The importance of socio-technical and community energy approaches to sustainability transitions: Key Concepts and examples.

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Abstract:

New approaches are needed to meet the challenges facing current and future energy systems. This paper explored this and how these challenges and solutions are critically social as well as technological. Crucial to this is conceptualising and developing these challenges and solutions in ways that account for how they are situated, operationalised and impact in everyday life, and the key actors and interdisciplinary dimensions and processes involved in this. This contention is enhanced by introducing three key frameworks and, for the former, redefining it. These are 'community energy', 'socio-technical' and 'social practices'. A complimentary account of all these is distilled in this paper to provide theoretical and practical guidance to actors in the energy and sustainability sectors for improving the success of related research, projects, policies and technologies. These contributions are enhanced further by showcasing significant real-world examples of why such approaches are needed, together with an empirical model integrating many of these insights and developments. The examples discussed are smart meters, energy communities, smart systems and the pioneering Project SCENe. This is an integrative approach that combines innovations for energy generation, energy research, storage, monitoring and interfacing, social and socio-technical interactions and demand-side management. The co-evolution of these shows the importance of partnership and dynamic energy approaches to embrace key actors, developments and the value of consumers and communities in research and development processes. The implications of this are significant and manifold and will be analysed and presented further in subsequent papers. This paper unpicks some of these. This includes that energy developments must work in harmony with the complexities of the systems within which they operate, that these are variously and co-dependently 'social' and 'technical', and theoretical and practical aids for this and optimising and reforming their energy and sustainability related interdependencies. These contributions are especially important with the changing energy era towards smarter grids, flexibility, and more sustainable, interdisciplinary, equitable and decentralised systems and services. Such changes are needed beyond the energy sector. The insights in this paper are thus pertinent for people, institutions and transitions beyond the energy sector. A socio-technical approach that considers the key social practices and diverse elements and partners implicit in their making and remaking is shown as both theoretically and practical invaluable for supporting this.

Keywords: 'Community energy'; 'socio-technical'; 'social practices; 'smart technology'; 'smart systems'

1. INTRODUCTION: towards a smart and sustainable energy transition

How we provide and use essential and everyday services is at the cusp of momentous change. This is a change to a greater penetration, role and reliance of more sustainable, automated and internet-based services. The energy sector at all key scales is an exemplar of this that is of pivotal importance for sustainability systems and technologies. Yet such 'smart' and sustainable transitions crucially depends on their social uptake: their commonplace and routine use, and the wider social structures that enable or constrain this. This social dependence and interplay between the social and technological remains the central barrier to the success of sustainability policies, projects and technologies (McMeekin and Southerton, 2012; Rodrigues and Gillott, 2013; Shove and Walker, 2007). Again, the energy sector is archetypal of this (Hargreaves et al., 2013; Spataru et al., 2010; Ulli-Beer, 2013).

For realising the potential of such transitions and technologies, therefore, pioneering approaches are needed that more fully account for the interdependencies that affect them (Geels, 2012; Markard et al., 2012). This paper introduces conceptual and practical frameworks that advance this, along with key supporting empirical examples. The approaches needed are approaches (i.e. methods, projects, policies) that encompass the key scales, processes, dimensions and actors. The key scales are the household, community and system-level. The key processes include how these factors interdepend and change and include how energy is provided, supplied, stored, used and managed. The key dimensions are simultaneously social and technological. The key actors are multiple. This paper argues, however, that communities and the collective interaction and impact of users and non-users are the most influential.

Through explaining why this is the case in relation to the norms and services we rely on everyday, those relating to energy being pivotal, we show how shifts to sustainable energy systems may be better realised. The discussion proceeds as follows. Section 2 introduces the crux of this paper's contribution: three key concepts - community energy, 'socio-technical' and 'social practice' - that support achieving this. These concepts, if critically defined, serve as an invaluable framework for real-world projects and are accordingly gaining considerable attention for matters of sustainability, energy, technology, society, design, engineering, governance and development. Section 3 then presents empirical examples that underpin this paper's contributions. These insights and examples culminate in presenting a pioneering energy approach, Project SCENe, situated in Nottingham, UK (www.projectscene.co.uk).

2. THE NEED FOR PIONEERING APPROACHES: community, socio-technical & social practices

How we provide and use essential and everyday services is at the cusp of momentous change. This is a change to smarter, more sustainable and interconnected systems that intersect forms of production, provision, consumption and management. The energy domain, particularly at the community level, is a pivotal archetype of the need and benefits of such integrated approaches. This is because it is here, at the collective-level of communities, essential resources, actors, processes and services critically intersect established routines and needs, wants and other dependencies, where their forms and impacts are especially formative and entrenched into key behaviours, spaces, customs and other cultural signifiers, and where the consumption patterns and social and technological interplays that co-constitute them are especially interrelated and consequential.

These insights emanating from branches of social science, and the ongoing challenges to improving the sustainability of energy systems and the success of related technologies, signify the need for new approaches and projects that address these interdependent factors (Lidula and Rajapakse, 2011; Seyfang and Smith, 2007; Wolsink, 2012). These interdependencies are between conventionally divided actors, dimensions, processes, disciplines and space and time considerations. Burgeoning concepts, however, can help bridge these gaps, both theoretically and in practical terms. These are community energy, socio-technical and social practices. This discussion will introduce a complimentary definition of these and provide examples of their added value for sustainable energy projects and technological development. This is because when done in certain ways, 'community' approaches can address key sustainability and technological barriers, provide new opportunities and do so with outcomes that resonate at scales far beyond conventional energy, project and community delineations (Seyfang, 2013; Sovacool and Dworkin, 2015).

Social cohesion, engagement, acceptance, wellbeing, resilience, regeneration and empowerment are prime examples (DTI, 2006; Evans et al., 2013; Hoffman and High-Pippert, 2005). These collectively are especially relevant for obligations and goals of sustainability, which involve energy technologies yet intimately entail various aspects of society. 'Community' energy, therefore, is a prime vantage or starting point from which to develop the prospects of smart and sustainable transitions and to realise the potential of such transitions. With the marked popularity and ambiguity of 'community' in energy discourses, policy, and interventions it is worthwhile clarifying now before proceeding further what this paper defines by this term, and further underscoring the value of this definition and vantage point. 'Community' and 'community energy' has problematically been taken to mean many different things. It is problematic as the lack of conceptual and practical scrutiny has led to a partial and uncritical involvement of 'community' in policy and practice, and consequently diminishing the impacts, equitability and legitimacy of many 'community' based approaches (Bäckstrand, 2012; Walker and Devine-Wright, 2008).

This, and solutions for it, is critiqued in detail in the context of sustainable energy, development, innovations and transitions by Cameron (2017). Such a critique reveals the essential yet often marginalised role of the social for influencing sustainability and technological developments through their key and myriad processes of innovation and

resource (re)interpreting, demand, use, non-use, learning, repurposing, adapting, improvising, resisting, disrupting, investing (more than monetary), diffusing, normalising and otherwise influencing technologies, projects and resources (Bijker et al., 2012; Latour, 1990; Lave and Wenger, 1991, 1998; Rip and Kemp, 1998). These processes occur most significantly at the collective scale, such as in societal groups and sub-groups, rather than at individual or macro-scales (Appadurai, 1988; Murray and Blackman, 2006; Rogers, 1963, 2010). Projects at this collective scale may thus more effectively tap into these key influencers of consumption, innovation and technological impacts and change. An effective definition of community energy must thus, although seldom does, encompasses these collective processes, and consider them throughout their dynamic purviews. This is thus a consideration beyond outcomes, prescribed dimensions and formalised set(s) of individuals or localities. In other words, it is instructive to consider the 'community' in community energy, as often having a geographical framing, yet being more significantly situated in collective and ongoing processes (Cass and Walker, 2009; Goodwin et al., 2009).

The importance of such processes are reinforced by considerations of sustainable energy and community energy from innovation (Seyfang et al., 2014), institutional (Geels, 2004), socio-technical (Walker and Cass, 2007), sociological (Guy and Shove, 2014; Wolsink, 2012) and socio-cultural (Gross, 2007; Walker et al., 2010) perspectives, and in the role of communities for improving policy and project making processes (Seyfang et al., 2014; Walker et al., 2007). Key reasons for this include improved design, acceptance, learning, financing models, use and thus viability and impact (Brown and Duguid, 1991; Guy and Shove, 2014; Wolsink, 2012, 2013). The importance of such is also reflected in the role accorded to communities in international and national policy following the Rio+20 United Nations summit on sustainable development, as well as processes identified in development theory, design and diffusion theories and engagement theory (Devine-Wright, 2012; Escobar, 2001; Griggs et al., 2013).

Key points to draw from such scholarship is that 'community' is not merely a geographical or spatial boundary or outcome, it is the processes and interconnections of a social group or groups that may transcend time and space through these processes and links, both social and technological. These are of great importance for sustainable energy and related technology developments and impacts as they include vital processes of social participation, use, learning, uptake, socialisation, needs, material cultures, consumption patterns and their embedding in and adjustment by the nuances and normalisation and reformation of these aspects and how they interact (Bourdieu, 1989: 21-22; Jackson and Thrift, 1995). 'Community', and the value of 'community energy', is thus intimately related to processes embedded in the social and how they may accordingly change and be scaled up or down and variously modified and influenced.

'Community', therefore, entails crucial factors typically overlooked in approaches to sustainability and energy, including those with a 'community' orientation. To highlight this and the importance of a comprehensive definition and approach to 'community' energy further, it includes the structural relations, barriers and diversity of the society in question, their norms, the array of organisations, institutions and infrastructures therein, how these are operationalised and (re)structured in everyday life, and the impact this has on patterns of resource endowments, choice, learning, behaviour, consumption and impacts (Bosshardt et al., 2013; Geels, 2004). Such factors shape and constrain individual and societal support, and influence meaningful policy, technology and project participation and impacts. Without critiquing such factors, therefore, 'community' involvement and 'participatory processes' can maintain entrenched and exclusive norms, ways of providing goods and services, and the use, ownership and elite capture of these essential resources, commodities and related projects and benefits (Glasbergen and Groenenberg, 2001; van der Horst, 2008). These tend to hence reflect the objectives of the powerful and focus on individualistic and spatially local rather than structural and collective factors (including of interests, identities, social pressure, norms, place, justice and moral responsibility) (Cloke et al., 2017; Devine-Wright and Devine-Wright, 2005; Devine-Wright, 2005). Yet such collective factors are key drivers of energy consumption, community and societal behaviours and capital, and how innovations are appropriated, situated and performed (Geels, 2002; Cameron, 2017). They are hence critical to energy project success, and to the social and technological patterning of sustainable energy behaviours and systems.

This perspective of community as process and plurality is gaining increasing traction for the benefits it signals for sustainability challenges. This indicates the processes and pluralities of social life as central to improving the form and function of projects and technologies. This is especially important for energy and sustainability as such matters are not standardised, static nor confined to the extraordinary and technological (Bijker, 2010; Elzen et al., 2004); they are dynamic and contextualised through the everyday social routines they are implicated in (Shove and Southerton, 2000; Southerton et al., 2004). How people in different cultures use and manage energy is a notable example (Lutzenhiser, 1993; Wilhite et al., 1996). Moreover, this perspective is consistent with the increasingly recognised importance of collaborative and socially inclusive project models, and the value of citizen-based co-design and co-research for improved sustainability interventions (Rogers, 2010; Strengers, 2011; Stringer et al., 2006).

This is achieved through the greater interactor, multi-stakeholder and user interactions, learning, support, capacity building and integration of dynamic and marginalised voices and practices that collective approaches enable (Reinicke, 1999; Reinicke et al., 2000). These are ongoing interactions between users and technologies, users and other key stakeholders, and users at a collective level (Geels, 2010; Oudshoorn and Pinch, 2003). Community-based approaches are, when most effective, premised on such aspects and provide a framing for addressing the multidimensional nature of energy and sustainability challenges and the sociologically and technologically engrained routines and relations that influence them (Shove et al., 2012; Cameron, 2017). Two final framings allow us and other key stakeholders and analysts to address these points. These are socio-technical and social practice frameworks.

Both highlight that the enactment of any activity (such as using energy and smart meters) and the functioning of any technology, always involves a range of social and material factors interacting systemically and dynamically. The interactions are co-dependent (such as individuals and society being influenced by technological arrangements and vice versa), such that classic 'human' and 'non-human' boundaries decay and socio-technical or socio-material framings are conceptually and practically more accurate and instructive. They are also co-dependent in scale and the interplay of actors, from the micro-scale of individual bodies, technologies, users and buildings, to the larger institutional and infrastructural scales that influence the performance and patterning of their socio-technical arrangements (Watson, 2013). The additional value of a practice approach is that it illuminates how this performance and patterning takes place (through socially shared and influential routines) and gives more emphasis to the variety of the socio-technical (including emotions, sensory perception, meanings, and competencies) within these routines and the socio-technical systems they constitute (Shove et al., 2012).

Both framings, therefore, afford more fully considering the complexities involved in sustainability technology development and transitions (Verbong and Geels, 2007; Watson, 2012). They advance other integrative frameworks, such as 'nexus' models, that also highlight the importance of inter-domain consumption patterns and their myriad actors, intersections, and the need for new relationships for less resource demanding routines (Weitz et al., 2014). A social practice framing supports this most fully by providing a simple unit of analysis that sensitises us to the situated dynamics of the above processes and dimensions and their relation to everyday life. This includes everyday modes of doing and exchange, and their embedded processes of learning and co-evolving by doing (Arrow, 1962), saying (Schatzki, 1996), using (Rosenberg, 1982) and interacting (Lundvall 2016). Empirical weight for the importance of these processes are numerable (Douthwaite et al., 2001; Douthwaite, 2002; Prahalad and Ramaswamy, 2000).

This processual and plural definition of 'community', agency and change is the one framed in this paper's definition of 'community energy'. This approach and multiplicities highlighted allies with the factors acknowledged in various paradigms as key to the development of any technology, not least renewable energy technologies (e.g. Berkhout et al., 2004; Smith et al., 2010; Wüstenhagen et al., 2007). Innovation theory, for instance, used to inform policy-making for sustainable technologies, focuses on diverse and dynamic 'elements and relationships which interact in the production, diffusion and use of new' innovations (Lundvall, 2016: 86), and do so via systemic processes revealing failures – or 'gaps' – and opportunities that need to be addressed (Foxon et al., 2005).

These concepts are useful for guiding policies and projects related to sustainability, energy and technology to the routines and underpinning processes and systems of society that shape their form, evolution and 'success'. Throughout these, the concern with users at a collective level through their constituting processes, notwithstanding the rich and often distinctive diversity within any society, allows us to better address key gaps and the role and forces of civil society as technology and innovation users, non-users, improvisers, and influencers (Foxon et al., 2005; Shove, 1998). Such considerations are key to the evolution and the success or otherwise of any innovation (Akrich, 1992; Seyfang, 2009; see also p3). In this refined and socio-technical definition of 'community energy', therefore, the influence of collective processes and actions of society and domestic energy users come to the fore as much as the materiality of the spaces and technologies implicated in these modes and influences of consumption. These all intertwine in the routines and norms of consumers. In other words, technological or material considerations always depend on human or social factors and vice versa. This duality includes what a relatively substantial number of people do, the collective and individual impacts of this, and thus further reinforces the value of 'community' in community energy, and reflexively and iteratively framing this through the social practices and their socio-technical elements and systems that shape and maintain them.

From this perspective we can realise new solutions for energy generation, storage, financing and demand-side management. This includes how civil society and different groups therein variously engage or not with energy projects, technologies and other types of innovations, how this influences others and the diffusion and potential development and impact of technologies, how they habitually reinforce their consumption demands and patterns, and to what extent these processes are fully rational, conscious and discretional or somewhat locked-in by routinised, automatic and systemic behaviours (Unruh, 2002; Wallenborn and Wilhite, 2014). In addition to the above points, this perspective has four key advantages for sustainable energy transitions and technologies.

The first is highlighted above: it focuses our analytical and practical gaze onto ordinary publics and their everyday routines. This reveals a key and often overlooked actor and a focal point for intervention. Hence although communities and society are now increasingly considered in energy projects and technological development, taking their collective routines as the focal point provides a way to improve key considerations (Cameron, 2017; Shove et al., 2012). This includes how to more effectively involve and influence domestic users of energy, which collectively account for a major share, 29%, of final UK energy consumption (UKGov., 2017). This importance reflects the push for better demand-side management and engagement, the extensive experiences of limited success with these, and the value of users in all project stages and wider value creation (Evans, 2011; Franke and Shah, 2003; Gilchrist, 2009).

The second core advantage of this community energy perspective is that it allows us to consider how the material world both shapes and is shaped by the social, and thus why any project intending to influence one must include both, and how they relate to the complex, dynamic and systemic, as well as the prosaic. The third key point therefore is that energy and sustainability solutions must include all the dimensions and actors that influence them through their underpinning processes. Failure to do so explains the limited diffusion, use and 'success' of smart meters and smart homes, with knock-on effects for smarter and more sustainable demand management and integrated energy systems at higher scales (Horne et al., 2015; Quinn, 2009). Hence, whilst the recent consideration of household-level actors

and dynamics in energy policy and programs in many countries is a progressive step for sustainable energy, the key now is the processes that interlink and influence them and sustainability over diverse boundaries.

The fourth core advantage is that this community energy perspective also indicates a good medium through which to do this: social practices. This medium affords a conceptual and practical approach that integrates all the points introduced in this paper. This includes the interplay of manifold elements, routines and structures within a society that inform what routines, including modes of consumption, are performed and how they may change (Shove et al., 2012). This interplay between the elements, practices and structures of practice render each, in their moments of practice and their influence on the performance of subsequent practices, socio-technical. The elements of practice in any society and culture thus influence the routines and structures of everyday life, which in turn influence the ongoing nature of the elements, routines and structures. The elements are broad categories encompassed by the terms 'meanings', 'materials' and 'competencies', as defined by Shove et al., (2012) in their seminal work. It is accordingly gaining considerable momentum in efforts to address significant social, technological and sustainability challenges (Hand et al., 2005; Shove, 2004; Shove and Spurling, 2013; Shove et al., 2009; Shove et al., 2015; Watson, 2012).

3. EMPIRICAL EXAMPLES: New approaches to energy in practice

For sustainable energy technologies, the unique value of the social practice and community energy approach defined above is for supporting the consideration of all the above points and how these and any technology or innovation may be operationalised and shaped. This operationalisation, how technologies or any innovation and project comes to function and gain impact, and how this may change, is through social practices. It predicates materialities as significant only through their appropriation within relatively mundane and collective practices, and the services and outcomes they enable and constrain. The social practices performed and intended to be performed, such as using smart meters, electric vehicles and shifting energy-intensive practices to non-peak consumption times, and how the performance and non-performance of these practices are variously structured and reformed, thus becomes the focus.

For reducing the energy sector and environmental cost of the thermal component of energy, for instance, a major policy consideration and one that has met limited success, it is not enough to address what energy sources and technologies bring heat or cooling into our homes and workplaces. This is the prevailing approach. The practice approach, however, reveals to us that it is the everyday routines of managing thermal comfort and their underlying factors that cause and may best address the problem of energy demand. This includes embedded norms, institutions, policy, media, skills, prejudices, affective comfort, feelings (e.g. freshness), convenience, meanings (e.g. of a warm home or shower), design and construction methods etc. - a socio-technical system of using less energy or not and routinely reinforcing this - (Gram-Hanssen, 2010; Kuijer and De Jong, 2012; Shove, 2003).

Looking then at the domestic and community scale, key social practices instruct us to analyse the material dimensions that are conventionally focused upon through the patterns of social routines and structures that construct them. Examples include the energy performance and energy demand in the built environment. Thus a technological or material focus, such as how to more resource-efficiently build, heat and power homes and workplaces, progresses to the socially-situated services and forms of interlinked routines and norms that underpin them. This takes analysis to the key routines and the socio-technical structures that inform and are reproduced by them, such as the temporal, spatial and cultural patterning of work practices influencing forms and patterns of consumption from commuting to cooking and showering. Focusing on practices thus provides a richer and more instructive account of why certain spaces are particularly resource-intensive, and why technologies and projects aiming to improve the sustainability of energy at certain scales often fail to realise their intended impacts. It follows, therefore, that technologies and projects do not configure users and effects (Winner, 1980); practices and their systems do through 'melding' their constitutive components, of which technologies are only a component (Watson, 2008: 8). Moreover, through ongoing practices, components become negotiated and reformed, including which projects and technologies are 'appropriate' and effective (Reckwitz, 2012: 255), and for whom. The performance of practices, however, is shaped by the socio-technical systems of which they are a part (Watson, 2013: 118).

Demand-side management and reduction, therefore, is most effective not solely by technological interventions such as smart meters, and economic measures such as increased and time-specific tariffing, but by also adjusting the routines within which technologies, policies and energy consumption patterns are implicated, and the socially made structures and sets of routines that most influence these (Shove et al., 2014a; 2014b). A prime sustainable energy challenge of modifying diurnal fluxes of demand to produce a more even load that better corresponds with the generation flux from renewables, may thus be partly addressed by strategies tackling the social dimensions of consumption patterns, such as their constituting practices, social scheduling and meanings. Examples include flexible working hours, work-based shower facilities, dynamic tariffing, smart homes optimising smart appliances, and home-based working to adjust what time the majority of a population goes to and from work, before and after which most in-home energy-demanding practices take place, the cause of the bi-diurnal energy demand spikes.

Another useful practice-related example to briefly reinforce this socio-technical approach took place in Japan. Here, energy consumption and related costs, emissions and national grid stress from air conditioning was best reduced and made more sustainable not by improving how this air conditioning was provided, such as through improved technologies, but via intervening in how much it was 'needed'. Energy needs, or demands, are socially constructed through the drivers of everyday social practices. This includes the cultural-specific meanings, expectations, feelings, norms, temporal and spatial demands, and the embedded habituated routines, institutions, technologies and wider

social and material infrastructures that meld and reinforce them (Maréchal and Holzemer, 2015; Walker, 2014; Walker et al., 2014). This need and the related energy consumption was reduced by addressing some of these factors, such as by employees collectively starting work earlier when temperatures were lower and wearing clothing more suited to the high temperatures. Changing these energy influencing customs of worktime and work dress was achieved through focusing on the drivers of routine action, that is collective factors such as societal norms and meanings via national-level narratives, campaigns, rewards and procedures endorsed by the key actors of state, civil society and employers (Janda, 2014; Shove et al., 2012).

The final exemplar that community-related approaches addressing collective and socio-technical multiplicities are pivotal for sustainable and smart energy system transformations is Project SCENe. Culminating from decades of research at the University of Nottingham (UoN), and the work of key partners, Project SCENe is a multi-partner scheme that integrates a range of key dimensions, sectors and actors to develop a more sustainable and effective energy project (Fox et al., 2017; Gillott et al., 2006; Jones et al., 2017; Parra et al., 2017; Rodrigues et al., 2016). It does this through providing integrated local renewable energy generation, storage, demand management, energy retailing, and policy lobbying and business-model development. The integrated and interdisciplinary approach enables key developments across these and is crucial to optimising energy systems. It also shows how energy schemes can and must combine with new and existing housing developments to substantially boost energy performance, emission and cost reductions, affordability, energy security and the viability of renewable urban energy schemes and community energy on a much larger scale.

Key to this is working intimately with key sectors and actors for sustainable energy – via local and national authorities and partnering with the award-winning housing developer Blueprint; the sustainability, policy and business model experts Smartklub; the engagement experts Stickyworld; smart technology developers and research and development expertise across these fields via the UoN and Loughborough University- using wasted space (council land, brownfield sites and rooftops, especially new build and third party owned) for urban PV electricity production; and involving communities and their energy practices. These combine with the largest community energy battery in Europe (2.1 MWh), a project-specific ESCO and in-home and community-level smart technologies, energy interfaces, engagement platforms and behavioural science methods to provide key grid services and a new model for enhancing the uptake, socialisation and impact of smart technologies and sustainable energy transitions.

The approach and ongoing experience of Project SCENe demonstrates that sustainable energy barriers and opportunities are inseparably social and technological. This includes how to develop and introduce first-of-a-kind partnerships and contracts that ensure high quality, zero costs and hassle to residents, a commercially viable model and mitigate risks to partners (e.g. related to temporary PV farm, rooftop solar, asset ownership, maintenance and management); how to engage with consumers and influence consumption cultures and patterns; and how to improve the functionality and uptake of smart systems and meters. Moreover, this project and the conceptual frameworks introduced in this paper also show how the social and technological developments related to these provide key infrastructures to catalyse further, long-term and considerable sustainability and energy developments. These infrastructures co-depend, include various levels of organisational, material and human-centric interconnections, routines and skills, and may be most effective when community developed or led, such as residential associations, community activities and smart energy practices. They collectively constitute a socio-technical system that indicates a key platform through which to improve the design and uptake of smart energy technologies, domestic consumption patterns and energy policies and projects. These and the wider developments they can support, such as related to electric vehicles, car sharing, business-models, smart appliances and smart health and wellbeing related services, are highly significant and reinforce the importance of community-based and socio-technical approaches to energy.

4. CONCLUSIONS AND IMPLICATIONS

This paper has highlighted the importance of the sociological and socio-technical context of sustainable energy technologies and projects for underpinning their success. This includes how they are defined, interpreted and variously redefined, accepted, adjusted, used, maintained, expanded or rejected, and the subsequent impacts of this. Throughout our discussion ‘success’ has been problematized as this too is shaped by the social context and the processes that constitute it. Better understanding these processes thus has significant practical implications. Three key concepts with supporting examples that equip up to realise these were critically defined and outlined. These are community energy, socio-technical and social practices. They highlight the normative rules and routines that are collectively constructed and reproduced, shape energy interventions and through which sustainability transitions may be achieved. Notably, this includes domestic consumers, consumption cultures and energy-demanding practices that shape national patterns of energy demand: major contributors to national energy use, carbon emissions, challenges of generation, intermittency and supply balancing, and the limited success of strategies struggling to address this.

The practical implications of this include considering the normative and routine context in which technologies and innovations are transformed and must be habitually appropriated for their functioning and impact. This context included the meanings, skills and materials of a society or sub-group that are made and melded in the routine doings, sayings and institutions of those societies. These can be considered as the elements, practices and structures of a society that co-depend (they are socio-technical and multi-level), mutually shape each other (they are systemic) and are produced, reproduced and changed by the performance of practices (multiply routinised, embodied yet dynamic). This includes the socio-temporal and cultural patterning of energy-demanding practices across households, communities, workplaces and sectors. This system explains vital considerations and processes for technological and sustainability

development, such as social and material innovation, interrelations, lock-in, transformation, learning, consumption, communication, participation, diffusion, and resistance. These and the context and requirements of energy projects and technologies can be better addressed by approaches that consider the key social practices implicated (such as domestic practices) and the socio-technical interdependencies (building and user cultures, expectations, policies, norms) that embed them and enable and constrain their reproduction or revision. This paper has introduced how a social practice and critically defined community energy approach is an excellent tool for this.

For improving the uptake and impact of smart meters, for instance, it is how they are used and situated in the aggregate that is key. This requires attending to the normative elements and routines of practice that shape their success. These include expectations, privacy concerns, ease-of-use, compatibility, social responsibility and other normative pressures, learning, improvising and diffusion; all of which influence consumption, investment, innovation and resistance patterns and are defined in relation to existing elements, routines and systems of practice. Making smart meters and systems as consistent with these as possible may thus accelerate their success. This could include making their interfaces and smart apps as addictive, physiologically rewarding, social and technologically compatible as other engagement and interaction platforms that are now culturally embedded and thus routinely and widely used.

For communities and energy policy and projects, it could include considering citizens and their assets (rooftops, financing, vehicles, homes, technologies, norms) as collectively key actors in energy systems through their practices that shape them and the above processes. This highlights the importance of process for energy projects, rather than the typical output-based focus of most projects. Incorporating citizens collectively through the social practices that bind them and influence energy technologies and sustainability, offer a compelling way to develop sustainable transitions and communities. It presents communities not simply as sets of individual and passive recipients of energy systems, projects and technologies, but as socio-culturally grouped and active users, investors, adopters, resisters, innovators and managers whose varied forms of these occurs in everyday practices and has profound and system-level influence on projects, technologies and sustainability. Framed thusly, we can better consider the key sites where sustainable energy and smart technologies are poised, and the multiplicities that affect them. Failure to do so is attributed to the failure of sustainable energy technologies and interventions. Through a multi-partner, socio-technical, multi-level and community-based approach, Project SCENe is in a unique position to demonstrate how this can be remedied.

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