improving policy decision

Goal: *Identify evidence-based adaptive interventions and strategies – policies, regulations, incentives and nudging – for managing consumer behaviour and improving the performance of policy decisions*

Behavioural economists indicate that it may be possible, under certain conditions, to trigger more effective changes in how end-consumers modify their consumption patterns in ways that are more compatible with goals of efficiency and sustainability (Dietz et *al*., 2013). For instance:

- In addition to benefiting electric utilities in load-balancing, the development and use of smart meters may improve consumers' awareness and assist consumers in better managing their consumption. Experience in developed countries however has shown that the actual benefit of using of smart meters is often limited. Specifically, changes in price – such as time-based pricing – have a relatively small effect on the quantity and time of electricity consumption (Gilbert & Graff Zivin, 2013; but see also, Gans et *al*., 2011). Behavioural psychologists, on the other hand, highlight the difficulties of triggering and sustaining long lasting changes in environmental behaviour (Schwartz et *al*., 2013).
- Some countries have developed "energy calculators", that be used to communicate with consumers important information regarding the consequences of their own consumption, as well as better inform decision makers and therefore improve decisions.

IRGC intends to discuss the design of appropriate information tools, instruments and incentives, as well as creative and socially rewarding approaches that are required to engage with consumers. Interdisciplinary and collaborative research is needed to investigate how energy customers can effectively be actors (instead of subject) of the transformation of the energy system. At this point three professional communities are working separately on the opportunities and limitations of influencing consumer behaviour:

- Behavioural economists stress the importance of monetary and more symbolic incentives for sustaining or changing behaviour;
- Behavioural psychologists stress the importance of information, insights and identification of opportunities for making people more cognizant and ready to change their behaviour;
- Behavioural social scientists stress the importance of contextual factors such as social recognition, symbolic gratifications, and situational constraints in shaping the conditions for individuals to deliberate or choose alternative options for their own actions.

Of special interest is the newly developed field of "nudging," which combines situational structuring with individual choice behaviour. These three traditions in behavioural research can be combined, for improving energy demand management.

See Appendix A.3: "Facilitating Consumer Behaviour Change and Improving Policy Decision."

5. Managing transition processes ("Governing energy transitions")

Goal: *Learn lessons from past energy transitions on issues such as political leadership, economic drivers, public participation and acceptance as well as supply side drivers.*

Transitions always come along with destabilisations, which, if not adequately managed, may lead to deep perturbation in the economy and society. For example, there are fears that European utilities may be threatened by the transition, having just gone through the deregulation process, which has weakened many of them.[5] In certain cases, radical shifts may be needed. A clear-eyed assessment of the likely cost, performance and scalability of future strategies and alternatives is essential if public support for energy transition policies is to continue and grow, and not erode.

See Appendix A.4: "Governing Energy Transitions".

Organisation and Work Process

IRGC Project leaders

- Prof. Inês Azevedo and Prof. Granger Morgan (Carnegie Mellon University)
- Prof. Ortwin Renn (Stuttgart University and Helmholtz Alliance Energy-Trans)

Contributing partners from the IRGC academic network

- Helmholtz Alliance Energy-Trans
- Acatech: National Academy of Engineering and Science, Berlin
- Stuttgart University
- Carnegie Mellon University (Department of Engineering and Public Policy and the Centre for Climate and Energy Decision Making)
- EPFL, Energy Center

When needed, additional expertise is sought from leading institutions in the field. While IRGC partners do the research work, the IRGC secretariat organises the international facilitation and the dissemination of the project outcome to decision makers.

Countries

Work focuses on the following countries:

- Germany
- Switzerland
- France
- United Kingdom
- USA (at federal level as well as some state-level)

Outcome

Workshop reports are published after each workshop. A concluding policy brief will summarise the main policy recommendations for energy strategies that account for the need to act on demand and consumer management.

Appendix A

A.1. Energy Transition Scenarios: Improving Methods to Assess Future Energy Demand

1. Motivation

Scenario development and scenario planning have been used in various contexts and sectors, with various objectives and for various purposes. In the field of energy, it is commonly used to better anticipate the energy production, demand, energy mixes or CO_2 emissions. A workshop organised in October 2014 discussed ways to improve the design of energy models and scenarios that combine quantitative and qualitative information, include institutional, social and behavioural aspects and can be used to develop action plans to meet a desirable objective (“backcasting”).

2. Background: Scenario Planning

Scenario **planning** implies planning for the future. In the context of the Energy Technology perspective, the International Energy Agency (IEA) defines scenario planning as both a forecasting and backcasting exercise. This includes the description of important factors that will impact on the future, as well as ways to reach a certain desirable outcome such as a specific reduction rate of greenhouse gas emissions in the year 2050. Scenario planning is useful and important whenever there is high complexity and high uncertainty (Peterson, Cumming & Carpenter, 2003) as in the case of major transformations of energy systems. In the course of developing and analysing scenarios, it is important to distinguish between *high impact* factors which are *highly predictable*—that is, **trends** that have clear development trajectories in all scenarios and high impact factors with *low predictability*—that is, **critical uncertainties** that have several possible outcomes and vary across scenarios. It is also important to identify the level of confidence about these evaluations.

Traditional **forecasting** approaches—based on current trend analysis and projections—can be of limited value for highly complex, sophisticated and interconnected systems laden with critical uncertainties, though they may turn out to provide more accurate projections in the short or near terms. Scenario planning aims instead to define steps needed to attain an envisioned future desired outcomes.

Exploratory scenario **development** refers to a process of looking to the future and developing possible stories about how the future may unfold. Scenarios often represent combinations of formal models and plausible narratives. Depending on the topic and the state-of-the-art of available knowledge, scenarios differ in the composition of formal modelling and storytelling. Some scenarios pursue well-known causal or functional relationships and vary only in their assumptions. In contrast, others develop imaginative futures based on basic knowledge, formal logic and plausibility. Almost all scenarios include methods for involving multiple actors and factors in describing what the future could look like. For example, the "Shell Scenarios," which are described in more detail below, ask “what if?” questions to explore alternative views of the future and create plausible stories around them. They consider long-term trends in economics, energy supply and demand, geopolitical shifts and social change, as well as the motivating factors that drive change. In doing so, they help build visions of the future. This is an open process and the resulting output represents the views of the participants.[6]

3. Three classes of scenarios

Philip Vergrat and Jaco Quist (2011) describe three classes of scenarios, in the context of using future studies for sustainability:

• The first class of scenarios are trend-extrapolating scenarios (what *will* happen?) and are also often called business as usual (BAU) scenarios. In those scenarios, "it is assumed that no major changes occur, and that societies and cultures develop accordingly to a continuous path from the past towards the future." These scenarios are useful if trends of the past can easily be detected and there is no reason to believe that context factors will change in the future. An example may be the projection of electricity demand in the United States in the coming year. These sort of trend-extrapolation scenarios are not suitable to cope with key events that may lead to dramatic changes in the system. For example, they may not be able to capture the effects associated with new energy policies, or economic shocks.

While these scenarios are widely used, Morgan and Keith (2008) caution that they sometimes lead users to place too much confidence in specific details of how the future may unfold, and do not do an adequate job of conveying uncertainty.

• The second class of scenarios includes exploratory scenarios to reveal possible challenges and undesired pathways and, thus, stimulate the discussion and analysis about critical events, monitoring requirements and actions plans in order to avoid undesired, but possible developments. They are based on a selection criterion for designing alternative futures (what *could* happen?). Such selection criteria include: worst/best case scenarios, scenarios facing a variety of context changes or surprises, probability-driven scenarios, or scenarios driven by the imagination for the possible but unlikely developments. This class of scenarios can be well illustrated by the scenarios that Shell has been producing since the 1970's: "Shell scenarios are contextual (to the company) and create a number of possible worlds in which Shell should be able to operate profitably […]. The function of these scenarios is manifold: most often they stimulate creative thinking and try to anticipate the unforeseeable" (Vergrat and Quist, 2011).[7]

• The third class of future studies refers to normative scenarios such as backcasting scenarios (what *should* happen?). Backcasting scenarios in its original meaning are typical examples where a goal is predefined such as reaching a specific composition of an energy system and several options are explored to reach this goal starting with the present. "Backcasting scenarios […] recognize the systemic nature of the challenges ahead, and often assume that systemic societal transitions are necessary in order to achieve desirable futures."

A.2. Understanding and Assessing Consumer Behaviour

1. Motivation

Over recent years, countries across the world have been adopting energy efficiency policies and behavioural programs in efforts to lower reliance on foreign fuel supplies, reduce greenhouse gas emissions and air pollution, mitigate climate change and make the supply of energy services more affordable.

Energy efficiency is generally defined as the use of less energy to produce a fixed amount of economic output (Lovins, 1976). Refined definitions distinguish between *energy intensity*—defined as the primary energy demand per unit of economic output; *energy savings*—defined as the reduction in energy use through reductions in demand for energy services, savings due to fuel and technology switching, and savings due to energy efficiency improvements; and *energy efficiency*—this involves the provision of same energy service while consuming less energy (IEA, 2013a). Finally, *energy conservation* relates to a decrease in energy consumption via changes in behaviour, which is sometime also associated with a decrease in the energy service consumed.

Energy Efficiency Policies (as of August 2014)

<u>USA</u>

In the United States, energy efficiency standards for several end-uses and technologies have been fostered under revisions of the Energy Policy Act of 2005 and under the Energy Independence and Security Act of 2007. The American Recovery and Reinvestment Act of 2009 included a budget of roughly US$17 billion allocated to energy efficiency investments (ACEEE, 2011).

At the state level, much activity is on-going, but certainly at very different levels of effort across states: in 2010, 10 U.S. states have accounted for 70% of customer funded utility energy efficiency programs: California, New York, New Jersey, Massachusetts, Washington, Florida, Oregon, Minnesota, Connecticut and Michigan (LBNL, 2013).

<u>Europe</u>

In December 2012, the new European Commission (EC) Directive (2012/27/EU) on energy efficiency entered into force. "This Directive establishes a common framework of measures for the promotion of energy efficiency within the Union in order to ensure the achievement of the Union's 2020 20 % headline target on energy efficiency (using 2006 as a baseline year (EU Commission, 2011) and to pave the way for further energy efficiency improvements beyond that date.[8]

The 2012 Directive specifically aims to help remove barriers and overcome market failures that impede efficiency in the supply and use of energy and provides for the establishment of indicative national energy efficiency targets for 2020.

New measures include:

- The legal definition and quantification of the EU energy efficiency target as the Union's 2020 energy consumption of no more than 1483 Mtoe primary energy (1569 in 1990, 1583 in 2012) or no more than 1 086 Mtoe of final energy (1080 in 1990, 1103 in 2012).
- The obligation on each Member State to set an indicative national energy efficiency target in

the form they prefer (e.g. primary/final savings, intensity, consumption).
- The obligation on Member States to achieve certain amount of final energy savings over the obligation period 2014 – 2020 by using energy efficiency obligations schemes or other targeted policy measures to drive energy efficiency improvements in households, industries and transport sectors.

On 22 January 2014[9], the EC presented the pillars of the new EU framework on climate and energy for 2030. These include: a binding reduction in greenhouse gas (GHG) emissions by 40% below the 1990 level, an EU-wide binding target for renewable energy of at least 27%, renewed ambitions for energy efficiency policies, a new governance system and a set of new indicators to ensure a competitive and secure energy system.

On 23 July 2014, the EC released its new Energy Efficiency Communication, a strategy that proposes mid and long-term objectives for the EU's energy efficiency policy by assessing progress towards the 20% energy efficiency target for 2020 and analysing how energy efficiency can drive competitiveness and strengthen security of supply. Overall, it found that with current measures the EU will achieve energy savings of 18-19% by 2020. However, if all Member States work seriously to implement the already agreed legislation, it found that the 20% target can be reached without the need for additional measures. It proposes a new 30% target for 2030.

A summary of the policies deployed by several countries, with the objective of improving efficiency by which energy is used, can be found in the International Energy Agency's (IEA) report for the Energy Efficiency Working Party (IEA, 2010) and (IEA, 2011). In 2012, the IEA highlighted that "member countries still have significant unexploited energy savings opportunities that could be achieved with additional energy efficiency policy implementation" (IEA, 2012). The 2013 IEA Energy Efficiency Market Report provides a practical basis for understanding energy efficiency market activities, a review of the methodological and practical challenges associated with measuring the market and its components, and statistical analysis of energy efficiency and its impact on energy demand (IEA, 2013b).

While nations across the world adopt different stances with respect to energy savings (by putting different weights on savings from energy efficiency, fuel and technology switching and energy conservation, to help the transition towards more energy-efficient economies, broadly defined), it is important to understand the drivers and barriers to the different approaches, and synergies and feedbacks that exist along the entire energy value chain.

A number of scholars have been interested in the grand challenges and opportunities to achieving energy efficiency improvements as well as energy savings from demand-side management programs, and in particular in addressing the issue of *WHY* consumers are not taking advantage of the so-called cost-effective opportunities, which would provide the same level of energy services while saving them money. Similarly, key questions arise regarding the success or lack thereof of behavioural programs that aim to achieve energy conservation – i.e., reductions in energy consumption via behavioural strategies. Academics and practitioners from different disciplines need to explore together the behavioural, regulatory and market aspects of energy demand to clarify the causes and prevalence of the energy efficiency gap as discussed below.

2. Background: Clarifying the causes and prevalence of the energy efficiency gap

The literature on energy efficiency often refers to an "energy efficiency gap," i.e., the difference between the current level of energy consumption and the level of energy consumption that would occur if consumers were to select the most efficient end-use energy alternatives that are cost-effective, i.e., that would save them money while providing the same level of energy services. This gap between the technical, economic, and/or overall potential for energy efficiency is generally attributed to several simultaneous factors, such as market failures, market barriers and behavioural failures (see, for example, Gillingham, et al., 2009).

Reasons for this energy efficiency gap as they relate to consumer choices are numerous. We list a few here:

- *Energy prices may not reflect true energy costs*. Distortive regulation or lack of inclusion of negative environmental externalities associated with the provision of energy services may lead to energy prices that to not reflect all/true energy costs.
- *Consumers need to assess capital and financing options to pursue investment in energy efficiency*. Such capital may not be available, and credit mechanisms may not be set in place for energy efficient investments.
- *There are misplaced incentives* that prevent consumers from selecting the most cost-effective energy technology options. For example, landlords do not have an incentive to include efficient appliances and devices in the houses/apartments if the tenants are the ones paying the energy bills; this is a well-known principal-agent problem.
- *Uncertainty in the future price of electricity or other fuels*.
- *Low priority of energy issues* for consumers in the face of their other types of expenditures and decision they have to do.
- Consumers' limited *cognitive capacity* to process information regarding the different trade-offs and attributes associated with energy technologies.
- *Insufficient or inaccurate information, communication and education.*
- *Energy efficiency* often is inseparable from unwanted features in products, e.g., product category downgrades or upgrades.[10]
- Acknowledgment of an expert disagreement about the saving potential of different efficiency measures or behavioural adaptations.
- *Free-ridership* in the adoption of energy efficient technologies and services.

In addition, there are many other aspects that may lead to the inference of an energy efficiency gap. Differences between potential energy and emissions savings and the actual savings may be, for example, due to:

- *Poor data collection and data quality* from the reporting, evaluation and monitoring mechanisms from energy efficiency programs from utilities or other agencies;
- Differences in the *baseline modeled and actual energy consumption*. For example, building simulation models are known to produce estimates of building energy consumption that will

differ very substantially from actual building energy consumption (perhaps not capturing occupancy patterns, and how consumer operate the appliances/decides in the house);

- *Rebound effects* and other unanticipated responses by consumers;
- *Methodological issues* when computing the achieved energy savings from energy efficiency and demand-side management programs

Given these and other factors, there is a need for a better quantitative evaluation of the energy efficiency gap as well as for a better understanding of consumer energy choices and behaviour.

3. IRGC contribution

The Center for Climate and Energy Decision Making (CEDM) at Carnegie Mellon University and IRGC are interested in reviewing the current knowledge about the aforementioned factors and elicit expert views on the quantitative ranges of each of these factors. We envision to use these findings to assess how these factors are likely to shape the traditional "*energy efficiency supply curve,*" which display the potential for energy efficiency technologies and measures, and related cost-effectiveness.

A very diverse group of researchers is working on aspects related with this gap, namely engineers and modellers, economists, behavioural economists and psychologists, and other social scientists. The methods, scope and findings differ substantially, and there is little cross-fertilisation between groups in terms of communicating the findings. Utilities and regulators are deploying and implementing energy and behavioural programs and have unique insights on the issues regarding data gaps, reporting issues, program design and implementation, and metrics for success or failure of existing programs.

This will require bringing together an interdisciplinary and international group (comprising of scholars -including social scientists and economics-, engineers, policy analysts, industry experts, regulatory agencies and energy efficiency programme managers) who have worked on different facets of the *energy efficiency* problem and *energy savings* programmes aimed at recommending various possible measures for designing effective policies, regulation and markets to promote energy saving and efficiency by end-consumers.

At least two proposed contributions are expected:

- ✧ A taxonomy of behavioural programs and measures, i.e., what should be included or considered as behavioural interventions vs. traditional energy efficiency programs.
- ✧ A taxonomy on barriers and failures associated with energy efficiency and behavioural issues

A.3. Facilitating Consumer Behaviour Change and Improving Policy Decision

1. Motivation

Achieving energy efficiency goals rely on an effective demand-side management policy to promote sustainable energy savings. Broadly, this involves smart intelligent energy services provided by the confluence of information technology and new business models. Some of these services may lead to energy savings, while others may have the goal of improving consumers' services. These new services require the integration of smart grid, smart meters, flexible appliances and decentralized energy generation and storage. This presumes an acceptance of the new technologies and corollary changes in consumer behaviour. In reality, consumers may exhibit behavioural biases (OFGEM, 2011) that may contribute to demand-side management failures, even where consumers recognize the long-term benefits. These include:

- *Limited consumer capacity.* Consumers have difficulties assessing many different options and large amounts of information as in the case of complex tariff information; this may lead to choices that are 'better' instead of the best one for them.
- *Status quo bias*. Consumers prefer the current option—whether through inadequate searches or availability biases (over-emphasis on knowledge about the current option)—such that consumers to not switch away from current option (package or provider). This problem is accentuated in the case of poor comparability between different suppliers' tariffs.
- *Loss aversion*. Consumers attach more weight to monetary losses than to monetary gains and avoid risk-taking behaviour. Consumers may not join demand-flexibility options, pre-empting energy savings, across the value chain, from demand-response.
- *Time inconsistency*. Preference for immediate gains means consumers place too much weight on costs incurred now compared to future gains in terms of monetary savings, such that consumers do not make investments in energy savings technology or recurrently postpone such decisions (as in the case of hyperbolic discounters).
- *Information ambiguity*: Often consumers are confronted with contradicting or at least inconsistent information about the prospects of different behavioural change options with respect to the energy or economic savings attributed to them.

Policy goals to foster energy efficiency generally assume that there is a subset of energy efficiency measures that would be cost-effective for consumers. For example, in the USA, the residential sector accounts for 37 per cent of national electricity consumption, 17 per cent of greenhouse gas emissions and 22 per cent of primary energy consumption[11],[12]. While it is widely acknowledged that the residential sector holds the potential for energy savings and other benefits they entail, the design of effective policies to realise that potential is challenging. It has been suggested that "people-oriented" strategies (i.e., strategies that focus on behaviour-related energy savings) could reduce energy consumption in the residential sector (Eherhardt-Martinez & Laitner, 2010).

2. Promoting energy saving through toward integrated policies

Consumer behaviour is critical for a successful energy transition, in which governments, industry and opinion leaders, together, will suggest new consumption patterns. At this point three professional communities are working separately on the opportunities and limitations of influencing consumer behaviour:

- Behavioural economists stress the importance of monetary and more symbolic incentives for sustaining or changing behaviour
- Behavioural psychologists stress the importance of information, insights and identification opportunities for making people more cognizant and ready to change their behaviour
- Behavioural social scientists stress the importance of context factors such as social recognition, symbolic gratifications, and situational constraints that shape the conditions for individuals to deliberate or choose alternative options for their own actions.

So far representatives of these three approaches have engaged in few cooperative initiatives. Yet with the need for demand management in the energy sector, the integration of these three traditions in behavioural research is essential, especially in view of the prevalence of heterogeneous consumer segments (EEA, 2013). Of special interest is the newly developed field of “nudging” which combines situational structuring with individual choice behaviour.

3. From understanding to managing consumer behaviour

Triggering consumer behaviour change cannot be undertaken without a prior good assessment and understanding of the gaps in energy-efficiency and broader demand-side management policies, stratified into market, regulatory and behavioural failures – Testing and experimentation of the various kinds of interventions that could be effective, efficient and fair and have the potential to decrease prime energy consumption by private households, is also needed. Synergies between four types of strategies (corresponding to four disciplines) can then be considered:

- Economic incentives (e.g., subsidies, taxes and levies) to influence consumer behaviour (micro economics) with respect to energy saving or other energy related actions;
- Informational and educational interventions (cognitive psychology, educational studies, communication research) to influence consumer behaviour;
- Legal and prescriptive interventions (legal studies, political science contributions, research on energy regimes);
- Changing the context for individual choices (sociology, and persuasive psychology).

A.4. Governing Energy Transitions

1. Motivation

Germany, France and Switzerland have embarked on ambitious plans to shift their energy systems to more sustainable ones and, therefore, engage in the so-called "energy transition." Other countries are also moving in this direction. For a country like the US that is larger, decentralized and diversified, it may neither possible nor desirable for the federal government to consider this type of radical shift, at least in the short- to medium- term. But there is one fundamental rationale underlying the governance of energy systems: energy production and consumption needs to be more efficient and produce less carbon emissions. These are likely to drive fundamental changes in the structure of the energy system.

2. Background

The governance of energy systems and their transition, where appropriate, rests on several building blocks, which are discussed in turn.

1. Welfare effects of energy transitions: the need for national debates

The scale and scope of the current transition can bring about significant welfare changes. In particular, there is a concern of a welfare loss as a result of, for example, anticipated increase in end-use energy prices and energy conservation (as described below). Governments and other organisations in Germany,[13] Switzerland and France[14] have acknowledged the need for such profound societal debates at international, national and local levels to create conditions for sustainable improvements in energy systems.

Societal debates serves as a two-communication platform between policy makers and society at large to communicate relevant issues about energy systems and its transformation.

- End-users need to be better informed about the end-use energy pricing as well as the operational and capital expenditures and external costs (e.g. environmental impacts) associated with different energy sources.
- End-consumers should also be educated about the goals of energy efficiency and energy conservation in particular, so that the gains from lower economy-wide energy intensity can be reaped.

2. Financing the energy transition

Energy transition requires the replacement of the legacy system and investment in new technologies (e.g., energy efficiency technologies). The UK has implemented the Green Deal in 2013, in order to negate the upfront cost associated with energy efficiency. Other measures include energy efficiency performance contracting. These measures highlight the need to overcome some of the financing obstacle to energy transition by proposing innovative funding schemes that differentially pool private and public venture capital funds across projects' life cycle and target different consumer segments; requisite regulation and risk-sharing mechanisms as well as risk metrics. The challenge is to design a portfolio of measures to align short-term costs and long-term benefits, and ensure stakeholder buy-in through discussion and communication.

3. The need to understand and manage the transition process

History is replete with stances of energy transitions: countries like the UK, Germany and France have formerly gone through transitions from coal to oil and oil to nuclear. Transitions proceed from complex interactions at different levels and with feedback mechanisms both within and between each level. Each country has a unique socio-technical network in which functions such as innovation and creativity, the provision of stable regulatory regimes, and external forces play a role in triggering, accompanying and institutionalising the transformation of a system such as the energy system.

Analysis of past transitions provides useful insights to overcome energy transition challenges such as path dependence, lock-ins, vested interests, regulations, behavioural patterns and deep-rooted belief systems that are difficult to change (see for example Vaclav Smil[15]).

Accordingly, Geels[16] emphasise the importance of opinion or change leaders in energy innovation, transformation or consumption, which have the capacity to trigger or amplify changes. Policy-makers at national, regional and local levels may be helped by identifying and targeting these leaders to facilitate the transition.

4. The need to create and accompany inevitable destabilisation and mitigate negative consequences.

Destabilisations have both negative and positive consequences; but destabilisations are necessary. There is ample historical evidence that countries and civilisations that have not gone through transitions eventually decline and may even fail[17]. The unlocking of entrenched industries is often necessary to open the door to more efficient and sustainable systems. This goes through a process of weakening the reproduction of core regime elements[18]. It may therefore be legitimate to forcefully weaken the flow of resources, to decrease legitimacy of systems, which need to be transformed and erode vested interests.

At the same time, those elements that will be destabilised need to be supported in their transformation. The shift to market regulation in some energy sectors has already contributed to such destabilisation, and, as aforementioned, it will be a challenge for European utilities to harness the opportunities of the shift towards renewable and cleaner energy sources.

3. Institutional governance of the socio-technological energy systems, focusing on the energy supply-demand systems.

Technologies, regulatory and institutional settings, economic systems, and consumer behaviour interact with feedback loops and systemic interconnections, resulting in energy systems that are extremely complex. It is therefore very difficult to anticipate the consequences of policy and industrial decisions. To inform the adaptation of regulatory frameworks, the design of appropriate incentives and to foster leadership to steer the transition, the following issues are to be considered:

- Exploring the upside and the downside of the energy transition as it entails both risks and benefits. Such investigations should help define the terms and conditions of a sustainable transformation of the energy system and facilitate policies that help reach this goal.
- Discussing past energy transitions, and identifying similarities and differences with the current one. This should help learn and extrapolate from lessons from the past.
- Defining features of critical nodes in the energy system (for example, who are the early adopters or who should be the ideal early adopters), which, upon adoption of new technologies, could have an exponential impact and trigger a desirable shift in the system.
- Addressing other issues related to policies for energy transitions, such as energy independence and security of supply: how will each country organise its infrastructure to manage risks of disruption.

Appendix B: About IRGC and its main partners

IRGC

A detailed presentation of IRGC can be found on www.irgc.org

IRGC is a non-profit and independent organisation whose purpose is to help improve the understanding and governance of systemic risks that have impacts on human health and safety, on the environment, on the economy and on society at large.

IRGC's activities are organised to meet IRGC's missions and focus, and in particular **the role of IRGC at the interface between science, technological developments and policy.**

IRGC acts as:

- **A multi-stakeholder international platform:**
  Acting as a major international platform for the development of a sound institutional culture of risk governance in government, industry and academia.

  IRGC contributes to the agenda setting in risk governance, bringing together and facilitating the dialogue among the most relevant stakeholders world-wide. In this role, IRGC systematically convenes international multi-stakeholders conferences and workshops and strives to assert itself as a trusted and competent independent international convener in the field.

- **A hub and facilitator of a globally distributed academic network, and international driver for research and education on risk governance:**
  Stimulating scientific research, advanced education and cooperation opportunities and needs related to risk governance issues.

  IRGC stimulates its academic partners in developing among themselves (and stimulating others to emulate) international cooperation in research and science-based academic training and international programmes relevant to risk governance. In doing so, IRGC contributes to new academic benchmarks of social responsibility, by triggering the inclusion of science-based risk governance issues in academic education and by encouraging risk governance issues to be present in research agenda setting processes. In this specific role, IRGC acts as a convener of an academic network.

- **An internationally respected source of publicly available policy advice on risk governance issues.**
  Publishing policy briefs and project reports on concepts and tools for risk governance, as well as addressing specific emerging, ignored or neglected issues.

  IRGC relies on its multi-stakeholder international experience and on scientific evidence to produce recommendations, often in the form of risk governance guidelines, for improving the dealing with complex and systemic issues marked with uncertainty and ambiguity.

- **A demand-driven organisation:**
  Responding selectively to demands by relevant stakeholders, whenever this may contribute significantly to achieving IRGC goals and to enlarging IRGC competences and its international and multi-stakeholder networks.

  IRGC organises specialised meetings and workshops (in partnership with or with the support of external entities). Although most of these activities are to be financially supported by external partners, they are based on a pre-existing level of organisation and dedicated human resources at IRGC and a systematic commitment from its academic partners.

IRGC is keen to meet invitations or demand from private sector organisations and governments to support their efforts to develop improved risk governance. IRGC also collaborates with initiatives from international governmental organisations on risk governance, as much as, through these collaborations, it can access directly representatives of individual countries.

Most IRGC activities target policy makers or policy. IRGC's role is to translate, aggregate and synthesize more than to develop its own deep expertise of risk governance issues. It is a conduit of advice to help decision makers navigate wisely between the scopes of available choices on a given topic.

Carnegie Mellon University, Center for Climate and Energy Decision Making (CEDM[19])

Decisions in climate and energy involve multiple factors, with each having aspects unique to it, due to the variety of decision-makers, time horizons, and uncertainties involved. The spectrum of factors ranges from the multitude of strategies available to reduce carbon dioxide emissions over the next fifty years to how to decide which marine ecosystems to protect from an increase in the oceans' pH levels.

CEDM center and its graduates develop and promulgate new and innovative, behaviourally and technically informed insights involving the intersection points between climate and energy. It also generates methods to frame, analyze, and assist key stakeholders in addressing important decisions regarding climate change and the necessary transformation of the world's energy system."

CEDM is a distributed research cooperative agreement, anchored at the Department of Engineering and Public Policy at Carnegie Mellon University.

Helmholtz Alliance Energy-Trans[20] and Stuttgart University

Research in the energy sector concentrated so far on the development of new energy technologies and their optimal combination towards an efficient and effective energy mix. With the envisioned energy transformation in Germany, energy supply will be primarily based on renewable sources of energy and efficiency gains. Furthermore, the demand side of energy will become a major topic of research and will be at the core of future energy policies.

The Helmholtz Alliance ENERGY-TRANS places the connections between and among energy technologies, planning procedures and consumer behaviour in the focus of the research interests and investigations.

Research projects include the interaction of energy supply, energy distribution and energy storage on the one hand and institutional governance and consumer behaviour on the other hand. The results are expected to provide policy-oriented knowledge for an efficient and socially acceptable design of a sustainable energy system.

Ecole Polytechnique Fédérale de Lausanne (EPFL)[21] – Energy Center

The Energy Center fosters multidisciplinary research projects and networks to develop sustainable energy conversion, storage, transportation, distribution and end-use systems and technologies.

Notes

[1] http://www.irgc.org/wp-content/uploads/2013/11/WORKSHOP-3.pdf

[2] http://www.irgc.org/wp-content/uploads/2013/04/IRGC_ReboundEffect-FINAL.pdf

[3] See for example, Vaclav Smil, "Energy transitions, history, requirements, prospects", 2010

[4] The presentation is available at http://www.irgc.org/wp-content/uploads/2013/02/3.-Granger-MORGAN_The-forecasting-problem_IRGC-Beijing-2013.pdf

[5] See The Economist (2013); See also the announcement from RWE on 21 October 2013: http://www.energypost.eu/exclusive-rwe-sheds-old-business-model-embraces-energy-transition/

[6] See also OECD on "Scenario Development: A Typology of Approaches." Retrieved from http://www.oecd.org/site/schoolingfortomorrowknowledgebase/futuresthinking/scenarios/scenariodevelopmentatypologyofapproaches.htm

[7] See also Bishop, Hines and Collins (2007).

[8] http://ec.europa.eu/energy/efficiency/eed/eed_en.htm

[9] http://europa.eu/rapid/press-release_IP-14-54_en.htm

[10] Energy efficient products (e.g. cars or refrigerators) are often larger size or higher-end products. Many consumers may not value these attributes and are therefore not willing to pay for them, while it may be more profitable for industries to embed most efficient technologies primarily in top-tier products.

[11] Using 2008 AEO detailed tables, Table 10 – Energy Consumption by Sector and Source, US Energy Information Administration (EIA).

[12] Using EIA GHG flow from 2006. EIA reports that the residential sector is responsible for 1,234 million metric tons of carbon dioxide equivalent, and that total greenhouse gas emissions in the United States are 7,076 million metric tons of carbon dioxide equivalent.

[13] For example, in Germany:
- Helmholtz Alliance Energy-trans http://www.energy-trans.de/english/
- Call for good governance of the Energiewende: http://www.hertie-school.org/fileadmin/images/Media_Events/BTW2013/20130820_Good_Governance_of_the_Energiewende_in_Germany_ClaudiaKemfert_Download.pdf

[14] For example, in France:
- national debate, IDDRI http://www.iddri.org/Publications/Scenarios-de-transition-energetique-pour-la-France-definir-un-espace-de-discussion-pour-le-debat
- http://www.lemonde.fr/planete/article/2013/09/20/hollande-detaille-sa-vision-de-la-transition-energetique_3481711_3244.html

[15] http://www.vaclavsmil.com/energy-transitions-history-requirements-prospects/; See also page 10 in: http://www3.weforum.org/docs/WEF_EN_EnergyVision_Report_2013.pdf

[16] Geels, F.W. (2010). "Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective." *Research Policy* **39**: 495–510

[17] See literature on rise and fall of civilisations and economies. For example: Jared Diamond, David Landes, Joseph Tainter

[18] See Geels above

[19] http://cedmcenter.org/

[20] http://www.helmholtz.de/en/joint_initiative_for_innovation_and_research/initiating_and_networking/helmholtz_alliances/energy_trans/

[21] http://energycenter.epfl.ch/homepage

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