Discussion Paper

From Energy Security to the Security of Energy Services: Shortcomings of Traditional Supply-Oriented Approaches and the Contribution of a Socio-Technical and User-Oriented Perspectives

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Traditional literature and policy approach to energy security focus on the security of energy supply. It is argued here that a supply-centric approach to energy security is too narrow to account for the complex nature of energy systems and tends to overlook energy users, their expectations from, interaction with and roles in future low carbon energy systems. From users' point of view, be they households, businesses or governments, the supply of kWh or oil barrels is often meaningless. What matters is not the source of energy, but rather the services provided by it. Therefore, securing energy services seems to be the public and the government's concern, and the security of supply is only one mean to achieving it. Stemming from science, technology and society studies, this discussion paper suggests that applying a multi-level socio-technical and user-oriented perspectives which focus on the energy services and considers also psychological, social and cultural aspects of energy consumption, could reveal new and overlooked actors, roles, means and strategies that may provide and contribute to energy services security.

Keywords: energy security, energy services, socio-technical systems

Background

Keeping the 'lights on,' the 'cars moving' and the 'economy growing,' which are seen by many as vital indicators for a thriving and healthy modern society, depends on functioning energy systems[1]. Interruption to the energy systems through technical failure, political reasons, higher energy prices or volatile energy markets are known to foster political and social unrest and disrupt economic growth (Olander et al., 2007). Securing a stable supply of energy, thus, becomes one of the highest priorities for many governments around the world (see for example, Hedenus et al., 2010; Kazantsev, 2012; Vivoda, 2012). International comparative public survey found that future energy sources and supply, in other words energy security, was rated by the public in different countries (including Australia, the UK, Belgium, Germany, Italy, China, Japan, South Africa, Sweden, the USA and others) as one of the key environmental concerns, higher even than climate change (Ipsos, 2011).

Today, energy systems need to comply with an increasing number of constraints posed by the economic, technical, social, political and environmental arenas. Energy systems need to respond to economic efficiency constrains and to be competitive and affordable. They also need to comply with environmental health and safety regulations (e.g. air pollution standards). Moreover, energy systems have to cope with the rapid increase in demand for primary energy sources, notably coal, oil and gas, in Asia and other developing regions (e.g. China and India's rapid growth); the depletion of conventional reserves of gas and oil (e.g. North Sea) along with the rise of unconventional energy resources (e.g. shale gas in the United States); the geopolitical instability in many oil and gas-rich regions which may have widespread implications on fuel supply (e.g. Nigeria, Sudan, North Africa, and the Persian Gulf); the reshaping of global energy markets (e.g. Chinese national oil companies play a more prominent role in global oil exploration and production); and the growing public awareness to risks and vulnerabilities of power supply technologies (e.g. Fukushima nuclear power failure). All of these compromise the ability to supply reliable affordable energy, and hence should be seen as a threat to energy security (Sovacool, 2011b).

The commitment taken by many states in the EU and elsewhere to decarbonise their energy systems in the next couple of decades (e.g. European Commission, 2011; Pielke, 2010: chapter 4), as a climate change mitigation measure, adds significant economic, technical and feasibility constraints to energy systems, which in turn, threat to widen the gap between energy supply and 'business as usual' demand scenarios (e.g. Skea et al., 2011). Future, low carbon energy systems could take various forms. For example, they may feature a centralized mode of power production (e.g. nuclear) or a decentralized one (e.g. renewable); they may include a greater interface with energy consumers (e.g. via demand management, smart metering, smart displayers); they are likely to involve different types of interactions with households and communities (e.g. utilities not only selling but also buying electricity from household/community owned generators); likewise, private and public transport may be bio-fuelled or electrified.

Those changes to the existing energy systems challenge the adequacy of the current supply-oriented governing structures to deliver low carbon energy, and introduce new types of threats and opportunities to the security of the systems (Skea et al., 2011). To illustrate, successful energy demand management schemes, which aim to improve energy security by modifying consumers' demand for electricity during 'peak time' through economic incentives or public education, rely on consumers' responsiveness. Lack of responsiveness to incentives (e.g. to price signals or information), therefore, poses a threat to energy security.

Science, technology and society (STS) scholars have acknowledged the complex socio-technical nature of energy systems and investigated the interactions between energy infrastructures, energy users, energy behaviour, society and cultures. They highlighted the importance of acknowledging those interactions for better understanding the ways through which energy systems have been shaped, and more recently in the context of the transition to a low carbon society (see for examples, Nye, 1998; Nye et al., 2010; Verbong & Geels 2010; Wilhite, 2008). However, the issue and concept of energy security did not receive enough attention from STS scholars. While a few did examine related issues (e.g. Bennett, 2005), they focused mostly on various aspects of failures in energy supply systems. In this discussion paper I argue that energy security scholars and policymakers alike perceive energy security as a supply issue and therefore fail to incorporate the STS insights regarding energy demand and energy practices into the discourse and policy. I suggest that approaching energy security from energy services point of view allows accounting for those insights and opens up a room for overlooked energy security strategies.

The paper begins with a brief review of the traditional academic and policy approaches to energy security. It then points at the weaknesses of such approaches and suggests the security of energy services as a complementary approach. The paper concludes with highlighting some insights for energy services security strategies.

Energy Security: Academic and Policy Perspectives

Definitions of energy security vary (for a review of 45 definitions for energy security see Sovacool, 2011a:3-6). One typical definition, taken from the Australian government (2011: 2, emphasis added), frames *energy security* as "the adequate, reliable and competitive *supply* of energy", where *adequacy* is "the provision of sufficient energy to support economic and social activity"; *reliability* is "the provision of energy with minimal disruptions to *supply*"; and *competiveness* is "the provision of energy at an affordable price that does not adversely affect the competiveness of the economy and that supports continued investment in the energy sector". Others add parameters and aspects of *equity*, *environmental concern* (International Energy Agency, 2011) and *public acceptability* (e.g. Jansen, 2009; Sovacool, 2011a). Public acceptability refers to social, psychological and cultural barriers, such as negative perceptions of generation technology that may hamper supply.

The rapidly growing literature on energy security elaborates on the different threats to the security of energy supply. The principal concerns are economic, political and environmental. This literature concentrates on resources (e.g. gas, oil, coal, renewable) their costs and markets; on international relations between exporters and importers of fuels and resources; and on technical, infrastructural and technological aspects of energy systems (e.g. Yergin, 2006; Chaudry et al., 2009; Hughes, 2009; Kruyt, et al., 2009; Claes, 2010; Pascual & Elkind, 2010). A similar approach is taken by leading supranational organizations and agencies (e.g. World Economic Forum, 2006; International Energy Agency, 2011), and by national governments around the world (e.g. Department of Trade and Industry, 2007; Australian Government, 2011).

Inevitably, a supply-side orientation to energy security leads to indicators, policies and measures that aim to diversify the fuel mix in order to avoid the dependency on a single fuel; diversify foreign suppliers and fuel transport routes, in order to reduce the exposure to various events (natural, social or political) at supplier's state or region; as well as to promote investments in technical elements of the system in order to improve efficiency of supply and prevent technical failures along the supply chain. Accordingly, the main actors that take part in the policy forums and that compose the governing structures of supply-oriented energy security are nations, international institutions/agencies, big energy/fuel companies and technology providers (e.g. Chester, 2010). Energy users are nearly absent from the energy security literature, practices and governance and have been so for many years.

One exemption to this practice could be found, to some extent, in the literature discussing events of severe failure in different components of the supply system, which lead to significant reductions in energy supply and/or blackouts, and which in turn result in broader societal and economic impacts (e.g. Bryan PaSquier, 2011; Trentmann, 2009). However, while in such events energy consumers are recognised as crucial for successfully implementing a package of demand-side energy-saving measures, their role ends when the system is restored and consumers are expected to resume immediately to previous demand patterns.

Another exemptions to this practice are policies and efforts to improve end-users' energy efficiency. Some estimate that more than 70% of global energy use could be saved by achievable demand-side changes to passive energy systems and efficiency (Cullen et al., 2011). Evidently, energy efficiency has been recognized by policy makers and energy providers for many years now as a cost-effective mean to improve energy security (e.g. Department of Energy and Climate Change, 2012), and more recently, as a mechanism to enhance other societal, economic and environmental benefits (Ryan & Campbell, 2012). However, despite being cost-effective many barriers and obstacles impede a wider installation of energy efficient measures, processes and appliances by small, medium and large end-users (Thollander et al., 2010). Different policies and programmes were issued in order to overcome these barriers with varying levels of success (World Energy Council, 2008). Energy efficiency policies often fail to alter the socio-cultural contexts which interact to effect energy use practices (Nye, 1998; Wilhite, 2008), and the heavy emphasis they put on techno-economic aspects of efficiency does not result in the expected savings. Indeed, despite the tremendous improvements in energy efficiency, a rebound effect[2] often offsets much of the claimed efficiency-related savings of both energy and emissions (Sorrell, 2009; Sorrell et al., 2009; Gonzalez, 2010; Druckman et al., 2011).

From 'Energy Security' to the 'Security of Energy Services'

Barrett et al. (2010: 4) point at the need to widen the scope of energy security analysis: "The level of security is not determined by supplies alone, but by the immediate balance between supply and demand and the longer term trade-off between more energy security and environmental considerations (e.g. more wind farms vs. open spaces or more nuclear power vs. global security and nuclear proliferation)". They suggest that a comprehensive understanding of energy security requires a socio-technical and interdisciplinary approaches. Approaches that take into account the interrelations between society, drivers for energy demand and a wider scope of energy security variables.

Along those lines, this paper suggests that a comprehensive understanding of energy security in a low carbon society requires the employment of a socio-technical and user-oriented approaches that concentrate on *energy services*, and the *security of energy services*.

The socio-technical approach refers to the relations and interactions between social and human aspects of a system and the system's institutional and technological aspects. This approach acknowledges that changes in a system are not determined by a single component (technical, behavioural or social), but rather are co-evolved and co-shaped by all of them (Hughes, 1987). Such an approach calls for the examination of energy security from new angles, which complement – rather than replace – traditional approaches that tend to concentrate on physical, political, economic and technical aspects of the energy system. In particular, the paper highlights STS contribution to our understanding of energy users and energy consumption.

To this end, energy services are the benefits – or functions – that energy carriers produce for human wellbeing. From the users' point of view, be they households, businesses or governments, kWh or oil barrels are non-tangible and often invisible, meaningless units. What matters is not the source of energy but, rather, the services provided by it. In effect, securing energy services seems to be the public and the government's goal, and ensuring th*e security of supply is only one mean to achieving it*.

Examples of energy services include heat for cooking, cooling for refrigeration, illumination for houses, power for water pumping and power to allow mobility, accessibility and communication. Energy services can be derived from a variety of energy carriers. For example, mechanical power can be produced from kinetic or potential energy of water, from kinetic energy of wind, from a liquid fuel, or from electricity. Energy carriers can be derived from a variety of primary sources; electricity for example can be generated from hydropower, petroleum, solar, or wind (Modi et al., 2005: 9).

A broader and more inclusive definition for energy services suggests the inclusion of *any useful output of energy input* (Kendal, 2008: 153). To illustrate, while illumination, cooling and heating services could be supplied by fuels or electricity (the narrow definition of energy services), they could also be provided via the design of passive buildings and spaces, which harness directly solar and wind energies (e.g. Kaan & de Boer, 2006; Schnieders & Hermelink, 2006). Likewise, significant contributors for thermal comfort are fabrics and clothes, which by means of insulation and ventilation better utilise energy embedded in the food that we eat. Unlike energy efficiency (i.e. using less energy from the grid to provide the same level of service), it is suggested here that low carbon energy services, such as thermal comfort, mobility, accessibility as well as others, could also be provided via means such as new consumption modes, cultural and social norms, behavioural change, and via various social and professional practices.

Energy services security (ESS) are "the extent to which the population in a defined area (country or region) can have access to affordably and competitively priced, environmentally-acceptable energy services of adequate quality" (Jansen, 2009: 7). This definition implies an end-use orientation that goes beyond the provision of energy to count also the ways in which energy is consumed. Because many of the energy services are demand driven, but are defined also by the supply system, exploring ESS requires the inclusion of psychological, social, cultural and political contexts in which energy is produced and consumed (e.g. Wilhite et al., 2003; Gram-Hanssen, 2008; Wilhite, 2008; Späth & Rohracher, 2010). Additionally, since provision and consumption of energy happen at different levels, ESS examination requires multi-level perspectives: from the top-down, i.e., suppliers and regulators' point of view; from the bottom-up, i.e., end-users' point of view; and from the middle-out, i.e., the point of view of actors who are neither energy suppliers nor consumers, but rather those who shape or construct various aspects of the ways in which energy is provided to end-users or used by them (examples include architects, building professional, town planners, social leaders) (see also Janda & Parag, 2013). This, in turn, calls for the deployment of a different set of enquiry tools than those traditionally employed in the study of the security of supply. A set of tools that also examines psychological, cultural and normative aspects of energy services, and ask questions such as who sets work-places dressing codes, what are the implications of these codes on energy demand for heating and cooling services, and what are the cultural functions of those codes in the work place; what factors impact mobility modes and preferences and what are the implications of these on the use of transport means and on the users themselves. Tools that analyse roles that state and non-state actors fulfil in shaping the demand and provision of energy services (e.g. private sector, NGOs, social networks, religious congregations, communities, opinion leaders, professional organizations, local authorities, etc.). Initial answers could be found in the STS and practice theory literature, which provides some inquiry tools and insights as to how energy-related technological, social and cultural aspects interact in the construction and shaping of everyday energy practices (e.g. Shove, 2003; Gram-Hanssen, 2008; Devine-Wright et al. 2010; Hargreaves, 2011; Devine-Wright, 2012) and essentially, everyday energy services. However, those insights were not framed, thus far, in an energy security context or framework and were not incorporated into the energy security research, discourse or narratives.

Significant challenges remain to identify the various energy services; understand how, what and who shape behaviours, norms and practices related to those services; and envisage what would make low carbon (and often off-the-energy-supply system) energy services becoming acceptable, desirable, widely available and used by the public.

Energy Services and Resilience

Resilience ought to be a pivotal concept in this discussion, as it is a key concept in energy security literature (e.g. McPherson et al., 2005; Pascual & Elkind, 2010; Skea et al., 2011; Sovacool, 2011b). According to one definition, *resilience of energy systems* refers to their ability to "tolerate disturbances and to continue to deliver affordable energy services to consumers" (Chaudry et al, 2009: iv). Resilience is most commonly viewed as a *system's attribute*: "a resilient energy system can speedily recover from shocks" (e.g. short-term interruption in electricity supply) and can "provide alternative means of satisfying energy service needs in the event of changed external circumstances" (Chaudry et al., 2009: iv). A supply-centric energy security approach leads to narrow resilience strategies that are implemented by a relatively small set of actors, and in which consumers have – if at all – a small and short term role.

When applying the broader definition of energy services security, resilience is understood as a *societal* attribute and therefore includes not only the suppliers of energy but also the consumers and intermediates of energy services. Hence, securing energy services requires identifying actors and roles which could response to interruptions in those services. It also calls for the examination of new resilience strategies, which incorporate a wider set of stakeholders and consider new roles for various, overlooked actors.

Insights for Energy Services Security Strategies

Energy security is a major concern for governments and societies, in particular given the increasing pressures on current supply systems, the required transition to a low carbon economy, and the uncertainty surrounding these processes. Securing energy systems is costly: trillions of dollars are invested around the world by states and the private sector in different elements of energy systems. Most of these investments are in technical elements of the system (e.g. 'smart grids', infrastructures, nuclear, renewables) and while some of these technical elements contain components of user-interface to some extent (e.g. smart metering and energy information displayers) their relevance is primarily to energy suppliers (e.g. for more efficient demand management). Significantly less attention and resources are allocated to other than techno-economic demand reduction means or to the funding and promotion of low carbon energy services that could be provided by technology, social innovation, practices and cultures (to illustrate, providing mobility services via car sharing modes or other modes of collaborative consumption of energy services). Likewise, agents of change outside the realm of the energy technology experts, such as those who influence our daily energy services norms of consumption, lifestyle and culture (e.g. Parag & Janda, 2010), are largely being overlooked. To illustrate, agents of change might be found within the fabrics and fashion industries, which via fabric technology, fashion and dressing culture and norms could contribute new approaches for achieving low carbon thermal comfort.

Events, such as the Fukushima nuclear power disaster in Japan, which resulted in a dramatic reduction of electricity generation capacity, expose the numerous everyday life routines and practices which are electricity dependent (see also Trentmann, 2009). At the same time they highlight the huge role that large and small energy consumers could play in building a society resilient to energy services security threats. While the energy supplied by the electricity grid was limited, new and innovative ways have emerged in Japan for providing energy services, and many daily practices had changed, including dressing codes in offices, mobility modes, lightning standards and consumption patterns (e.g. Stanford, 2012). Many of the resiliency strategies emerged from the bottom-up and from the middle-out, and involved state and non-state actors, which were not supplier, energy experts or the regulator. Those actors and practices were neither the 'usual suspect' to be included in energy security governance structures nor tools to be considered in energy security policy strategy.

The traditional approach to energy security seems to perceive such demand side 'saving energy in a hurry' strategies (Bryan PaSquier, 2011) as valid and justified only for a short period of time or as emergency practice. A challenge for policy makers would therefore be to closely examine such bottom-up and middle-out emerging sustainable low-energy and off-grid energy services, and to recognise and support those that could be maintained. And this, as highlighted by STS scholars, might also require changes in energy related cultures, norms and practices at both policy and users levels.

Given the threat of dangerous climate change, broadening the policy scope from focusing nearly solely on securing the supply of *more* energy to considering also securing the provision of adequate *energy services* might point at new and overlooked directions for promoting resilient, low carbon, societies: societies which are less dependent on the energy grid but at the same time enjoy high level of energy services. For achieving such thriving low carbon society there is a need for actors who can 'build' more 'Negawatts' (power stations avoided) instead of Megawatts (power stations built to meet escalating demand) (Lovins, 1989)[3]; actors who can help constructing sustainable, secure and resilient energy services.

Table 1 highlights the additional components and elements that STS and user-oriented perspectives contribute for the study and perception of energy security.

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Table 1. The contribution of user-oriented and socio-technical perspectives to the study of energy security.

Perspective	Traditional	Socio-technical and user-oriented
Main concern	Security of supply	Security of services
Relevant actors	Energy suppliers Regulators Governments International institutions Technology providers	End-users State and non-state actors Off-grid services providers Actors that shape norms and practices
Means	Regulation International relations Incentives Technological innovations Improved energy efficiency	Energy related behaviour, norms and cultural changes Provision of low carbon energy services via social innovation New modes of energy consumption
Main strategy for energy security provision	Top down	Bottom up Middle out Both supported by top actors
Resilience	An attribute of the energy system	An attribute of the society
Disciplines	Economics Political science International relations Engineering Geology	Psychology Sociology Planning Design

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Notes

1 Energy systems, to slightly rephrase one working definition produced in the UK, can be characterized as "set of technologies, physical infrastructure, institutions, policies and practices", located in and associated with a state, "which enable energy services to be delivered to … consumers" (Chaudry et. al., 2009: iv).

2 Rebound effect describes a situation in which (some) money that was saved as a result of a new energy-saving technology, is used to increase the consumption of the same (direct effect) or other (indirect effect) energy consuming goods. This, in turn, partially offsets the initial energy-saving potential (Sorrell, 2009)

3 Negawatt power is a measuring unit theorized by Amory B. Lovins (1989). It indicates how much electric power has been directly conserved by means of higher energy efficiency, energy saving, or both.

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