15th European Roundtable on Sustainable Consumption and Production
(15th ERSCP)
2012, May 2 – 4, Bregenz, Austria

Socio-technical configurations for green growth

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Abstract

Science and technology studies analyses of infrastructures and technical systems have consistently pointed to the deficit of exclusive supply side perspectives which have long dominated economic and policy thinking and to the inseparability of technological artifacts and social practices, social understandings of normality, actor interests and expectations and broader cultural and institutional contexts. Such perspectives would help us develop a better understanding of requirements for green growth, a notion which has recently gained political esteem and attention and stresses the aim to move beyond an exclusive focus on GDP and quantitative growth orientation. Implicitly such a re-orientation also means putting more emphasis on sufficiency and the limits of resource-consuming growth in addition to efficiency improvements and ecological modernization. A socio-material integration of production-consumption systems helps us bridge the separation of strategies to increase production efficiency and more sustainable lifestyles and consumption patterns.

Keywords: socio-technical systems, infrastructures, energy efficiency, behaviour

Introduction

Discourses about efficiency and sufficiency as strategies for sustainable development reveal a split between a technology-centred and a behaviour-centred view (Brand, 2005). Technology is the core 'agent' in increasing the efficiency of production processes (cleaner production) or reducing the resource consumption of products (e.g. energy-efficient appliances). Critique of "technological fixes" often points to this belief in efficiency solutions as a panacea for sustainable development. Sufficiency on the other hand, i.e. the quest about what level of output or services is enough, is mainly portrayed as a social question. It addresses the "quality of life" as a guiding principle and involves some personal understanding of the externalities of consumption practices, reflexion about one's own 'true' needs to live a good life, and a sense of responsibility of the individual for the effects of his/her own actions (Muller, 2009, 1083). Approaches such as practice theory succinctly criticise the individualistic focus of such understandings (see e.g. Røpke, 2009) and point out how practises of consumption are embedded in institutional and infrastructural contexts and are closely linked up with other practices and broader social changes, such as notions of cleanliness and normality (Shove, 2003). In this context, we are particularly interested in the mediating role of technology not only for efficiency improvements, but also for sufficiency-based strategies of sustainable consumption and sustainable development, in general. The often derisive talk about 'technical fixes' should not lead us to discard technology as an important element of sustainable development strategies. It is rather the false opposition between social and technical solutions which should be overcome.

Strategies for green growth are aiming beyond an exclusive focus on GDP and quantitative growth orientation and rather emphasise aims such as sufficiency, or quality of life as well as sustainable lifestyles and consumption patterns. From our point of view, such strategies should not only focus on institutional and cultural conditions framing our economies, but should also focus on the roles of artefacts and material infrastructures in generating more sustainable practices of consumption and product use. The core question we want to pose in this paper is whether it is possible to identify and devise socio-technical configurations of production and consumption which inherently link energy and resource efficiency with a greater inclination towards sufficiency oriented (social) practices. Simply put: Is it possible to build social and political qualities such as a voluntary limitation of consumption (sufficiency) into socio-technical systems of provision? And to which extent does the choice, type and design of technology have an impact on social practices generated within these systems?

To give an example: A combination of large-scale wind power development with policies and institutional provisions for sustainable consumption (information campaigns, price incentives, etc.) follows separate technical and social agendas and probably does not inherently give rise to sufficiency practices. Micro-generation, one might argue in contrast, facilitates changed usage patterns of electricity and heat and could be seen as an example of a socio-technical configuration which more closely integrates sustainable practices of production and consumption. This may not only be an issue of scale: a closer socio-technical integration of production and consumption can also be achieved e.g. by energy cooperatives and joint ownership of renewable energy production. Other examples would be neighbourhood energy management systems combining and balancing different modes of consumption and production in spatial vicinity or, in the field of sustainable food systems, urban gardening in various organizational forms.

We do not propose that such forms of socio-technical integration of efficiency and sufficiency are a substitute for large-scale renewable energy generation or sustainable food production, but they may serve as important models and orientation marks for green growth strategies, understood as qualitative sustainability improvements without growing resource consumption. Such integrated approaches may also make sustainable production and consumption more independent from changes in socio-economic contexts, such as times of financial crises and times of greater affluence. In this chapter we want to explore this idea further and build on our own empirical research in the field of energy and the built environment, but also take examples from fields such as sustainable food production and consumption.

We will start out in the next section with a short review of how science and technology studies have been dealing with the interdependencies of product/technology design and use from different perspectives. We will ask to which extent these ideas can also be applied to production-consumption systems in which technologies and sustainable consumption and use practices are intrinsically interwoven. In section 3 we will then discuss some cases of production-consumption systems, mainly in the field of energy and buildings, and ask in which way these socio-technical configurations shape our use and consumption of goods, particularly with respect to the issue of sufficiency.

The interdependency of design and use / supply and demand from a science and technology studies perspective

The interrelations of technology design on the one hand and social structures and practices on the other have been at the core of social studies of technology (STS) since its beginnings. Technologies and social structures are co-produced and mutually constitute each other. Social practices of using and consuming technologies and products are an essential part of this interrelationship. An important insight of STS thus is the inseparability of behaviour and social practice on the one side and technologies and material structures on the other. In real-world situations we are always dealing with socio-technical assemblages or systems. More radical changes in behaviour, consumption patterns or practices of use require the transformation of such socio-technical relationships. Before this backdrop, we are particularly interested in the extent to which characteristics of technology and product design have the potential to shape (un)sustainable consumption behaviour and how such insights can be used to establish socio-technical configurations which induce or are better compatible with sustainable lifestyles and behaviour.

Technological affordances

In this respect it seems interesting to re-visit an older debate within science and technology studies about the possibility of ‘inherent’ political or social qualities of technology. At a broader level, the history, philosophy and sociology of technology has addressed the impact of different types of technology on social structure and social practice since long time. An outstanding representative of such studies is historian Lewis Mumford, who already in the 1930s has written a universal history of technology and machine-like social structures and sees a certain idea of order culminating in the mega-machines of Egyptian pyramids and modern spaceships (Mumford, 1934, 1967) – or large-scale, hierarchical fossil-fuel based energy systems, we might add. While there were historic periods dominated by mega-machine technology and human organisation, Mumford also elaborates on alternative historic periods creating 'democratic' technologies, beginning with Neolithic techniques of cultivation to the 'polytechnic tradition' of medieval times with the water mill as its prototype. The 'idea' of the machine thus is deeply entrenched in the history and development of civilisation, in its organisation but also its ethics and aesthetics, and different types of machines are interdependent with different forms of (authoritarian or democratic) social organisation.

The embodiment of social structure and policy in technology has prominently been put forward also in Langdon Winner's – often disputed – article "Do artifacts have politics?" (Winner, 1980). One of his famous examples for the embodiment of power and authority in technology are the low-hanging highway bridges built in New York during the twenties under the supervision of master builder Robert Moses. The construction of these bridges kept off public transport (buses were too high to pass under) – and consequently poorer people – from wealthy recreational areas such as Jones Beach. As Winner concludes, this social and racial bias has been deliberately constructed into these bridges. "Many of his monumental structures of concrete and steel embody a systematic social inequality, a way of engineering relationships among people that, after a time, becomes just another part of the landscape" (ibid., 124). Winner speaks of a type of "‘inherently political technologies,’ man-made systems that appear to require or to be strongly compatible with particular kinds of political relationships." (ibid., 123) An example for such compatibilities would be decentral solar energy technologies as better compatible with egalitarian social relationships versus centralised nuclear or fossil fuel power plants.

Such ‘essentialist’ accounts of technology which attribute certain political or social qualities to technology have been strongly disputed by social constructionists who rather emphasise the enactment of social structures in machines. “The politics and values of technology result from the gaze of the human; they do not lie in the gauze of the machine. This does not mean that the machine is neutral. (…) Technological practices and descriptions of technology, by which we come to know it, necessarily embody social and political values, but these do not lie within the hard creases or soft folds of the machine. (Grint and Woolgar, 1995, 305) Seeing technologies as 'affordances' may be a way of reconciling constructivist positions stressing the ‘interpretive textual’ properties of technology and realist positions focusing on 'essentially technical' properties. As Hutchby puts it, "affordances are functional and relational aspects which frame, while not determining, the possibilities for agentic action in relation to an object" (Hutchby, 2001, 444). In this way technologies are conceptualised as both shaping the practices of humans and being shaped by it.

These disputes about specific social qualities of particular types of technology have not yet been put to rest. A recent book (Dolata and Werle, 2007) requests to “bring technology back in” and asks whether certain characteristics of technical artefacts or types of technologies open up particular corridors of organisational and institutional (re)structuring. Along these lines one can argue that institutional changes such as the deregulation of electricity markets have only become possible by technological changes such as smaller-scale gas turbines (CCGT) or the extensive use of information technologies, although closer scrutiny reveals how despite these techno-institutional compatibilities the concrete implementation of electricity markets has been re-shaped by strategic action, power relations and historic contingencies (Rohracher, 2007).

What does this mean for our quest for sustainable production-consumption systems? Although there is wide agreement that there is no deterministic relationship between technologies and social structures or practices, certain technologies appear to be better compatible with sustainable social practices than others. Climate impact is just one way of assessing the impact of nuclear power plants, they are also inherently related to a much more centralised organisation of the electricity grid, they induce institutional provisions in terms of security, policing, etc. Infrastructure systems including such technologies “orchestrate demand” (Chappells and Shove, 2004) in a way which necessarily puts more emphasis on the requirements of the supply side of the energy system. However, we have to ask similar questions in regard to other technological projects such as large scale solar electricity production, e.g. in the Desertec project. What are the affordances of such configurations of renewable energy technologies for the use of electricity and e.g. the internationally asymmetric roles and relations of users to the grid? How much leeway is there for institutional provisions and particular forms of implementation and embedding of such systems to overcome some of these affordances and create sufficient flexibility for sustainable practices of electricity use?

Agency as a quality of hybrid networks

A different tradition within STS research, actor-network theory, provides a more sophisticated but also more abstract view on the role of artefacts and technology with respect to social practice. The core point is that agency (and thus also the possibility of more sustainable practices) becomes a quality of socio-technical assemblages as a total and can neither be attributed to human intentionality nor technological affordances. Networks as hybrid actants consist of humans and non-humans and are ordered and held in place by processes of translation. Micro-generation at household level, say a PV panel with grid-integration, constitutes such a hybrid network of generation technologies, meters, grid connection as well as household members as users, grid operators, green electricity companies, etc. and attains particular forms of agency within the electricity system. Latour proposes four different meanings of technological mediations that are at work in such hybrid assemblages (Latour, 1999, 216ff). The first one is a programme of action, a sequence of aims, steps and intentions that can be described from the perspective of both agents, the human and the non-human artefact. In our micro-generation assemblage the user becomes an electricity producer interested in using as much as possible of this energy in his/her own household or selling green electricity at a premium price, while incumbent utilities may try to make it as difficult as possible for the micro-generation owners to get permits and sell electricity at a good price. The micro-generation plant, the grid and ICT control structures are inherent part of these aims and programmes of action such as the user as power producer or load manager of his/her household electricity system. These technologies ‘translate’ the user by orienting and configuring his or her interests and action strategies.

This leads to the second meaning of technical mediation: agency is a quality of associations. Even if one of the actors is granted the role of a prime mover, this should not make us forget the necessity to explain action by the composition of various forces. Acting, and this is one of the core points of ANT, is not the ability of humans alone, but the ability of an association of actants such as the ones described above. The third meaning of technical mediation is folding up time and space. Through a procedure of black-boxing the joint production of actor and artefact, the networks that lie behind, is covered up and disappears from sight. Only as long as new technologies, products or services are in the making, are mal-functioning or become problematic for other reasons, such networks and programmes of action have to be negotiated, disputed etc. Over time they become 'normal' such as the current configuration of our electricity system which are taken for granted although they embody a history of conflicts, changing social relations, institutionalisation and technological development (see e.g. Hughes, 1983, on the making of our electricity system and the different cultural contexts – e.g. the earlier role and autonomy of communities over grids and power generation – which defined what a 'normal' electricity system would look like).

The fourth and final meaning of technical mediation is crossing the boundaries between signs and things. Thresholds on roads in residential areas, to take a different example, translate the aim of drivers from "Drive slowly in order to be no danger for children crossing the road" into "Drive slowly to take care of your shock absorbers" (Latour, 1999). This delegation of morality to things is not a translation of meanings but the translation of an action (slow down cars) into a different kind of expression. In our case we might argue that 'morality' such as efficient use of energy is translated into an interest to adapt energy use behaviour in order to use as much as possible of the self-produced electricity and not sell it cheaply to the grid operator.

Conceiving sustainable production-consumption systems in the relational perspective of actor-networks also means that the inside-outside distinction of systems breaks down. Garud and Gehman (2012 in press) nicely show how such a shift in analytical perspective also may change our understanding of sustainability. While in an evolutionary perspective sustainability is portrayed as a more or less definable aim for system transformation, in a relational perspective it rather becomes an emergent property of the actor-network which is much more fluid and part of the sense making processes between the actors involved. Emerging networks around electric vehicles are also a 'battleground' for new understandings of sustainability in transport and where such socio-technical systems could go.

The mutual shaping of design and use

The delegation of 'programmes of action' to technologies (Latour, 1992) which we have discussed above is closely related to the notion of scripts as coined by Madeleine Akrich. What is 'inside' and 'outside' of an object, i.e. what programmes of action (such as sustainable use practices) are delegated to an artefact and what is left to the competencies of other actants is negotiated in an interactive process. On the one hand innovators 'inscribe' their visions of the future 'world' of this object (e.g. the aspirations and competencies of users, but also assumptions about politics or morality) in the technical content of the new object. The end product of this work is a kind of script or scenario, an "attempt to predetermine the settings that users are asked to imagine for a particular piece of technology and the pre-scriptions (notices, contracts, advice, etc.) that accompany it" (Akrich, 1992, 208). This is what Woolgar succinctly calls 'configuring the user' – "defining the identity of putative users, and setting constraints about their likely future actions" (Woolgar, 1991, 59). Users may come forward to play the roles envisaged by the designers, but they also may define roles of their own. As Akrich's (1992) case study on the introduction of a central electricity system in Ivory Coast shows, these technologies indeed define to some extent the space in which actors move and interact and they prescribe new relationships between the user and the state (which is rather obvious in the case of electricity systems). As the examples show, efforts have to be taken to implement the technical scripts according to its original intentions (e.g. by combining the agreement of villages to install an electricity network with other advantages and projects) and still the outcome may be different, as users find ways around certain prescriptions. While technologies open up certain corridors of preferred practices of use, they do not determine it. In an analysis of the privatisation of the electricity system in Nicaragua, Julie Cupples (2011) shows how the introduction of electricity meters as a core "programme of action" in a neo-liberal electricity system organisation were turned against the privatised electricity distributor who was accused of illegal and unfair billing practices by electricity consumers.

These examples of shaping electricity systems vividly demonstrate how the establishment of (sustainable) socio-technical configurations is mutually shaped (sometimes in contentious ways) by different logics of design and use. Both 'logics' restrain and focus the way technologies co-evolve with their social and institutional environments while at the same time they are important drivers for new developments (see Rohracher, 2006a). A 'logic of design' points to the narrowing down of options along the design process, through 'technological affordances' and the embodiment of scripts in artefacts, or the expectations, cognitive focus and path-dependence of technical development they create. In a 'logic of use', product use is also influenced by being part of a broader system of social and cultural practices which are not determined by the material qualities of a product. Uses of technologies and products are part of wider systems of meaning—meanings that often have not been anticipated by designers, meanings which may change over the life time of a product or which may be different for different social groups. Artefacts are important for mediating social relations and may help to constitute and maintain social structures and power relations. They are part of wider social categories and social practices, such as the (re)production of gender differences or forms of unsustainable behaviour, and thus intrinsic part of the ordering and classifying of culture and society.

Production-consumption systems and systems of provision

These insights of science and technology studies about the interrelations of design and use have been taken up in various system concepts of socio-technical relations organized around different focal issues. The multi-level perspective of innovation has introduced the notion of socio-technical regimes (and their possible transition to more sustainable configurations). Such regimes can be understood as socio-technical systems fulfilling particular societal functions, such as transport, housing or energy. This conceptualization brings with it a strong focus on use and functionality (Geels, 2004). The explicit consideration of demand and consumption and thus of users has been an issue in the transition literature since its beginning, and it has also acquired great prominence in the debates about innovation systems and associated policies in recent years (see e.g. Edler and Georghiu, 2007). Instead of a sectoral delimitation (Malerba, 2002), such systems of production and consumption rely on the concept of production-consumption chains, ranging from the resource base to the final products and services, i.e. cutting across several sectors.

While the regime concept in the multi-level perspective has a strong focus on institutions and structures, the related literature on systems of provision puts more emphasis on consumption and social practices of use. These approaches draw attention to the interaction of supply and demand structures and to "the variety of institutional, organizational and technical regimes that may potentially influence the way demand is constructed and managed" (Chappells, 2008, 263). Such a perspective also means "moving research, policy and practice away from a focus on end-users to consider more fully the range of social and technical actors involved in managing demand" (ibid., 273). Habits of showering for example are better explained by the "routinization of practice and its interrelation with broader socio-cultural changes that together reconfigure the way people go about cleaning bodies" (Southerton et al, 2004, 33), than by reference to technological change or individual lifestyles and behaviour. This 'practice turn' opens up new perspectives on sustainable consumption while at the same time acknowledging the role of technology and technical infrastructures in shaping practices of consumption and use (see e.g. Chappells and Shove, 2004; McMeekin and Southerton, 2012). Nevertheless, empirical analyses and examples of such systems of provision put their main emphasis not on the qualities and influence of these material infrastructures, but on socio-cultural contexts, the stability of routines and the interdependency of different social practices. As our previous discussion of the agentic role of technology in shaping (but not determining) practices of use has shown, closer attention to the material basis of social practice could deepen our understanding of sustainable consumption and production.

In our following empirical examples we will put special emphasis on the material dimension of (un)sustainable systems of provision and try to understand how particular affordances and qualities of technology may enable or restrain sustainable consumption and use practices within these systems.

Socio-technical configurations for sufficiency and green growth

In this section we scrutinize some examples of technology–social practice configurations; not so much as original empirical investigations, but rather by drawing on some cases from literature and our own research. These cases shall help us frame some questions regarding the role of technologies in sustainable production-consumption systems and open routes for further investigation.

A case we have alluded to earlier are micro-generation technologies at household level. In particular we have investigated the development of solar thermal collectors in Austria (Ornetzeder, 2001; Ornetzeder and Rohracher, 2006), as well as roof-top photovoltaic installations and combined heat and power generation (CHP) with a pellet heating system and attached Stirling motor (Rohracher, 2006b). Solar collectors for water heating underwent a remarkable growth in Austria since the early 80s resulting in one of the highest collector areas per capita worldwide and the development of a collector industry which supplies around a third of the whole European market. What is particularly intriguing about this case is its roots in a civil society movement for the self-building of collectors which kick-started the market (originally in opposition to professionals) and led to a series of technological improvements such as the integration of collectors in roofs as well as the use of solar collectors for (partial) room heating. While broader contexts and discourses such as the oil crises in the 1980s and environmental motivations did play a crucial role for driving this development, many users and self-builders were also motivated by a range of other issues such as cost savings, tinkering with technical installations, or the joy of working collectively in a group of like-minded people. Eventually and as installers acquired the necessary competences, the self-building projects were substituted by commercial installations. As it turned out, solar-collector users (and even more so, self-builders) changed their hot-water-use-behaviour in reaction to these technologies – they often eagerly metered and controlled the heat generation from their collectors and developed an intense awareness of how and where they used and actually needed hot water and how they could maximize the share of regenerative heat in their overall warm water usage by e.g. adapting their showering behaviour. With respect to our overall topic one can state that the technology used for water heating shaped the social practice of using hot water in households. In many cases it made this practice more sustainable, but it always contributed to rethinking and problematizing existing practices which had to be adapted to the new situation. However, it is important to notice that these reconfigurations of water using practice not only were driven by the characteristics of the technology, but also of broader discourses about the need to replace fossil fuels, environmental concerns and the role solar collectors might play in this context. Interactions at a local and regional level were at least as much important: the organization of self-building groups and ensuing identification with this technology, the pride about international and national recognition and environmental awards for these activities, and the visibility of these technologies and interaction with neighbours and other locals about the advantages and disadvantages of using such technologies. As emphasized by STS theories, the practices of use of such technologies as well as the collective agency of adopting and integrating such technologies can only be taken into account if we recognize the interrelation of artefacts (collectors, technical integration in heating system), competencies (of professionals and users), broader discourses (oil crisis, environment), intermediary organizations facilitating self-building (the Association for Renewable Energy as an outcome of the self-building movement), a tradition of collaboration in the region etc. Only this hybrid network generates sustainable changes in energy consumption practices we are looking for.

Similar observations can be made with electricity production from roof-top PV panels and micro-CHP. In this case we studied the attitudes and behavioural changes of a sample of 'solar partners', who were supplying PV electricity to a green electricity company (oekostrom AG, Austria), as well as a sample of households with wood-pellet heating about the prospect of additional electricity generation with a Stirling engine attached to their pellets burner. Similar to the solar collector owners, PV users had a high emotional attachment to this technology; they installed programs to visualize electricity generation from their own plant and tried to adapt their behaviour to make as much use as possible from their 'own' electricity. Some PV owners e.g. reported that they would rather use their washing machine during the day when the sun was shining, and one user even pointed out that she tried to refuel her electric car particularly during sunny spells. In all cases, interviewees pointed to the linkages between electricity production and environmental loads and showed a high awareness of their own electricity consumption. Similarly, pellets stove owners were most intrigued by the idea of electricity self-production in combination with their heating system and by the resulting independence and autarky - also in case of an electricity black-out (which in fact would render their heating system obsolete). Again, we found connections between electricity generation technology and sustainable social practices of electricity use. In addition to the solar collector example, self-production of green electricity can be configured into different product-service models: a configuration predominantly serving one's own household demand (with connotations of autarky and savings for buying electricity), as part of a utility controlled virtual utility (with the supplier being able to virtually control electricity production in the household according to their demand) or by producing green electricity compensated with regulated feed-in tariffs (implying that the whole production has to be sold to the grid operator). These models are also distinct at the technical level in the way they are integrated and managed within the wider grid system. They are linked to different configurations of demand (autonomous producer; user as 'utility partner', or user as seller of green electricity to the state). Users with an interest in self-supply showed the highest propensity to change use practices, while feed-in tariffs rather seem to be driven by a mix of public good orientation ('contributing to an increased green electricity share') and economic interest (pay-back times). The 'virtual utility configuration' was seen most critical by users – they were not sure how much to trust the utility or whether they should grant them access to (and control over) their micro-power plant. The main motivation for this third case was a purely commercial one. Again we find that sustainable use practices are strongly shaped by the different institutional and organizational relations (regulations; user-utility interaction), values (self-supply; environment) and complementary technical systems PV technologies are embedded in. It appears to be a quality of micro-generation technologies to open up corridors for such kinds of energy efficient, autarky, and sufficiency oriented social practices, notwithstanding the influence of different social and institutional framings.

If we compare micro-generation in households with large-scale renewable electricity supply as in off-shore wind or Desertec-style solar electricity power plants as mentioned earlier in this paper, it seems obvious that demand and resulting social practices of use are configured differently in such systems. The more direct involvement of users in micro-generation systems and the increased flexibility in developing 'customized' demand configurations (in interaction with the local utility or as self-supply) can be more directly connected to sustainable practices of use than large scale systems which rather lean themselves to other kinds of social and political relations such as potentially neo-colonial international relations (Desertec) or hierarchically controlled and managed super-grids. Still, even in these cases there are various possibilities of bringing users (at least virtually) closer to the source of electricity generation, e.g. through green electricity labels or joint ownership of renewable electricity plants. It is also important to see that household micro-generation and more centralized renewable electricity generation do not exclude each other but rather represent opposite ends of a transnationally integrated electricity supply system. Only in a rather weak way do the different qualities and affordances of these technologies generate particular practices of electricity consumption. Large-scale solar electricity generation may also be tied to more sustainable practices through green electricity certificates, while there are configurations of household micro-generation integrated into load management systems of virtual utilities may which rather detach these technologies from sustainable practices of household energy use.

Let us look at one more instructive example. Smart meters can be regarded as a technology which induces changes in the social practices of household electricity use – doubtlessly depending on the actor relations, institutions, values and other social practices this artefact is linked up with. In addition, the design of the meter (information provided, visualisation, etc.) and the integration into the home is important, too. As a result of these different configurations, smart meters may just improve load management of utilities and give them new opportunities to introduce additional commercial services, or they may give an immediate feedback to energy consumption for users in households (for an STS perspective on these devices, see Marvin et al, 2011; Coutard and Guy, 2007). They may also become elements of neighbourhood energy management systems which link together households in energy management and saving efforts and induce interactions and changes in collective behaviour. While these different types of configurations only make sense in different institutional and socio-economic settings, they also represent different "technical development pathways" as Marvin and colleagues point out (Marvin et al, 2011, 177) and modify social relations between electricity users and utilities as well as related social practices in a different manner. Moreover, these reconfigurations of social relations and practices can have different effects at different levels. Pre-payment meters as one of the different configurations may induce more energy-efficient behaviour at the household level, they are an element of a more individualistic and neo-liberal configuration of users within the electricity system. If a user cannot afford to pay for electricity with a pre-paid card, this is his or her individual problem, while disconnecting a household from electricity supply is also a problem of the community (e.g. municipality) and access to public services.[1] Similarly a more active integration of users in managing their electricity use efficiently may also mean different means of social control by the utility or an outsourcing of responsibility. In all these examples, smart metering is an active element of changing social practices and relations and of making them more or less sustainable – but does in no way determine outcomes. Even if smart meters are intrinsically linked to increased information on electricity use and enhanced efficiency management possibilities, they may rather further the interests of utilities in controlling the electricity system and locking in users, or they may contribute to a reduction in electricity consumption through changed practices of household electricity use. How this plays out in reality not only depends on the opportunity space created by these technologies, but on the embedding in socio-economic structures as well as the power, strategy and tactics of actors involved in making smart meters part of a new hybrid socio-technical assemblage. Much depends on the regulations policy makers put in place, the ability of users to voice their concerns and organize, or researchers pointing out possible consequences of the different pathways, such as data protection and privacy issues.

In a similar vein, we could turn our attention to the way electric cars may be an active component in shaping new mobility practices and the history of failed attempts of implementing these technologies in their 'cultural ambience' (Hård and Knie, 2001), we could work out how passive houses change dwelling and energy use practises, or how the establishment of alternative agri-food production chains or urban gardening change system of food provision. In all such cases it would be well worth investigating how different technologies, infrastructures and production processes shape social practices, but also how they unfold their change potential and gain more influence on mainstream consumption and use patterns.

Overall conclusion

Moving towards more sustainable systems of production and consumption and changing social practices of energy and resource use, in fact means reconfiguring socio-technical systems at different levels of structuration. Strategies to achieve such transformations are often split up into technology oriented strategies of improving efficiency and reducing environmental impacts over the lifecycle of products on the one hand, and socio-culturally oriented strategies of sufficiency, changing behaviour and promoting certain lifestyles.

In this paper we have used insights from science and technology studies approaches to overcome this split and analysing social and technical change as intrinsically connected. In particular, we have tried to engage more closely with the role of technology and artefacts. Even as the relevance of the material layer of production-consumption systems is acknowledged, often only lip service is paid to the specific characteristics and the contributions to agency of the technologies and products involved, or technological characteristics are left aside in order to avoid the allegation of technical fixes or technological determinism.

With our cases we have only touched upon some of these issues without going in any empirical or analytical detail. Still, we hope that our illustrative examples have shown that the aim of more sustainable consumption and use practices also requires a close look at characteristics and optional development paths of technologies and artefacts involved. As we have seen, technologies to some extent pre-structure social relations of use and sustainable social practices, they create certain affordances with respect to their social and institutional embedding, and they stabilize and solidify social structures, power relations or corridors of action (whether sustainable or not). At the same time they are ambiguous enough to leave substantial room for manoeuvring and interpretation by different social groups.

[1] However, as Coutard and Guy (2007) rightly emphasize, the consequences of such configurations are more ambiguous and many users prefer pre-payment meters for various reasons.

As these technologies shape practices, meanings and social relations, and they are in turn often used as a vehicle for furthering particular interests, power relations and goals (whether for utilities or users). One crucial challenge for achieving more sustainable social practices thus is the political, democratic shaping of technological development and the weaving of material and social elements together in constellations which frame the space for desired kinds of sustainable practices without determining them. How such socio-technical change processes are governed, how regulatory contexts are set, how institutions are built becomes a core issue of such a transition towards greater sustainability. As Maarten Hajer (1995, 27) puts it succinctly, “politics of sustainable development have become a matter of how this notion congeals, how the language of sustainability solidifies in new technologies, new fiscal regimes, new socio-cultural practices. Politics, then, is about dominating this process of translation.”

Green growth, post-growth or no-growth, we can conclude along these lines, not only needs institutional reform and new ways of life, it also requires a different kind of machinery.

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