ENERGY & MULTI-STAKEHOLDER INTERESTS

a social sciences and humanities
cross-cutting theme report

SHAPE ENERGY

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Executive summary

Different technical and social systems contribute to energy supply. Whilst they all solve particular problems - from moment to moment, hour to hour, day to day, and over the medium- and long-term - none of them are responsible for the whole energy complex (e.g. generation, transportation, distribution, storage, marketing etc.) at once. Instead, a division of labour is in place to allow for a high degree of 'organised complexity', since all those pieces play together in providing energy services.

This division of labour is only possible if people, groups or organisations that operate mainly in one functional system of society (e.g. economy, politics, science or law) are freed from considering the details of all other domains. Since there is no all-purpose-machine generating and distributing energy, there is also no societal agent overseeing all energy-related actions. This includes, for example, politics as an agent: although energy supply is widely considered to be a public service, stakeholders from academia (experts), industry (power plant operators) and the general population (clients) all contribute to energy system operation. In general, it is accepted that only the 'bounded rationality' of interest-driven actors maintains energy services.

But research in the Social Sciences and Humanities (SSH) very often criticises corporate actors for following, maintaining and protecting their own, limited interest (in the outcome of some operation, exercise, project or process) as a 'stake', while neglecting the overall system value of energy as a 'common good'. 'Multi-stakeholder interests' are therefore a reoccurring topic in energy-SSH and this report aims to set out the major debates and conceptual omissions from which we can derive research and policy implications.

A problem-oriented approach is proposed in this report, in order to achieve an overview of SSH research in the field of various stakeholder interests. Instead of summarising all possible stakeholder interests in the energy field, this report showcases the various contributions of different actors to cross-cutting problems. For this purpose we differentiate three analytical dimensions: (1) Complexity and control; (2) Institutional change and learning; and (3) Coping with uncertainty, risk and danger. In this way, we can clarify how energy-SSH research analyses stakeholder interests:

1. ***Complexity and control:*** structural problems of control (e.g. security, safety and optimisation), despite an increasing number of technical and social elements operating simultaneously to provide energy services. Herein, energy-SSH scholars are concerned with analysing organisational changes, governance problems, critical transactions, and/or exogenous threats stemming in part from tensions between the overall rationality of the energy complex and the goals and interests of organised stakeholders.

2. ***Institutional change and learning:*** institutional (un)intended changes through incremental, endogenous regime changes and exogenous pressures (e.g. global developments) or through niche developments (e.g. innovation from challenger actors). Herein, energy-SSH research favours change and innovation in the energy sector, as part of which strategies of learning and experiments are prominent concepts. But SSH research is also concerned with the resilience of established regimes due to vested interests leading to institutional inertia.

3. ***Coping with uncertainty, risk and danger:*** operational problems of action capacity (i.e. the ability to act) despite increasing uncertainty in complicated energy infrastructures and opaque markets, in which operators have to cope with 'smart grids' and administrative supervisors with 'smart markets'. An example of a related operational problem would be how the general public is supposed to get involved in future smart appliances usage and, more generally, how stakeholders are supposed to change their overall energy behaviour.

On the basis of this, we conclude that the relation of how limited stakeholder interests still generate a coherent overall energy system could receive more attention, e.g. through research funding. The same applies to uncertainty research, which would aim at discovering stable stakeholder expectations against the need for change, and facilitation of action capacity of business and private stakeholders. Finally, we recommend to support a role of the energy-SSH community as possible moderator of multi-stakeholder interests instead of pointing out good or bad interests and motives. This seems most salient with regard to current developments of needed co-operation between stakeholders to realise the 'smart grid'.

1. Introduction

'Multi-stakeholder interests' are a central theme in European discussions on energy transitions. In order to realise the ambitious aims of "*great transformations*" (Magnuson, 2013; WBGU, 2011, p. 5), multiple actors are involved in carrying out the visions set forth by designers, industry, and politics (Appelrath et al., 2012; JRC, 2011). The European Commission (EU) Horizon 2020 most recent work programme on 'Secure, Clean and Efficient Energy' (European Commission, 2017) for instance, mentions "*consumers*" (p. 25), "*industry*" (p. 43) and "*SMEs*" (Small and Medium-sized Enterprises; p. 141) as relevant actors in energy transitions. In order to work "*towards an integrated EU energy system*" (p. 66), the relevance of involved stakeholders is additionally stressed through a section on "energy stakeholders" as a cross-cutting issue: "*To address such a significant investment challenge, it is fundamental that public and private stakeholders involved in the relevant sectors join their forces, agree on common objectives and align strategies for achieve them*" (p. 134).

These political ideals of stakeholder co-operation to achieve a broader goal are confronted by energy-related Social Sciences and Humanities (energy-SSH) research that frequently focuses on conflicting interests, hidden motives and lobbies in the energy sector who prevent change and have no interest in co-operation (see for example: Sovacool, 2009; Geels, 2014). Other scholars, often with more of a Science, Technology, Engineering and Mathematics (STEM) background, argue in favour of so-called 'roadmaps' (i.e. overarching step-by-step plans) that merely need to be developed to coordinate multi-stakeholder co-operation for the betterment of society (see for example: Appelrath et al., 2012). In this report, instead, we argue that looking at multi-stakeholder interests allows for a comparison of overall energy system rationality (i.e. system output through aggregated interplay of actors), on the one hand, and the interests, motives and goals of a multiplicity of actors[1] in the field, on the other.

By structuring energy-SSH contributions alongside three distinct dimensions (subsections 2.1-2.3), we will introduce a problem-oriented approach to showcase the various contributions of multiple stakeholders to cross-cutting problems in the energy system. These problems include security, safety, optimisation, experimentation, action capacity, opaqueness and others, and relate to permanent system operations that stakeholders have to attend to with different priorities. Before these three dimensions and the multi-stakeholder contributions are discussed, we introduce the common understanding of 'energy systems' (with a focus on electricity) in SSH debates, as the underlying narrative stakeholder interests are embedded in.

In general, energy systems are analysed by SSH scholars as a socio-technical system or large technical system (representative for many others: Mayntz, 2009):

- Socio-technical systems entail not only all kinds of artificial and physical, chemical or biological components, but also psychological, cognitive and social elements which are linked to each other recursively, forming 'socio-technical' entities.
- They also penetrate and cover all areas of life in modern society, connecting not only infrastructure systems, but also the functional areas of politics, the economy, law and science.
- They are a prerequisite for the functioning of the majority of all other technical systems.
- Finally, socio-technical systems are expected to fully include the entire population within the range of services they offer. This inclusion of the population in the function and performance capability of large-scale systems is achieved through a network-like interaction of specialised organisational systems, whereby the population has been largely excluded from (infrastructure) decision-making processes.

Accordingly, as overall goals of grand-scale energy systems, we can identify the issues of safety of operation, security of supply (which includes also data protection in smart grids), affordability of services, as well as sustainability in the use of scarce resources and in reducing emissions (Appelrath et al., 2012; JRC, 2011; WBGU, 2011). This normative system rationale based on societal values (i.e. data protection, sustainability) is not necessarily congruent with the goals and interests of the contributing social actors.

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1 The term "actor" refers here to address social entities like single persons or a group of persons, as well as organisations or networks of organisations, to whom we assign the ability to act and to assume responsibility in the context of values and interests (Japp, 2006, p. 243).

For instance, not only is there conflict about how to achieve these goals, but there is also debate about how safe, secure, affordable, or sustainable energy services can and shall be. Multiple goals and values are also interfering with each other, and pursuing conflicting aims always generates trade-offs. Prominent examples include that safety and security are expensive, affordability for everyone cuts into profits, and sustainability means to forego present opportunities when considering future opportunities is the main objective. As a consequence, the term 'stakeholder' has become popular in the SSH field to describe the pursuit of potentially one distinct ('particularistic') interest. In addition to the meaning of 'actor', *there is the clear presumption that a social entity (e.g. an individual, group, organisation) pursues interests in the outcome of some operation, exercise, project, or process*.

Specifically, to identify what actor has what at 'stake' in the energy field, we need to identify which parties contribute to the provision and consumption of services. Scholars emphasise the affiliation of different actors to specific domains of society: "*At root, socio-technical regimes are produced and reproduced by networks of state, civil society and market-based actors and institutions*" (Smith et al., 2005, p. 1504). There is a consensus in the SSH that modern society is somehow differentiated in fields, sectors, or functional systems (e.g. Luhmann, 2012a, 2012b) - the justification for this claim, however, is based on completely disparate theoretical premises. Broken down to the energy field, we can easily see how any energy issue has multiple references to the corresponding functional fields: every power plant operation has scientific, economic, legal, and political implications. Every power plant planning, implementation, operation and, in the end, decommissioning unifies, incorporates and consolidates multi-stakeholder interests up to the point where some useful output can be expected.

In order to structure the multi-stakeholder interest landscape, we refer to specific cross-cutting dimensions, which require ongoing attention in order to reproduce energy services: 'Complexity and control' (subsection 2.1), 'Institutional change and learning' (subsection 2.2), and 'Coping with uncertainty, risk and danger' (subsection 2.3)[2]. Within these three dimensions, problems of system operation and optimisation are empirically tackled by stakeholders on a regular basis, and therefore serve as a real-world reference for multi-stakeholder interests and their output. The presentation of the multi-stakeholder interest landscape in this report is selective, yet roughly displays ongoing (and some neglected) debates which highlight conceptual issues of stakeholder discussions in energy-SSH. As various stakeholders contribute to the solution of the aforementioned problems in the energy sector, we emphasise perspectives from business/ industry, administration/politics, and consumers/population.

2 For a more thorough explication of this concept, see: Büscher and Sumpf (2015). There, we have defined socio-technical systems like energy as "expectation complexes of services, to which technical and social systems contribute, to dissolve from moment-to-moment socio-technical problems" (ibid, p. 3).

2. Stakeholder contributions and interests in solving cross-cutting energy service problems

This section is structured around the following three problem dimensions:

1. *Problem dimension #1: Complexity and control*

   For the provision of energy services, maintaining control despite increasingly complex technical and social structures. e.g. System operation and control (power plants, grids), supervision of operation and market activities, protection of technical installations and cyber-infrastructures.

2. *Problem dimension #2: Institutional change and learning*

   For the development and improvement of the energy complex, maintaining stable orientations despite the need for experimenting and learning. e.g. Knowledge protection and exchange, legal ruling, norm setting, investment programmes in economics, funding schemes in politics, fostering innovation and the diffusion of innovation, scaling up of experiments, implementing participatory exercises etc.

3. *Problem dimension #3: Coping with uncertainty, risk and danger*

   For sustaining action capacity, the need of absorbing uncertainty despite increasing non-transparency in socio-technical structures and institutions. e.g. trust-building in systems, education, active participation of consumers etc.

2.1. Problem dimension #1: Complexity and control

This subsection explores problems of complexity and control in energy systems in order to illustrate stakeholder interests of energy system operation and control (power plants, grids), supervision of operation and market activities, and protection of technical installations or cyber-infrastructures. The production of services, i.e. service provision of electricity, have been organised in terms of vertical control of Large Technical Systems (LTS): coal-, water-, uranium-power plants, physical networks like pipelines, electricity networks, etc. In this regard, large power plants demand long-term planning and financial commitment, and investors favour monopolies and centralised organisation of production (Mayntz, 2009). Economic mix, load factor, optimisation etc. are economic variables which have to be enacted by transactions that are critical to the system performance like operational balancing, capacity utilisation and allocation, or system transformation and innovation (Künneke et al., 2010).

As for the governance of LTS, political programs generally foster liberalisation and enforce the 'unbundling' of vertically integrated systems of generation, transportation and distribution of energy (Künneke, 2008; Mayntz, 2009). The associated political expectations are better services, cheaper prices, and higher reliability. Yet in the energy-SSH community, researchers challenge the effectiveness in achieving these goals (Pollitt, 2012). Within this context, the organisation of energy supply was enforced through system external regulation: vertically integrated companies have to implement the legal, operational, informational and accounting unbundling[3]. As scholars such as Künneke (2008) note, this involves a case of a structural break between technical installations and social organisation. This has the potential to corrupt the overall function of the system: "*The electricity value chain seems to evolve towards unbundling and specialisation, whereas technology is based on integrated system planning*" (Künneke, 2008, p. 239). From this observation, one can derive contradictions in the system's development, which crystallise in light of different rationalities: on the one hand, there are individual actors and their economic calculations of return in investment, and on the other hand, the overall system and the technical requirement of central control. As a consequence, for example, developments can be observed in direction of power plant expansion being enacted along economic incentives and stakes and not necessarily with regard to the overall needs and long-term stability of the system.

3 See the Energy Industry Act [EnWG] in Germany, for instance.

Further discussions appear in the form of envisioning smart grids or smart markets (Lösch and Schneider, 2016). This involves engineers, scientists, industry and energy businesses accelerating the system transformation in favour of decentralised energy generation, which leads to an interwoven network of various energy sources, distributive structures, storage capacities and, significantly, requires active consumers (Ramchurn et al., 2012). In the US and Europe, numerous projects evaluate the opportunities of the implementation of innovative technical components. These concern digital information and controls, smart technologies for metering, communications, automation, smart (consumer) appliances, peak shaving technologies, advanced storage, etc. (Brown and Suryanarayanan, 2009).

This kind of digitalisation has consequences for the organisation of energy production and consumption. In particular, two-way communication between consumers and suppliers is made possible by smart meters, allowing for innovative social arrangements like new market mechanisms. These visions are about the widespread interlinking of households, commerce and industry into an intelligent system of energy management, so as to improve efficiency, lower CO_2 emissions and enhance the affordability of electricity (JRC, 2011). However, these visions also have implications for operational safety and for increasing complexity where problems of system modelling arise (Kröger, 2017; Kröger and Zio, 2011), as well as raising issues of data privacy (Cavoukian et al., 2010).

Additionally, researchers on the interdependencies of infrastructures investigate how socio-technical entities enable or impact each other, and this development embodies an ambivalent outlook: intelligent, more efficient infrastructures are envisioned in terms of opportunity and progress; systemic risks are anticipated with regard to vulnerability and/or resilience of interdependent infrastructures. In essence, we find these kinds of interdependencies in:

- physical terms: network installations like transportation routes with industrial production; or interconnection of different services (Roe and Schulman, 2016);
- in spatial terms, i.e. geographically, for example in dense agglomerations (Büscher and Mascareño, 2014; Kraas, 2007; Perrow, 2007);
- or in terms of electronic systems (e.g. SCADA) which operate across different socio-technical systems (Kröger, 2017; Moteff et al., 2003; Perrow, 2011).

The development of a "*Smart Electricity System*" (JRC, 2011, p. 10) that connects to other infrastructures has been depicted as the future with regard to, for example, the convergence of infrastructures such as electricity with transportation and the world wide web (e.g. internet of everything).

For energy-SSH research, one task is to investigate the process of increasing complexity and the problem of maintaining control within these new domains of infrastructure convergence. The interests of stakeholders in these debates on evolving energy systems are incumbents who try to preserve the status quo (Kungl, 2015), as opposed to proponents of the smart grid - a development that empowers not only consumers but countless other SMEs to intervene in new markets (Shomali and Pinkse, 2016). The next subsection demonstrates this conflict of interest further and shows how both stability (incumbents) and change (new market players) are important.

2.2. Problem dimension #2: Institutional change and learning

The transformation/transition[4] of the energy complex has been the most prominent topic of energy-SSH research in recent decades, with, in general, its explicit objective being to achieve a 'sustainable' state of energy supply (Elzen et al., 2004; Grin et al., 2010; Weber and Rohracher, 2012). Relatedly, SSH research claims that a system's (energy, transportation, agriculture, etc.) sustainable transformation cannot only be achieved through replacing technologies. Far-reaching changes relate to the way in which the interplay of technologies is organised in socio-technical systems, and how technologies are controlled, funded and used. To this end, the transformation research assumes that alongside technologies, the organisational forms of production and consumption, as well as the generalised action coordination, need to be changed concomitantly with values and preferences (Rip and Kemp, 1998). These changes require social innovations that are capable of significantly changing the corresponding system or, at least, major portions of it.

This complexity is also reflected in the descriptions of the energy system in recent publications, such as Verbong and Loorbach (2012, p. 9): "*The energy system as a complex societal system can be defined as all those actors and artefacts that together produce the societal function energy. It is an open and nested system, that is, it is interconnected with other societal systems (like mobility, food provision, construction) and embedded within broader society*". Use is often made of the so-called Multi-Level Perspective (MLP) in approaches of transition research, where different stakeholder positions are incorporated in the analytical levels of 'landscape', 'regime' and 'niche'. The MLP concept is attributed to Rip and Kemp (1998) and was refined and further developed, among others, by Frank Geels (2004; 2005). Geels, in line with this approach, understands transitions as the result of the interaction between micro levels (niches), meso levels (regimes) and macro levels (socio-technical landscape):

- *The macro level* refers to the slowly changing landscape, which influences the regime at the meso level, and the niches at the micro level. It includes framework conditions, such as overarching paradigms, macroeconomic developments, physical infrastructures, the natural environment or demographic factors.
- *The meso level* refers to the socio-technical regime. This label explicitly emphasises how *differentiated stakeholder interests and the resulting actions form emergent institutional settings*. Not only firms and engineers are involved, but also other social groups, such as politicians, NGOs, organised users, etc. The term relates to work by Rip and Kemp (1998, p. 338) who define a technological regime as "*the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems - all of them embedded in institutions and infrastructures*". Geels (2004) provided the approach with a wider perspective, by advocating the term 'socio-technical regime'. Regimes are generally characterised by a high degree of stability, where innovations tend to be incremental.
- *The micro level* refers to niches - and accordingly niche actors - in which (radical) innovations arise: new practices, business models, technologies, forms of policy intervention, which can involve application contexts, actor constellations or geographic areas with special characteristics. At the micro level, innovations take place in a kind of "*protected*" space, in which they can develop without immediately coming into direct competition with the approaches of the 'old' regime (Geels et al., 2012, p. 53).

Energy-SSH research, in part, portrays a strong normative bias, not only in understanding transitions, but also in creating governance options to support the transition/transformation in direction of sustainability. Indeed, transformation research intends to contribute to the goal-oriented governance of transformations through the analysis of these processes, or else the influence of external factors and stakeholder constellations. However, such research does not usually involve formulating concrete rules or concepts for action and policy-making. As stated by Schneidewind and Scheck (2012, p. 51), the outlined approaches pertain to "*basic meta-principles of governance, with the help of which the direction and speed of the conversion processes should be derived*". An example of such an approach is the popular concept of 'Strategic Niche Management' (Hoogma et al., 2002), which considers a targeted support of niches, in which innovations

4 For a discussion of which term is more appropriate, see: Child and Breyer (2017).

that are deemed sustainable can develop. In addition, the idea of fostering (societal) experiments is widely discussed (Gross and Mautz, 2015; Loorbach, 2010).

In recent years, the resilience of regime constellations - including the stakeholder interests of incumbent actors to sustain the established situation - is the focus of energy-SSH research. Geels (2014) exposes how large utilities in the UK exert political influence, dominate discourses, promise technologies which extend the lifetime of fossil-based energy generation, and activate networks of stakeholders to protect vested interests. Sovacool (2009, p. 4511) refers to "*congealed cultures*" in US-based energy infrastructure and shows how the dominating regime limits consumer choices for energy supply, resulting in the continuation of established habits and practises. Also, Kungl (2015) reports how the German-based incumbent utilities first exploited the liberalisation process ('unbundling'), and afterwards attempted to block the entrance of challengers trying to ride the renewable energy wave. Fuchs (2014, p. 49f.) supports these findings in his study: "*Incumbent actors (like the four big energy providers in the German PV case) will try to defend their position and to damage the position of the challengers*".

The analysis of conflicting stakeholder interests is also incorporated in recent debates about the speed of transformations, for example in a special issue of Energy Research & Social Science (ERSS, 2016, Vol. 22) and corresponding discussions (Sovacool and Geels, 2016). Along the discussion of several factors speeding up or slowing down transitions, including the role of incumbent and challenger stakeholders, Sovacool and Geels anticipate an active role for energy-SSH in shaping transitions: "*The language we use to describe transitions serves as more than a mere analytical tool - it can shape how energy system users, investors, operators, builders and financiers frame energy problems and also envision future pathways for change*" (Sovacool and Geels, 2016, p. 236).

In conclusion, we can say that the focus on *change* in energy-SSH research, and the corresponding bias for sustainability, innovation, and niche development, has produced a rich corpus of insights into transformational dynamics. However, the balance toward necessary *stability* in energy systems, for stable orientations in highly complex fields, has been partially neglected. Instead, SSH investigations into the acute problem of *uncertainty* would be valuable here, i.e. referring to investor or consumer uncertainty. One exception in this regard are Gross and Mautz (2015, p. 144), for example, who hint at the consequences of extended real-world experiments which cannot be assessed methodically "*because there is not enough experiential data to rely on for evaluating future events in a meaningful way*". All involved actors must cope with uncertainty, which is still different for decision-makers on the one hand (e.g. politics, utilities, start-ups), and those affected by decisions (consumers, population, businesses) on the other. The latter might be hesitant and reluctant in participating in for large scale energy transitions inevitable experiments, or might even be opposing them all together, which is a strong argument in favour of conducting more uncertainty research in energy-SSH. The next subsection broadens issues of uncertainty, risk and danger.

2.3. Problem dimension #3: Coping with uncertainty, risk and danger

Structural changes in the provision of energy services and in the organisation of energy production (subsection 2.1), as well as in energy system regulation and its interconnection to other infrastructures (subsection 2.2), result in high degrees of complexity. Additionally, the overall institutional settings in the energy sector change in the course of energy transitions and affect the state of accepted knowledge, technical norms, market rules, regulation, etc. Under these circumstances, all actors and stakeholders face uncertainty and risk if they are involved in active participation and decision-making in the energy system.

One of the most glaring features of the energy transition is the widespread introduction of 'smartness' through means of information and communication technology, and subsequently the two-way-data exchange of provider and consumer. Especially consumers are expected to become involved more actively by producing and consuming electricity at the same time. The label 'prosumer' (producing and consuming electricity) has become prominent in this regard. While industry stakeholders search for viable business cases and models for smart appliances and prosumer roles, for example "*virtual power plants*" (JRC, 2011, p. 35), politics and administrations in Europe are investigating ways of allowing for both innovation and protection of prosumers simultaneously (ibid). Only if uncertainty is mitigated that future energy technologies and services are safe from abuse (from tampering personal information or fraud), smart meters or more broadly smart appliances will become successful. Already observed rejections of smart meter technologies by certain users can serve as a warning in this regard (AlAbdulkarim et al., 2012).

Energy-SSH research, consequently, is looking into data security issues, e.g. setting standards for smart grids to foster trust (Hoenkamp and Huitema, 2012) and protecting privacy (Cavoukian et al., 2010). Overall, this development calls for novel trust relations to be developed in coming decades for any active involvement of the general population to happen (Büscher and Sumpf, 2015). In this sense, Kasperson and Ram (2013, p. 94) also relate to trust and confidence regarding the current US situation, where they observe a systematic loss of confidence in administration and governments, infrastructures and technologies ("*outmoded U.S. energy grid*") and in market coordination ("*who reaps the benefits, who bears the risks and burdens?*"). As such, stakeholder trust and confidence are therefore mandatory for a national commitment to an alternative energy future.

More precisely, trust and confidence will be influenced by the way energy conflicts are managed. For example, there is the potential for considerable opposition towards infrastructural developments (e.g. power plants, transmission lines) because of stakeholders 'being affected' by siting decisions. Consequently, participatory exercises have become routine, with the hope that they will ease conflict between decision-makers and those affected, i.e. stakeholders that might oppose the new infrastructure. For industry stakeholders and administrations, participation procedures have the function of avoiding implementation hindrances and procedural delay, as well as preventing conflict and strengthen legitimacy. At this point, energy-SSH research is considerably active in investigating what it means to be affected and to analyse different forms of participation of 'the public' and involved stakeholders: wider, i.e. full impact on decision making; or narrower, i.e. just small decision corridors are possible for involved actors (see the various contributions in: Devine-Wright, 2014).

From a slightly different angle, some philosophers call for the participation of non-engineers in the design of modern infrastructures to increase, as they call it, 'capabilities' of persons to actively participate despite the complicated nature of those designs (Künneke et al., 2015; Ribeiro et al., 2012). In essence, through emphasising the aspect of system evolution, the latter authors present a different pathway for involvement than debates about participatory proceedings in 'siting-decisions' (which often refer to simple 'yes', 'no', 'maybe' alternatives).

A final important issue is energy consumption, because it tackles certainties (like routines in households) and investigates how to change behaviour - which introduces uncertainty. Historically, studies have revealed how industries throughout decades have fostered increased energy consumption: bigger refrigerators and more kitchen machinery in every household, for instance (Gerber, 2014). Nowadays, there is a debate on how to decrease energy use and to design programs for environmentally 'sound' behaviour: ideas range from feedback systems (Karlin et al., 2015; Nachreiner et al., 2015) to nudging (Kaiser et al., 2014), i.e. leading stakeholders (mostly average consumers) into desired behavioural frames through hardly variable default settings. While feedback systems are supposed to present stakeholders with helpful information to make informed decisions (*rational uncertainty absorption*), nudging is supposed to erect some form of behavioural inconvenience, which represents a relief if accepted as such (*technical uncertainty absorption*). On the other hand, it rather represents a burden if not, including that the urge to behave otherwise prevails. However, some SSH researchers claim that energy efficient behaviour in one area can lead to increasing activities in others, and, in the end, even more consumption of energy. This phenomenon is discussed in terms of 'rebound effects' (Kaiser et al., 2014). Stakeholders like industries contribute to the ease of this problem by producing and offering more energy efficient appliances - however, trends toward enlarging technology such as 4K television sets, large-size refrigerators, or large and heavy Sport Utility Vehicles, in the end possibly devaluate behavioural changes made in some areas and provoke the use of more energy in others. Social Psychology approaches investigating into these paradoxes thus pose a valuable contribution to energy-SSH in presenting mental heuristics to social interaction affecting energy use, as well as the often conflicting stakeholder interests (e.g. consumer - industry) following from this.

3. Recommendations

For the funding of EU energy research

- In general, there is a need to acknowledge the difference between the development of the overall energy complex (generation, transportation, distribution, consumption) and the interests of all involved stakeholders from business and industry, as well as from politics and the broader public. Particularistic agendas relating to stakeholders are the 'normal mode' and in part, keep the system running. Yet the issue of how those limited stakeholder interests, through their interplay, actually generate a coherent overall energy system that undeniably conveys output (e.g. electricity) could receive more funding through, for example, social science systems research.
- Due to the pointed focus of energy-SSH on questions of promoting sustainability transitions and therefore change, the balance toward necessary stability (e.g. for stable orientations in highly complex fields) has been partially neglected. In particular, more elaborate investigations into the problem of uncertainty research would be valuable, regarding market uncertainty (e.g. stable investments) as much as consumer uncertainty (e.g. trust, confidence-building). Funding for these types of energy-SSH could illuminate how change and stability interact on the road to sustainability.

For interdisciplinary energy projects and platforms

- In order to manage complexity and control as an important dimension of transitioning energy systems, both academic/industry researchers (through projects and platforms) and policymakers have to be aware of the emerging infrastructure convergence between analogous and digital energy technology. This convergence ('smart grid') creates hybrid knowledge between engineering, computer science and social sciences. A lack of reflection in this area could lead to omissions in realising the potential of smart grids in particular: for example, some stakeholders not only try to slow down this development, but also do not engage in cooperation due to communication barriers among the disciplines.
- Instead of trying to expose supposedly noble or malicious interests and motives of stakeholders, energy-SSH should try to focus on moderating communication between multiple stakeholders. In this way, SSH could contribute to the urgent need of coordinating the different interests of academia, the economy and civil society - a process intended by the European Commission under Horizon 2020 to foster successful energy transitions. Of special relevance could be a platform, or set of platform activities, focusing on knowledge management to: (1) enable reflexivity among usually closed disciplines and thereby (2) support the merging of different fields of expertise (e.g. engineering, computer science, social sciences). Energy-SSH, through its overall systems perspective with partial knowledge of technical realities, could prove suitable as a moderator for this process, as could EU or national political institutions.

For SHAPE ENERGY activities

- Within SHAPE ENERGY, *multi-stakeholder workshops* are of special importance regarding multi-stakeholder interests. In conducting them, we recommend following a problem-oriented approach that tries to expose scientific or operational problems of the energy system (e.g. optimisation, security of supply, affordability) that the local stakeholders put forward. This entails sensitivity for economic, legal, political or technical interests as much as the transformation of those stakes into SSH research problems as possible conclusions from the workshops.
- In connection to the former, the partners' *participant observation diaries* should aim at fostering common problem exposure and definition, especially when conflicting stakes are involved. This strategy would once again run counter to merely insinuating possible interests and motives tied to role expectations (businesses follow economic interests, politicians want power, and so on), but would also present an opportunity to analyse potential similarities for the common good.

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